Aging and Property Prices: Evidence from a Panel of Diverse Economies

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Organization of the Presentation

Motivation

Speed of Aging: Selected Economies

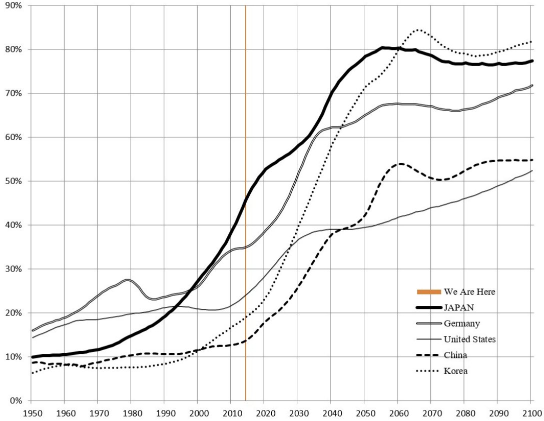

Figure: Old-age dependency ratio

source: United Nations World Population Prospects, 2012 Revision

Demography (Aging), Economic Activities and Asset Prices

- Demography:
  - Slow Moving, Seemingly Predictable in the Short-Run
  - However, Long-run Accumulative Effects of Small Prediction Errors Are Mind-Boggling
  - It Becomes Very Important in a Very Long Run, Spanning Over Generations

- Economic Activities:
  Saving, Investment, and Asset Prices
  - Mostly Driven by Expectations about the Future
  - Future Asset Prices, Future Social Security (Pensions), Future Medical Costs, etc.
  - Current Decision Is Dependent on Expectations of Near Future,
  - and Expectations of Near Future Is Dependent on Expectations of Distant Future,
  - and $\cdots$
  - Expectations of Distant Future Shape the Present Economic Activities

- Crucial Importance of Very Long Run Expectations (Expectations about Future, Say, One Generation From Now) and Demography as their Important Determinant
  - However, They Are Mostly Ignored (or Assumed to Be Constant) in the Short Run of "Now and a Year or Two Later" (Business Cycles) Which We Are Concerned With.
  - Moreover, When They Are Considered, Focus Is Mostly on the Steady State (see "Growth Theory")
  - Since Baby-Booms and Subsequent Aging Populations Are a Transitional Phenomenon, the Effect of Aging Is Thus Not Properly Analyzed.
  - Quite Unsatisfactory State

Demography, Very Long Run Expectations and Asset Prices: What Do We Know?

Two Issues

- Are Expectations "Rational" or Perfect Foresight on the Average?
- Is the Supply of Assets in Question Inelastic?

- If Expectations are "Rational" or Perfect Foresight on the Average, AND the Supply of the Assets Are Elastic, then CHANGE IN DEOMOGRAPHY IS NOT LIKELY TO MATTER MUCH
  - Implications of Mankiw-Weil (1989) controversy and a special issue of *Regional Science and Urban Economics* (1991)
  - Properties = Buildings → Elastic Supply (Depreciable Capital)
    + Land → Inelastic Supply (Non-Depreciable)
  - Focus on the Building Component of Property Prices
  - When property prices are anticipated to rise, then more buildings will be built to counteract expected price increases.
  - Since (1) demographic factors change very slowly and (2) they are mostly anticipated, and that (3) all anticipated changes in real conditions are already incorporated well in advance in property prices, a change in current demography is not likely to change property prices very much.

- If Expectations are "Rational" or Perfect Foresight on the Average, BUT the Supply of the Assets Are Inelastic, then DEOMOGRAPHY MATTERS for the Assets of Inelastic Supply:
  - Very Long Run Portfolio Choice Model for Retirement of Nishimura and Takáts 2012, Tamai et al 2017
  - Focus on Land Component of Property Prices. Land as Physically Non-Depreciable Real Assets with Limited Supply (Inelastic Supply)
  - Also Money as A New Class of Assets in Non-Inflationary Environment, which is Physically Non-Depreciable Nominal Assets with Limited Supply (Exogenous, Policy-Determined)
    - Intuition: Baby-boomers demand more land and more real money than previous generation, to push up land prices and the price of real money (reciprocal of the price level). The central bank keeps price stable, which means land prices are even higher.
- However, although demography matters, its theoretically derived impacts under perfect foresight are not of the magnitude of the observed changes in property prices in many countries.

