Aging, Inflation and Property Prices

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Overview

1. Motivation
2. Literature reviews
3. Models
4. Empirical analysis
   - Data
   - Unit root tests
   - Estimation results
5. Conclusion
Many economies in the world will soon be or already are aging rapidly

1. **Aging of society** is manifesting **slowly and steadily** in many countries
   
2. Implementation of **policies** to counter declining birthrates only improve the situation slowly
   
3. Changes in the **population makeup** impact various markets, in a different way from economic shocks that bring about short-term economic fluctuation

4. Most notable impact that demographic changes may be on the **housing market**
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4. Most notable impact that demographic changes may be on the housing market
**Literature review on housing markets**

- **Mankiew and Weil (1989)**
  - Focusing on birth rate, which leads to future housing demand, and housing demand by age group, the study projected future housing prices in the United States.
  - Predicted that over the 25-year period from the time of this study, *U.S. housing prices would decrease by 47% in real terms.*

- **A special issue of *Regional Science and Urban Economics* (1991)**
  - Changes in housing demand have an effect on housing rents, but **no direct effect on housing prices**
  - Housing supply is elastic in the long term, thus a change in housing demand will be **adjusted by housing supply**
  - Housing prices are fluctuating, the (short-term) housing demand for a given year alone will not affect housing prices
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- Housing supply is elastic in the long term, thus a change in housing demand will be adjusted by housing supply.
- Housing prices are fluctuating, the (short-term) housing demand for a given year alone will not affect housing prices.
Empirical studies (in Japanese markets)

- Ootake and Shintani (1996) and Shimizu and Watanabe (2010) calculated housing demand with an index similar to that proposed by Mankiw and Weil (1989)

- The results suggested that although population factors have an effect on housing stocks, they do not have an effect on housing (residential land) prices

- These studies were not able to explicitly address changes in population makeup, such as the aging of society.
Nishimura (2011) and Nishimura and Takáts (2012) have noted that residential properties are an important asset class in households’ portfolio, and have focused on the asset-market determination of residential properties. Then they investigate the relationship between people’s life cycles and residential property prices in terms of long-term equilibrium spanning generations and analyzed the relationship between changes in population structure and the residential property prices.

Takáts (2015), Saita et al. (2013) and Shimizu et al. (2015) consider changes in the old-age dependency ratio as a factor explaining residential property price fluctuations, and have developed empirical models concerning the relationship between population structure and the residential property prices.
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Literature review of goods and services markets

- Does the aging of society have a negative impact on goods and services prices (price level/inflation), in a similar way to its effect on asset prices (residential property prices)?
- Changes in population makeup, such as the declining birth rate and aging of society, will affect goods and services prices via a more complex process than in asset markets such as residential properties.
- Some hypotheses are based on assumptions that the adjustment of production capacity and asset stocks will not progress swiftly and sufficiently.
- Our hypothesis here is that the existence of uncertainty caused by unexpected changes in population makeup has made it impossible to properly adjust production capacity and residential property stocks swiftly and sufficiently.
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Question

How will the declining birthrate and aging of society affect the goods and services prices and residential property prices?

How the changes in population makeup affect short-run inflation in both the goods and services markets and the residential property markets?

In this paper, we investigate the demographic effects on:

1. CPI (Consumer Price Index) inflation
2. RPPI (Residential Property Price Index) inflation

and

Using panel data from 23 economies for the period 1971-2015

Effects of demographic factors, such as age dependency ratios, and shares of generations, on the CPI and housing price inflations are examined.
Our research

Question
- How will the declining birthrate and aging of society affect the goods and services prices and residential property prices?
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CPI inflation model

- Baseline model: the Phillips curve

\[ \Delta \log P_{jt}^{cpi} = \mu + \alpha Y_{jt}^{gap} + \mu_{j0} + \lambda_t + \epsilon_{jt} \]

where

- \( P_{jt}^{cpi} \): CPI (in levels) of country \( j \) at year \( t \)
- \( Y_{jt}^{gap} \): Output gap (of real GDP)

CPI inflation model with demographic factors

\[ \Delta \log P_{jt}^{cpi} = \mu + \alpha Y_{jt}^{gap} + \mu_{j0} + \lambda_t + \text{demographic factors}_{jt} + \epsilon_{jt} \] (1)
**RPPI inflation models**