Are Very Long-Run Expectations "Rational"? NO! (1) Wishful Thinking of "Return to Normal (Past Average)"

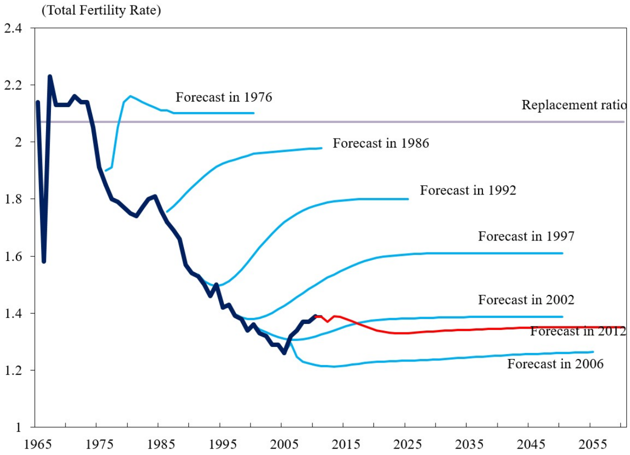

Figure: Revisions in Japanese Total Fertility Rate Forecasts

Are Very Long-Run Expectations "Rational"? NO! (2) Extrapolation of the Past Movement

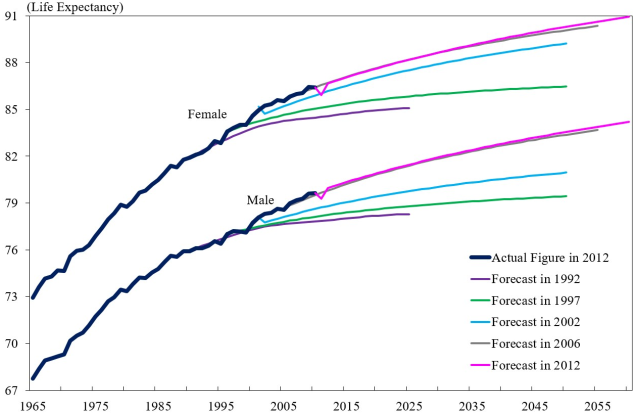

Figure: Revisions in Japanese Life Expectancy Forecasts

Economic Consequences of Non-Rational, Extrapolating, and "Return to Normal" Expectations

- Population Bonus Period
  - Demand Side:
    - Economy has more prime-age, output-producing workers than before, relative to dependent elderly individuals.
    - Economy produces more discretionary income for consumption and investing; more left over after supporting dependent seniors.
    - This is tantamount to a lasting bonus in paychecks, fostering a vibrant economy and optimistic expectations.
    - If people extrapolate from their experience, a demographic bonus can nurture optimism and higher demand for properties
  - Supply Side:
    - Supply of buildings will increase but not sufficient to satisfy this self-feeding excessive optimism, because of resource constraints and conservatism in business investment ("return to past normal" expectations)
  - Result: Persistent and Significant Increases of Property Prices

- Population Onus Period: Reverse in Course
  - Demand Side:
    - Spiral of pessimism, deleveraging, lower growth, and lower demand for properties
  - Supply Side:
    - significant oversupply, and "return to past normal" expectations prevent rapid liquidation of the oversupply
  - Result: Significant decreases of property prices
- Moreover, When Population Bonus Is Coupled with Easy Credit, the Swing of Property Prices Become Significantly Larger.