1. **Present value relation**
   - Assume that the real asset price is determined as
     
     \[
     \text{real asset price} = \text{PDV of } \frac{\text{future real rent}}{\text{future real discount rate}}
     \]
   
   - Assume that
     - future real rent = current real rent
     - future discount rate = current discount rate
   
   - Then we have a following relation
     
     \[
     \log \left( \frac{\text{nominal asset price}}{\text{general price level}} \right) = \log \left( \frac{\text{current real rent}}{\text{current discount rate}} \right)
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RPPI inflation models

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We further assume

- \( \log (\text{current real rent}) = \xi_0 + \xi_1 \log (\text{real GDP per capita of working age population}) \)
- \( \log (\text{current discount rate}) = \phi_0 + \phi_1 (\text{current real int rate}) \)
- \( (\text{real int rate}) = (\text{nominal int rate}) - (\text{inflationary expectations}) \)
- \( \Delta (\text{inflationary expectations}) = \eta_0 + \eta_1 \Delta \log (\text{general price level}) \)

Then we have

\[
\Delta \log (\text{nominal asset price}) = (\phi_1 \eta + 1) \Delta \log (\text{general price level}) \\
+ \xi_1 \Delta \log (\text{real GDP per capita of working age population}) \\
- \phi_1 \Delta (\text{nominal interest rate}) + \eta_0 \phi_1
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\]
Using our definition of variables, the model of RPPI inflation is

\[ \Delta \log P^{rppi}_{jt} = \mu + \alpha_0 \Delta \log P^{cpi}_{jt} + \alpha_1 \Delta \log \left( \frac{Y_{jt}}{\text{pop}_{jt}} \right) \]

\[ + \alpha_2 \Delta R_{jt} + \epsilon_{jt} \]

where \( \alpha_0 = \phi_1 \eta + 1, \alpha_1 = \zeta_1, \) and \( \alpha_2 = -\phi_1 \)

Independently, using an OGM with a lifecycle, Nishimura and Takáts (2012), Takáts (2012) have derived a following equation

\[ \Delta \log P^{rppi}_{jt} - \Delta \log P^{cpi}_{jt} = \mu + \alpha_1 \Delta \log \left( \frac{Y_{jt}}{\text{pop}_{jt}} \right) \]

\[ + \alpha_2 \Delta \log \text{depr}^{o}_{jt} + \alpha_3 \Delta \log \text{pop}^{\text{total}}_{jt} + \mu_j + \lambda_t + \epsilon_{jt} \]

\( \text{real RPPI inflation} \)

\( \text{demographic variables} \)
Using our definition of variables, the model of RPPI inflation is

\[ \Delta \log P_{jt}^{rppi} = \mu + \alpha_0 \Delta \log P_{jt}^{cpi} + \alpha_1 \Delta \log \left( \frac{Y_{jt}}{\text{pop}_{jt}^{working}} \right) \]

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\text{real RPPI inflation}

\text{demographic variables}
Due to frictions such as transaction costs, it is likely that the price adjustment occurs with some lags.

**RPPI inflation model with demographic factors**

A long-run equilibrium relation

\[
\log P_{jt}^{rppi} = \mu + \alpha_0 \log P_{jt}^{cpi} + \alpha_1 \log \left( \frac{Y_{jt}}{\text{pop}_{jt}} \right) \]

\[
+ \alpha_2 R_{jt} + \mu_j + \lambda_t + \text{[demo.factors (in levels)]}_j + \epsilon_{jt} \]  \hspace{1cm} (2)

An error-correction mechanism

\[
\Delta \log P_{jt}^{rppi} = m + a_0 \Delta \log P_{jt}^{cpi} + a_1 \Delta \log \left( \frac{Y_{jt}}{\text{pop}_{jt}} \right) \]

\[
+ a_2 \Delta R_{jt} + m_j + l_t + \text{[demo.factors (in diff)]}_j + \theta \epsilon_{j,t-1} + \nu_{jt} \]  \hspace{1cm} (3)
Due to frictions such as transaction costs, it is likely that the price adjustment occurs with some lags.