Our Research

- Question
  - How the declining birthrate and aging of society affect in both the residential property markets? Or How will the changes in population makeup affect the residential property prices?
  - We investigate the demographic effects on: RPPI (Residential Property Price Index)
- Although ideally long time-series data of property prices are desirable to account for the effect of very slow-moving demography, we cannot find such data in one country.
- Thus, we look for a panel of economies sufficiently diversified in their demographics and economic activities.
- Panel data from 23 economies for the period 1971-2015 are collected and used (Seven Asia-Pacific, Thirteen European, Two North American, One African)

Demography and Property Prices: A Literature Review

Literature Review on Residential Property Markets

- Mankiw-Weil (1989) on Demand and Supply in Housing Markets
  - Mankiw-Weil: focusing on birth rates, which determine future housing demand, and also on 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
- These studies did not explicitly address the issue that a growing share in property prices of land (Knoll et al AER 2017), of which supply is inelastic (at least relative to buildings).

- Nishimura (Cambridge 2011), Nishimura-Takáts (BIS 2012) & Tamai et al (AEP 2017) on Residential Properties ("Land") as Long-Term Assets
    - N, N-T and T_+ have noted that residential properties (esp. "land components") are an important asset class in households' long-term portfolio, which spans generations, alongside with money as a new asset class in a non-inflationary environment.
    - They show population makeup (aging) has an impact on residential property prices (esp. "land components").
    - However, although demography matters, its theoretically derived impacts under conventional "rational expectations" (or perfect foresight on average) are not of the magnitude of the observed changes in property prices in many countries (see Saita et al. (2013) and Shimizu et al.(2015) and also see Takáts (2015) for a prediction based on the theory).

- Nishimura (Bruegel 2014) suggested long-run expectations involving demography are not rational, and Nishimura (IntFi 2016) hinted demographic bonus/onus brought about excessive optimism/pessimism leading to higher/lower property prices
  - Nishimura (2014). Demographic expectations are full of wishful thinking including those of experts (National Institute of Population). "Return to normal" expectations about birth rates and "extrapolation of the past" expectations about longevity.
  - Nishimura (2016) suggests that these non-rational expectations (non-perfect-foresight-on-average) generate excessive optimism in the phase of demographic bonus (higher ratio of working people to elderly one) leading to higher property prices and *vice versa*.
  - Nishimura also pointed out by using historical correlation that if demographic bonus was coupled with easy credit, the swing of property prices between bubbles and busts became significantly large.

Models and Data

RPPI Model

- Baseline Model: Asset Pricing Based on Present Value Relation
  - Assume that the real property prices are determined by

$$\text{real property price} = \text{PDV of } \frac{\text{expected future real rent}}{\text{future required rate of return}}$$

  - Assume further that

$$\begin{aligned}
&\text{expected future real rent} \\
&\qquad = \text{current real rent} \times \text{expected future rent growth factor} \\
&\text{future required rate of return} \\
&\qquad = \text{current required rate} \times \text{expected future change} \\
&\text{current required rate} = \text{cur. nominal rate} - \text{expected inflation}
\end{aligned}$$

  - Then we have a following relation

$$\log\left(\frac{\text{nominal asset price}}{\text{general price level}}\right) = \log\left(\frac{\text{cur real rent} \times \text{exp growth}}{\text{cur req rate} \times \text{exp change}}\right)$$

- Demographic factors may influence:
  1. expected future rent growth factor
     - Population bonus ⇒ optimistic
       ⇒ Higher expectations on future rent growth and *vice versa*
  2. expected future change in required rate of return
     - Population onus ⇒ pessimistic
       ⇒ Expecting decreasing investment opportunities
       ⇒ Lower expectations about future required rate and *vice versa*
  3. expected inflation
     - Population bonus ⇒ optimistic ⇒ demand outpaces supply
       ⇒ higher inflation and *vice versa*

RPPI regression model with demographic factors

$$\log P_{jt}^{rppi} = \mu_0 + \alpha_0 \log P_{jt}^{cpi} + \alpha_1 \underbrace{\log \left(\frac{Y_{jt}}{pop_{jt}^{wrk}} \right)}_{\approx \text{current real rent}} + \alpha_2 \underbrace{i_{jt}}_{\approx \text{current nominal rate}} + \lambda_t + [\text{demo.factors (in levels)}]_{jt} + \epsilon_{jt} \quad (1)$$

Variables in the RPPI Regression Model

- Three core variables in RPPI regression models
  1. RPPI index, logged ($\texttt{lnrppi}_{jt}$)
     - Source: Quarterly "Long-term Series on Nominal Residential Property Prices" in BIS Residential Property Price database
     - Quarterly index are average for each year
  2. Nominal interest rate ($\texttt{nint}_{jt}$)
     - Source: Annual "Interest Rates, Government Securities, Government Bonds, Percent per annum" (IFS).
  3. Real GDP per working population, logged ($\texttt{ly2wpop}_{jt}$)

$$\log\left(\frac{Y_{jt}}{pop_{jt}^{wrk}}\right)$$

     - Source: Nominal GDP taken from IFS is divided by CPI taken from IFS, except for Germany, UK and Korea, for which OECD statistics is used.

Population variables

- Source: UN population database

	young generation			working generation			old generation			total
cohort	1	2	3	4	$\cdots$	13	14	$\cdots$	17	1-17
age	0-4	5-9	10-14	15-19	$\cdots$	60-64	65-69	$\cdots$	80+	0-
pop	$-_{1jt}$	$-_{2jt}$	$-_{3jt}$	$-_{4jt}$	$\cdots$	$-_{13jt}$	$-_{14jt}$	$\cdots$	$-_{17jt}$	$-_{jt}$

- $pop_{kjt}(: -_{kjt})$: populations of cohort k for country j at year t
- Shares of young, working, and old generations

$$n_{jt}^{yng} = \frac{\sum_{k=1}^{3} pop_{kjt}}{pop_{jt}}, \quad n_{jt}^{wrk} = \frac{\sum_{k=4}^{13} pop_{kjt}}{pop_{jt}}, \quad n_{jt}^{old} = \frac{\sum_{k=14}^{17} pop_{kjt}}{pop_{jt}}$$

Generation Shares and Estimation

1. Recall that all three population variables are ratios, thus

$$n_{jt}^{yng} + n_{jt}^{wrk} + n_{jt}^{old} = 1$$

2. Impose a restriction on the parameters $\delta_1 + \delta_2 + \delta_3 = 0$ at the time of estimation (Stoker(1986), Fair & Dominguez (1991))
3. Demographic factor is written as:

$$\begin{aligned} \text{demographic factors}_{jt} &= \delta_1 n_{jt}^{yng} + \delta_2 n_{jt}^{wrk} + \delta_3 n_{jt}^{old} \\ &= \delta_1 n_{jt}^{yng} + (-\delta_1 - \delta_3) n_{jt}^{wrk} + \delta_3 n_{jt}^{old} \\ &= \delta_1 (n_{jt}^{yng} - n_{jt}^{wrk}) + \delta_3 (n_{jt}^{old} - n_{jt}^{wrk}) \end{aligned}$$

then one can estimate δ_1 and δ_3 and their standard errors.

Complete List of Countries/Regions in Our Sample

Asia-Pacific (7)
Australia(AU) Hong Kong(HK) Japan(JP) Korea(KR) Malaysia(MA) Thailand(TH) New Zealand(NZ)

America (2)
Canada(CA) United States(US)

Rest of the World (1)
South Africa(ZA)

Europe (13)
Belgium(BE) Switzerland(CH) Germany(DE) Denmark(DK) Spain(ES) Finland(FI) France(FR) United Kingdom(GB) Ireland(IE) Italy (IT) Netherlands(NL) Norway(NO) Sweden(SE)