**RPPI inflation model with demographic factors**

**A long-run equilibrium relation**

\[
\log P_{jt}^{rppi} = \mu + \alpha_0 \log P_{jt}^{cpi} + \alpha_1 \log \left( \frac{Y_{jt}}{\text{pop}_{jt}^{\text{working}}} \right) \\
+ \alpha_2 R_{jt} + \mu_j + \lambda_t + [\text{demo.factors (in levels)}]_{jt} + \epsilon_{jt}
\]  

(2)

**An error-correction mechanism**

\[
\Delta \log P_{jt}^{rppi} = m + a_0 \Delta \log P_{jt}^{cpi} + a_1 \Delta \log \left( \frac{Y_{jt}}{\text{pop}_{jt}^{\text{working}}} \right) \\
+ a_2 \Delta R_{jt} + m_j + l_t + [\text{demo.factors (in diff)}]_{jt} + \theta \hat{\epsilon}_{j,t-1} + \nu_{jt}
\]

(3)
Variables in the regression models

1. CPI inflation \((\pi_{\text{cpi}})_{jt}\)
   - Main source: Quarterly “CPI, all items” (IFS)
   - For Germany, UK, and Korea, OECD statistics is used
   - Quarterly index are average for each year, and then log-differenced to obtain the inflation rate.

   \[
   \pi_{\text{cpi}}_{jt} = 100 \cdot \Delta \log P^c_{jt}
   \]

2. Output gap \((\text{gap})_{jt}\)
   - Calculated from the annual real GDP (IFS) by Hodrick-Prescott filter

   \[
   \text{gap}_{jt} = 100 \cdot \frac{\text{HP}^\text{cyclical}_{jt}}{\text{HP}^\text{trend}_{jt}}
   \]
CPI inflation
Output gap (available from 1970-)

Empirical analysis

Data
3 core variables in RPPI inflation regression models

3. **RPPI inflation** ($pi_{rppi,jt}$)
   - **Source:** Quarterly “Long-term Series on Nominal Residential Property Prices” in BIS Residential Property Price database
   - Quarterly index are average for each year, and then log-differenced to obtain the inflation rate.

   \[
   pi_{rppi,jt} = 100 \cdot \Delta \log P_{jt}^{rppi}
   \]

4. **Nominal interest rate** ($gbond_{jt}$)
   - **Source:** Annual “Interest Rates, Government Securities, Government Bonds, Percent per annum” (IFS).

5. **Real GDP per working population, log-differenced** ($dlrgdp2wpop_{jt}$)

   \[
   dlrgdp2wpop_{jt} = 100 \cdot \Delta \log \left( \frac{Y_{jt}}{pop_{jt}^{working}} \right)
   \]
Empirical analysis

Data

RPPI inflation (available from 1971-)

AU

BE

CA

CH

DE

DK

ES

FI

FR

GB

HK

IE

IT

JP

KR

MY

NL

NO

NZ

SE

TH

US

ZA
Nominal interest rate (Government bonds yield, %)
Nominal interest rate and CPI inflation
Real GDP per working population, log-differenced
Population data

- Source: UN population database
- \( p_{kjt} \) is the populations of age cohort \( k \) \((k = 1, \ldots, 17)\) in total population for country \( j \) at year \( t \)

<table>
<thead>
<tr>
<th>cohort ( k )</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>( \cdot )</th>
<th>13</th>
<th>14</th>
<th>( \cdot )</th>
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</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>0-4</td>
<td>5-9</td>
<td>10-14</td>
<td>15-19</td>
<td>( \cdot )</td>
<td>60-64</td>
<td>65-69</td>
<td>( \cdot )</td>
<td>80+</td>
</tr>
<tr>
<td>pop.</td>
<td>( p_{1jt} )</td>
<td>( p_{2jt} )</td>
<td>( p_{3jt} )</td>
<td>( p_{4jt} )</td>
<td>( \cdot )</td>
<td>( p_{13jt} )</td>
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- Shares of young, working, and old generations (\( n_{\text{young}} \), \( n_{\text{working}} \), and \( n_{\text{old}} \))

\[
\begin{align*}
    n_{\text{young}}^{\text{jt}} &= 100 \cdot \frac{\sum_{k=1}^{3} p_{kjt}}{\sum_{k=1}^{17} p_{kjt}} \\
    n_{\text{working}}^{\text{jt}} &= 100 \cdot \frac{\sum_{k=4}^{13} p_{kjt}}{\sum_{k=1}^{17} p_{kjt}} \\
    n_{\text{old}}^{\text{jt}} &= 100 \cdot \frac{\sum_{k=14}^{17} p_{kjt}}{\sum_{k=1}^{17} p_{kjt}}
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Age dependency ratio (depr)

\[ depr_{jt} = 100 \cdot \frac{n_{\text{young}} + n_{\text{old}}}{n_{\text{working}}} \]