- Twenty-Three Countries: Asian Countries and South Africa Are Included for Diversity
- Unbalanced Panel (Data Missing in Some Countries/Regions)
- Actual Data Used in Empirical Analysis Are Selected from This.
- Compare: Jeselius-Takáts Panel (Balanced Panel 1955-2014)
  Common: Australia; Belgium; Canada; Switzerland; Germany; Denmark; Spain; Finland; France; United Kingdom; Ireland; Italy; Japan; Korea; Netherlands; Norway; New Zealand; United States.
  Excluded: Austria; Greece; Portugal;
  Included: Hong Kong; Malaysia; Thailand; South Africa

Empirical Analysis

Unit Root Tests

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

	Common Unit Root Tests	Individual Unit Root Tests			
		Without CD		With CD	
	LLC	IPS W-stat(1)	ADF-Fisher χ^2	IPS W-stat(2)	CIPS
H_0	unit root	unit root	unit root	unit root	homogeneous non-stationary
H_1	no unit root	some CS without UR	some CS without UR	some CS without UR	otherwise

- LLC: Levin, Lin & Chu Test
- IPS: Im, Pesaran, and Shin Test
    - IPS(2) removes CS means
- CD: Cross-section Dependence
- CS: Cross-section
- CIPS: Cross-sectionally augmented IPS

Table: Summary of Unit Root Tests

	without CD		with CD	
variables	IPS(1)	Fisher-ADF	IPS(2)	CIPS
$\log P^{cpi}$		I(1)	I(1)	
$\log P^{rppi}$	I(1)	I(1)	I(1)	I(1)
$\log(Y/pop^{wrk})$	I(1)	I(1)	I(1)	I(1)
i	I(1)	I(1)	I(1)	I(0)
$\log pop^{total}$	I(1)		I(1)	I(1)
$n^{yng} - n^{wrk}$	I(1)	I(1)	I(0)	I(0)
$n^{old} - n^{wrk}$	I(1)	I(1)	I(0)	I(0)

- AR parameters are panel-specific. Panel means are included in the regression models. The lag number of ADF regressions is fixed as four.
- In Im-Pesaran-Shin (2), the cross-section means are removed.
- In Pesaran's CADF test, the cross-section average in first period is extracted and extreme t-values are truncated.

Summary Interpretation of Panel Unit Root Tests

1. $\log P^{cpi}$: Both Fisher-ADF and IPS(2) indicate that it is I(1)
2. $\log P^{rppi}$: All four tests support that it is I(1)
3. $\log(Y/pop^{wrk})$: All four tests suggest that `ly2wpop` is I(1)
4. i: IPS(1), Fisher-ADF, and IPS(2) indicate that `nint` is I(1)
5. $\log pop^{total}$: Among the demographic variables, the total population (`ltpop`) is identified as I(1) by three tests.
6. $n^{yng} - n^{wrk}$ and $n^{old} - n^{wrk}$: As for the young-ratios (`ny_nw`) and old-ratios (`no_nw`), IPS(1) and Fisher-ADF suggests I(1), though IPS(2) and CADF suggests I(0)

Empirical Results

RPPI model with demographic factors

$$\log P_{jt}^{rppi} = \mu_j + \alpha_1 \log P_{jt}^{cpi} + \alpha_2 \log\left(\frac{Y_{jt}}{pop_{jt}^{wrk}}\right) + \alpha_3 i_{jt}$$
$$+ \alpha_4 \log pop_{jt}^{total} + \alpha_5(n_{jt}^{yng} - n_{jt}^{wrk}) + \alpha_6(n_{jt}^{old} - n_{jt}^{wrk}) + \epsilon_{jt}$$

Main findings

1. Panel cointegration tests suggest that a long-run relationship exists.
   1. Pedroni (1999,2004) test: The panel/group ADF tests reject the null of no cointegration at 1%
   2. Kao (1999) test: rejects reject the null of no cointegration at 1%
2. Panel cointegrating regressions are then estimated by:
   1. Fully-Modified OLS (pooled FMOLS and weighted FMOLS)
   2. Dynamic OLS (pooled DOLS and weighted DOLS)
   3. Pooled Mean Group

which show that there exists the above long-run relationship.

Summary of Panel Cointegration Tests

Pedroni's Panel Cointegration Tests (1999, 2004)

	within-dimension Statistic	within-dimension Weighted Statistic	between-dimension	
Panel v	1.614*	1.482*		
Panel rho	2.329	2.378	Group rho	3.747
Panel PP	1.455	1.612	Group PP	2.568
Panel ADF	-2.849***	-2.275**	Group ADF	-2.493***

Kao's Panel Cointegration Tests (1999)

ADF	-6.284***

***/**/* significant at 1%/5%/10% levels, respectively.

Note: Calculated by EViews

Comments on the Panel Cointegration Tests

1. Among the test statistics by Pedroni (1999,2004), panel v-stat and panel ADF-stat reject the null at 5% and 1% levels. In addition, group ADF-stat also rejects the null at 1% level.
2. According to Pedroni (2004), if $T < 100$, the most powerful tests are group ADF and panel ADF. Both group ADF and panel ADF reject the null at 1% significance level.
3. Kao's (1999) test indicates that the model is panel cointegrated with 1% significance level.
4. Overall, we conclude that there exists a significant long run relationship between the variables. That said, we estimate the long-run coefficients in the next slides.

The model

- Consider a fixed effect panel cointegrated regression:

$$y_{it} = \alpha_i + x'_{it}\beta + u_{it}$$
$$\Delta x_{it} = \epsilon_{it}$$

- Define an innovation vector $w_{it} = (u_{it}, \epsilon'_{it})'$.
- The long-run covariance matrices of $\{w_{it}\}$ is given by

$$\Sigma = E(w_{i0}w'_{i0}) = \begin{bmatrix} \Sigma_u & \Sigma_{u\epsilon} \\ \Sigma_{\epsilon u} & \Sigma_\epsilon \end{bmatrix}$$

$$\Gamma = \sum_{j=1}^{\infty} E(w_{ij}w'_{i0}) = \begin{bmatrix} \Gamma_u & \Gamma_{u\epsilon} \\ \Gamma_{\epsilon u} & \Gamma_\epsilon \end{bmatrix}$$

$$\Omega = \sum_{j=-\infty}^{\infty} E(w_{ij}w'_{i0}) = \Sigma + \Gamma + \Gamma' = \begin{bmatrix} \Omega_u & \Omega_{u\epsilon} \\ \Omega_{\epsilon u} & \Omega_\epsilon \end{bmatrix}$$

$$\Delta = \Sigma + \Gamma = \begin{bmatrix} \Delta_u & \Delta_{u\epsilon} \\ \Delta_{\epsilon u} & \Delta_\epsilon \end{bmatrix}$$

Pooled FMOLS (fully-modified OLS)

- The pooled FMOLS estimator (Phillips and Moon, 1999) is an extension of the standard Phillips and Hansen estimator.
- The pooled FMOLS estimator is given by

$$\hat{\beta}_{FP} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\bar{x}_i)(x_{it}-\bar{x}_i)'\right]^{-1}\left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(x_{it}-\bar{x}_i)\hat{y}_{it}^{+} - T\hat{\Delta}_{\epsilon u}^{+}\right)\right]$$

where

$$\hat{y}_{it}^{+} = y_{it} - \hat{\Omega}_{u\epsilon}\hat{\Omega}_{\epsilon}^{-1}\Delta x_{it}$$

and

$$\hat{\Delta}_{\epsilon u}^{+} = \hat{\Delta}_{\epsilon u} - \hat{\Delta}_{\epsilon}\hat{\Omega}_{\epsilon}^{-1}\hat{\Omega}_{\epsilon u}$$

- The limiting distribution of $\hat{\beta}_{FP}$ is

$$\sqrt{N}T(\hat{\beta}_{FP}-\beta) \Rightarrow N(0, 6\Omega_{\epsilon}^{-1}\Omega_{u.\epsilon})$$

where $\Omega_{u.\epsilon}$ is a long-run variance of u_{it}^{+}:

$$u_{it}^{+} = u_{it} - \Omega_{u\epsilon}\Omega_{\epsilon}^{-1}\epsilon_{it}$$

Weighted FMOLS

- Pedroni (2000), and Kao and Chiang (2000)
- The long-run variances differ across cross-sections, i.e. Ω_i, Γ_i, and Σ_i are varied for different i, thus the panels are heterogenous.