Age dependency ratios of young and old (depr\(_y\) and depr\(_o\))

\[ depr_{jt}^y = 100 \cdot \frac{n_{\text{young}}}{n_{\text{working}}} \quad \text{and} \quad depr_{jt}^o = 100 \cdot \frac{n_{\text{old}}}{n_{\text{working}}} \]

Growth rate of total population (dlnum_total)

\[ \text{dlnum\_total}_{jt} = 100 \cdot \Delta \log(p_{jt}^{\text{total}}) \]

where \( p_{jt}^{\text{total}} = \sum_{k=1}^{17} p_{kj} \)
Age dependency ratio (depr)

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depr_{jt} = 100 \cdot \frac{n_{jt}^{young} + n_{jt}^{old}}{n_{jt}^{working}}
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Age dependency ratios of young and old (depr_y and depr_o)

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Empirical analysis

Data

4 specifications of “demographic factors” in Eq. (1), (2), and (3).

1. Age dependency ratio

\[
\text{demographic factors}_{jt} = \delta_1 \text{depr}_{jt}
\]

2. Age dependency ratios of young and old

\[
\text{demographic factors}_{jt} = \delta_1 \text{depr}_{jt}^y + \delta_2 \text{depr}_{jt}^o
\]

3. Shares of young, working, and old generations

\[
\text{demographic factors}_{jt} = \delta_1 n_{jt}^{young} + \delta_2 n_{jt}^{working} + \delta_3 n_{jt}^{old}
\]

4. Shares of age cohorts

\[
\text{demographic factors}_{jt} = \sum_{k=1}^{17} \delta_k \times n_{kjt}^{\uparrow \text{share of cohort } k}
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4 specifications of “demographic factors” in Eq. (1), (2), and (3).

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Empirical analysis

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↑ share of cohort \( k \)
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Modeling the population effect by a flexible polynomial function

- Original idea comes from Almon’s (1965) polynomial-distributed lag technique
- Fair and Dominguez (1991) estimate the effects of the changing U.S. age distribution on consumption, housing-investment, money demand, and labor-force-participation equations.

Fair and Dominguez (1991) estimated the relevant coefficients by imposing two restrictions.

1. The age-group coefficients are summed to zero
2. Coefficients lie on a $p$-th degree polynomial such that

$$\delta_k = \sum_{p=0}^{P} \gamma_p k^p$$
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$$\delta_k = \sum_{p=0}^{P} \gamma_p k^p$$
Using this specification, demographic factor is transformed as

\[
\text{demographic factors}_{jt} = \sum_{k=1}^{17} \delta_k n_{kjt} = \sum_{p=1}^{P} \gamma_p \tilde{n}_{pjt}
\]

where

\[
\tilde{n}_{pjt} = \sum_{k=1}^{17} \left( k^p n_{kjt} - \frac{k^p}{17} \right)
\]

with \( P \) parameters to be estimated. We select \( P = 4 \) (Juselius and Takáts (2014)).
### Complete list of countries in our sample

<table>
<thead>
<tr>
<th>Region</th>
<th>Countries</th>
</tr>
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<tbody>
<tr>
<td>Asia-Pacific</td>
<td>Australia, Hong Kong, Japan, Korea, Malaysia, Thailand, New Zealand</td>
</tr>
<tr>
<td>Europe</td>
<td>Belgium, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom, Ireland, Italy, Netherlands, Norway, Sweden</td>
</tr>
<tr>
<td>America</td>
<td>Canada, United States</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>South Africa</td>
</tr>
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</table>

- 23 countries, mainly European countries
Before proceeding the regression analysis, we have applied a battery of unit root tests to our dataset.

<table>
<thead>
<tr>
<th>Common Unit Root Tests</th>
<th>Individual Unit Root Tests</th>
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<tbody>
<tr>
<td>LLC</td>
<td>Without CD</td>
</tr>
<tr>
<td></td>
<td>IPS W-stat</td>
</tr>
<tr>
<td></td>
<td>ADF-Fisher $\chi^2$</td>
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<tr>
<td>$H_0$</td>
<td>unit root</td>
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<td>unit root</td>
</tr>
<tr>
<td>$H_1$</td>
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<tr>
<td></td>
<td>some CS without UR</td>
</tr>
<tr>
<td></td>
<td>some CS without UR</td>
</tr>
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</table>

- LLC: Levin, Lin & Chu Test
- IPS: Im, Pesaran, and Shin Test
- CD: Cross-section Dependence
- CS: Cross-section
- CIPS: Cross-sectionally augmented IPS
Pesaran (2004) proposed a test statistic based on the average of the pairwise correlation coefficients which is asymptotically standard normal.

Table 2 reports Pesaran’s test.

The CD test always strongly rejects the null hypothesis of no cross-section dependence.
CPI inflation models

CPI inflation model with demographic factors

\[
\Delta \log P_{jt}^{cpi} = \mu + \alpha Y_{jt}^{gap} + \mu_j + \lambda_t + demo.\text{factors}_{jt} + \epsilon_{jt}
\]

- Phillips curve
- fixed effects

Types of demographic factors

1. Age dependency ratio
   \[
   age\text{ dependency ratio}_{jt} = \delta_1 depr_{jt}
   \]

2. Two age dependency ratios
   \[
   2\text{ age dependency ratios}_{jt} = \delta_1 depr^y_{jt} + \delta_2 depr^o_{jt}
   \]

3. Three generation share
   \[
   3\text{ generation share}_{jt} = \delta_1 n^\text{young}_{jt} + \delta_2 n^\text{working}_{jt} + \delta_3 n^\text{old}_{jt}
   \]

4. Four cohort shares
   \[
   k\text{ cohort shares}_{jt} = \sum_{p=1}^{4} \gamma_p \tilde{n}_{pjt}
   \]
Demography and CPI inflation (Sample period: 1971-2015)

<table>
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<tr>
<th>Model:</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<td>0.505</td>
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<td>5.246</td>
<td>4.886</td>
<td>5.206</td>
<td>4.877</td>
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</table>
Findings about CPI inflation

1. CPI inflation is procyclical with respect to the output gap
2. The models of “Generation Shares” (Models 7 and 8) indicates:
   - \( n^{\text{young}} \) (N_YOUNG in the table) strongly inflationary
   - \( n^{\text{old}} \) (N_OLD) strongly deflationary

Thus it worth investigating the effects of “Population Makeup” on CPI inflation by using “polynomial models”
Findings about CPI inflation

1. CPI inflation is procyclical with respect to the output gap

2. The models of “Generation Shares” (Models 7 and 8) indicates:
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   - $n_{old}$ (N_OLD) strongly deflationary

Thus it worth investigating the effects of “Population Makeup” on CPI inflation by using “polynomial models”
Demography and CPI inflation (Sample period: 1971-2015)

<table>
<thead>
<tr>
<th>Model: 9</th>
<th>Model: 10</th>
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<tbody>
<tr>
<td>Dep. Var:</td>
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<td>0.113**</td>
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<td>0.000**</td>
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Fixed effects: cs & period

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>No. of Obs:</td>
<td>1025</td>
<td>1025</td>
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<tr>
<td>R-squared:</td>
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<td>F-statistic:</td>
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<td>AIC</td>
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<td>4.522</td>
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<tr>
<td>BIC</td>
<td>5.030</td>
<td>4.868</td>
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</tbody>
</table>
An increase in the ratio is **inflationary until aged 15-19 (Age Cohort 4)**.

The impact decreases for subsequent age cohorts, hits the bottom at aged 35-39 (Age Cohort 8), who are typically married and have a family

- Strongly **deflationary from aged 75-** (Age Cohort 16-)
Robustness check

Adding the growth rate of total population to the model

Logic

1. From the money demand function, we have $M = k \cdot PY$. Thus

$$\Delta \log M = \Delta \log P + \Delta \log Y$$

2. Assume that
   - $\Delta \log M$ is exogenous
   - $Y$ is associated with $N$ (total population) as

$$\log Y = a + b \cdot \log N$$

3. Then we have

$$\Delta \log P = \text{exogenous var} - b \cdot \Delta \log N$$

Thus, the coefficient of $\Delta \log N$ is expected to be negative.
Robustness check

- Adding the growth rate of total population to the model

Logic

1. From the money demand function, we have $M = k \cdot PY$. Thus

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3. Then we have

$$\Delta \log P = \text{exogenous var} - b \cdot \Delta \log N$$

thus, the coefficient of $\Delta \log N$ is expected to be negative.
Robustness Check: Growth Rate of Total Population” (1971-2015)

<table>
<thead>
<tr>
<th>Model:</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dep. Var:</td>
<td>PI_CPI</td>
<td>PI_CPI</td>
<td>PI_CPI</td>
<td>PI_CPI</td>
</tr>
</tbody>
</table>
| INTERCEPT | 4.850 | 5.592 | 2.145 | 11.
| | 0.709** | 0.774** | 1.394 | 12.
| GAP | 0.206 | 0.208 | 0.210 | 13.
| | 0.032** | 0.032** | 0.032** | 14.
| DEPR | -0.007 | 0.014 | | |
| DEPR_Y | 0.018 | | | |
| DEPR_O | -0.082 | | | |
| N_YOUNG | 0.104 | | | |
| N_WORKING | 0.031 | | | |
| N_OLD | -0.135 | | | |
| DNUM_TOTAL | 0.365 | 0.105 | -0.043 | |
| Fixed effects | cs & period | cs & period | cs & period | Fixed effects | cs & period |
| Observations: | 1047 | 1047 | 1047 | Observations: | 1047 |
| R-squared: | 0.735 | 0.736 | 0.738 | R-squared: | 0.745 |
| F-statistic: | 38.575 | 38.289 | 38.718 | F-statistic: | 38.928 |
| AIC | 4.572 | 4.568 | 4.560 | AIC | 4.537 |
| BIC | 4.908 | 4.909 | 4.900 | BIC | 4.887 |
Summary: Findings about CPI inflation

1. CPI inflation is procyclical with respect to the output gap
2. Using the generation shares, we found that
   - \( n^{young} \) (\( N_{YOUNG} \) in the table) strongly inflationary
   - \( n^{old} \) (\( N_{OLD} \)) strongly deflationary
3. Using the polynomial model, we found that
   - An increase in the ratio is inflationary until aged 15-19 (Age Cohort 4)
   - The impact decreases for subsequent age cohorts, hits the bottom at aged 35-39 (Age Cohort 8), who are typically married and have a family
   - Strongly deflationary from aged 75- (Age Cohort 16-)
RPPI inflation models

RPPI inflation model with demographic factors

A long-run equilibrium relation

\[
\log P_{jt}^{rppi} = \mu + \alpha_0 \log P_{jt}^{cpi} + \alpha_1 \log \left( \frac{Y_{jt}}{\text{pop}_{jt}} \right) \\
+ \alpha_2 R_{jt} + \mu j_0 + \lambda_t + \text{[demo.factors (in levels)]}_{jt} + \epsilon_{jt}
\]

An error-correction mechanism

\[
\Delta \log P_{jt}^{rppi} = m + a_0 \Delta \log P_{jt}^{cpi} + a_1 \Delta \log \left( \frac{Y_{jt}}{\text{pop}_{jt}} \right) \\
+ a_2 \Delta R_{jt} + m j_0 + l_t + \text{[demo.factors (in diff)]}_{jt} + \theta \hat{\epsilon}_{j,t-1} + \nu_{jt}
\]
Demography and RPPI inflation (Long-run equilibrium, Period: 1971-2015)

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<td>Observations:</td>
<td>919</td>
<td>919</td>
<td>919</td>
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<tr>
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<td>0.938</td>
<td>0.928</td>
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<td>0.938</td>
<td>0.951</td>
<td>0.937</td>
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</tbody>
</table>
Findings about the Long-Run

1. Similar to the CPI inflation case, the models of “Generation Shares” (Models 21-L and 22-L) indicates:
   - $n_{young}$ (N_YOUNG) strongly positive effect on residential property price
   - $n_{old}$ (N_OLD) strongly negative effect on residential property price

2. 3 core variables, i.e., LRGDP2WPOP, GBOND, and LCPI, have correct signs as theory predicted, and are all statistically significant.
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2. 3 core variables, i.e., LRGDP2WPOP, GBOND, and LCPI, have correct signs as theory predicted, and are all statistically significant.
Demography and RPPI inflation (Error-correction model, 1971-2015)

<table>
<thead>
<tr>
<th>Eq Name</th>
<th>15-S</th>
<th>16-S</th>
<th>17-S</th>
<th>18-S</th>
<th>19-S</th>
<th>20-S</th>
<th>21-S</th>
<th>22-S</th>
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<tbody>
<tr>
<td></td>
<td>0.574**</td>
<td>0.675**</td>
<td>0.568**</td>
<td>0.671**</td>
<td>0.729**</td>
<td>0.815**</td>
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<td>DLRGDP2WPOP</td>
<td>1.286</td>
<td>1.358</td>
<td>1.234</td>
<td>1.326</td>
<td>1.237</td>
<td>1.320</td>
<td>1.236</td>
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<td></td>
<td>0.085**</td>
<td>0.100**</td>
<td>0.084**</td>
<td>0.098**</td>
<td>0.083**</td>
<td>0.098**</td>
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</tr>
<tr>
<td>D(GBOND)</td>
<td>0.429</td>
<td>0.504</td>
<td>0.513</td>
<td>0.539</td>
<td>0.501</td>
<td>0.558</td>
<td>0.490</td>
<td>0.546</td>
</tr>
<tr>
<td></td>
<td>0.185*</td>
<td>0.218*</td>
<td>0.184**</td>
<td>0.182**</td>
<td>0.214**</td>
<td>0.182**</td>
<td>0.214*</td>
<td>0.214*</td>
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<tr>
<td>PI_CPI</td>
<td>0.728</td>
<td>0.735</td>
<td>0.592</td>
<td>0.730</td>
<td>0.588</td>
<td>0.722</td>
<td>0.596</td>
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<td>0.062**</td>
<td>0.096**</td>
<td>0.062**</td>
<td>0.096**</td>
<td>0.061**</td>
<td>0.096**</td>
</tr>
<tr>
<td>D(DEPR)</td>
<td>-1.808</td>
<td>-2.525</td>
<td>0.374**</td>
<td>0.434**</td>
<td>0.374**</td>
<td>0.434**</td>
<td>0.374**</td>
<td>0.434**</td>
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<tr>
<td>D(DEPR_Y)</td>
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<td>D(DEPR_O)</td>
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<tr>
<td>D(N_YOUNG)</td>
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</tr>
<tr>
<td>D(N_WORKING)</td>
<td></td>
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<tr>
<td>D(N_OLD)</td>
<td>1.048</td>
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<td>0.830</td>
<td>0.974</td>
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<td>-5.737</td>
<td>-6.443</td>
<td>-6.022</td>
<td>-6.483</td>
<td>-6.029</td>
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<td></td>
<td>0.970**</td>
<td>0.971**</td>
<td>0.960**</td>
<td>0.956**</td>
<td>0.984**</td>
<td>1.012**</td>
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<td>2.604</td>
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<td>3.583</td>
<td>2.446</td>
<td>3.843</td>
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<td></td>
<td>0.630**</td>
<td>0.620**</td>
<td>0.627**</td>
<td>0.611**</td>
<td>0.633**</td>
<td>0.608**</td>
<td>0.653**</td>
<td>0.626**</td>
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<td>897</td>
<td>897</td>
<td>897</td>
<td>897</td>
<td>897</td>
<td>897</td>
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<tr>
<td>R-squared:</td>
<td>0.419</td>
<td>0.512</td>
<td>0.435</td>
<td>0.530</td>
<td>0.446</td>
<td>0.530</td>
<td>0.445</td>
<td>0.530</td>
</tr>
</tbody>
</table>
Findings about the Short-Run

- Obtained results are very different from the ones in the long-run.

- The models of “Generation Shares” (Models 21-S and 22-S) indicates:
  - $n_{young}$ (N_YOUNG) strongly deflationary
  - $n_{working}$ (N_WORKING) strongly inflationary

- Similar tendency is confirmed by “polynomial models” (Next slides)
Findings about the Short-Run

- Obtained results are very different from the ones in the long-run.

- The models of “Generation Shares” (Models 21-S and 22-S) indicates:
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- Similar tendency is confirmed by “polynomial models” (Next slides)
## Demography and RPPI inflation (Polynomial models, Period: 1971-2015)

<table>
<thead>
<tr>
<th>Eq Name:</th>
<th>23-L</th>
<th>24-L</th>
<th>23-S</th>
<th>24-S</th>
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<td>Dep. Var:</td>
<td>LRPPI</td>
<td>LRPPI</td>
<td>PI_RPPI</td>
<td>PI_RPPI</td>
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<td>C</td>
<td>0.676</td>
<td>4.104</td>
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<td>1.939</td>
<td>1.872*</td>
<td>1.461</td>
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<tr>
<td>LRGDP2WPOP</td>
<td>0.836</td>
<td>0.528</td>
<td>1.239</td>
<td>1.303</td>
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<td>0.071**</td>
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<td>0.085**</td>
<td>0.099**</td>
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<tr>
<td>GBOND</td>
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<td>-0.015</td>
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<td>0.546</td>
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<tr>
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<td>0.003**</td>
<td>0.004**</td>
<td>0.184**</td>
<td>0.215*</td>
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<tr>
<td>LCPI</td>
<td>1.101</td>
<td>1.025</td>
<td>0.496</td>
<td>0.681</td>
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<tr>
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<td>0.033**</td>
<td>0.040**</td>
<td>0.077**</td>
<td>0.098**</td>
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<td>NTILDE1</td>
<td>-0.035</td>
<td>-0.021</td>
<td>D(NTILDE1)</td>
<td>7.673</td>
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<td>0.011**</td>
<td>0.011</td>
<td>1.798**</td>
<td>2.047</td>
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<td>NTILDE2</td>
<td>0.005</td>
<td>0.005</td>
<td>D(NTILDE2)</td>
<td>-1.289</td>
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<tr>
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<td>0.002*</td>
<td>0.003*</td>
<td>0.409**</td>
<td>0.485</td>
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<tr>
<td>NTILDE3</td>
<td>0.000</td>
<td>-0.001</td>
<td>D(NTILDE3)</td>
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<tr>
<td></td>
<td>0.000</td>
<td>0.000**</td>
<td>0.036*</td>
<td>0.043</td>
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<tr>
<td>NTILDE4</td>
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<td>0.000</td>
<td>D(NTILDE4)</td>
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<td>0.152**</td>
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<td>Error Correction (-1)</td>
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<td>-5.587</td>
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<td>0.999**</td>
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<th>Fixed effects</th>
<th>cs</th>
<th>cs &amp; period</th>
<th>Fixed effects</th>
<th>cs</th>
<th>cs &amp; period</th>
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<tbody>
<tr>
<td>Observations:</td>
<td>919</td>
<td>919</td>
<td>Observations:</td>
<td>897</td>
<td>897</td>
</tr>
<tr>
<td>R-squared:</td>
<td>0.940</td>
<td>0.952</td>
<td>R-squared:</td>
<td>0.446</td>
<td>0.530</td>
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<tr>
<td>F-statistic:</td>
<td>480.409</td>
<td>231.893</td>
<td>F-statistic:</td>
<td>23.229</td>
<td>12.707</td>
</tr>
</tbody>
</table>
The long-run impact is **larger for younger cohorts**

- Overall, the long-run impact decreases over the age cohort
The short-run impact is larger for the cohorts in working generation
Summary: Findings about RPPI inflation

1. In the long-run equilibrium, $P_{cpi}$ and $Y/pop_{working}$ are positively related, and $R$ is negatively related with $P_{rppi}$ as theory predicts.

2. Depending on the time horizon, the demographic impacts are very different:

<table>
<thead>
<tr>
<th>generations</th>
<th>long-run</th>
<th>short-run</th>
</tr>
</thead>
<tbody>
<tr>
<td>young</td>
<td>strongly inflationary</td>
<td>strongly deflationary</td>
</tr>
<tr>
<td>working old</td>
<td>strongly deflationary</td>
<td>strongly inflationary</td>
</tr>
</tbody>
</table>
Conclusion

Our research

Question

- How will the declining birthrate and aging of society affect the goods and services prices and residential property prices?
- How the changes in population makeup affect short-run inflation in both the goods and services markets and the residential property markets?

In this paper, we investigate the demographic effects on:

1. CPI(Consumer Price Index) inflation
2. RPPI(Residential Property Price Index) inflation

and

- Using panel data from 23 economies for the period 1971-2015
- Effects of demographic factors, such as age dependency ratios, and shares of generations, on the CPI and housing price inflations are examined.
Major findings of this paper

1. Demographic impacts have similar impacts between goods and services price inflation and residential property prices in the long-run.

2. Short-run residential property price inflation dynamics has markedly different demographic impacts from the long-run counterpart.
Leftovers

1. Issues on the data
   - Missing observations may be extrapolated (especially for RPPI regression models)

2. Issues on the specifications
   - Models with higher degree of polynomial function may be estimated

3. Issues on testing
   - Re-examination of the integration order of variables may be needed
   - Panel co-integration may be formally tested
Thank you very much