Pooled DOLS (dynamic OLS)

- Kao and Chiang (2000)
- The DOLS of β, $\hat{\beta}_D$, is obtained by running an augmented cointegrating regression equation:

$$y_{it} = \alpha_i + x'_{it}\beta + \sum_{j=-q}^{q} c_{ij}\Delta x_{it+j} + \dot{v}_{it}$$

- The limiting distribution of $\hat{\beta}_D$ is

$$\sqrt{N}T(\hat{\beta}_{FP} - \beta) \Rightarrow N(0, 6\Omega_{\epsilon}^{-1}\Omega_{u.\epsilon})$$

thus $\hat{\beta}_D$ and $\hat{\beta}_{FM}$ have the same limiting distribution.

Weighted DOLS

- Kao and Chiang (2000)
- This estimator accounts for heterogeneity by using cross-section specific estimates of the conditional long-run residual variances to reweight the moments for each cross-section when computing the pooled DOLS estimator

Pooled mean group

- Shin, Pesaran, and Smith (1999)
- ARDL (1,1) model

$$y_{it} = \delta_{0,i} + \lambda_i y_{i,t-1} + \beta_{0i} x_{it} + \beta_{1i} x_{i,t-1} + \epsilon_{it}$$

can be written in an error-correction form as

$$\Delta y_{it} = \phi_i (y_{i,t-1} - \theta_i x_{it}) + \delta_{0,i} + \delta_{1,i} \Delta x_{it} + \epsilon_{it} \tag{2}$$

- Impose that
  - Long-run homogeneity: $\theta_i = \theta \ \forall \ i$
  - Short-run heterogeneity: δ_i
- Then the PMG model is

$$\Delta y_{it} = \phi_i (y_{i,t-1} - \theta x_{it}) + \delta_{0,i} + \delta_{1,i} \Delta x_{it} + \epsilon_{it}$$

- The PMG method constrains the long-run coefficients to be the same across countries, while the short-run coefficients to vary
- The PMG occupies an intermediate position between the MG and the classical FE
  - The MG allows both the slopes and the intercepts to differ across countries
  - The FE allows the intercepts to vary only

Demography and RRPI

Baseline Model: Balanced Panel of 17 Countries in Period 1971-2015

ES, FI, HK, KR, MY, TH are excluded due to missing observations

Eq Name:	FMOLS1	FMOLS2	DOLS1	DOLS2	PMG
LCPI	1.072	0.989	0.987	1.053	1.075
	(0.047)***	(0.006)***	(0.070)***	(0.058)***	(0.083)***
LY2WPOP	0.780	1.064	1.577	1.386	2.077
	(0.110)***	(0.010)***	(0.170)***	(0.150)***	(0.238)***
NINT	-2.876	-1.968	-1.731	-1.960	-3.379
	(0.594)***	(0.011)***	(0.818)**	(0.648)***	(0.800)***
LTPOP	0.847	0.966	-0.146	-0.022	-3.780
	(0.213)***	(0.002)***	(0.343)	(0.268)	(0.779)***
NY_NW	2.558	2.601	2.839	2.817	4.709
	(0.640)***	(0.002)***	(0.925)***	(0.774)***	(0.880)***
NO_NW	-3.584	-3.432	-4.128	-4.152	-3.961
	(0.534)***	(0.001)***	(0.914)***	(0.719)***	(0.916)***
Observations:	765	765	748	748	765
R^2:	0.953	0.954	0.995	0.995	NA

- ***/**/* indicates the estimates are significant at 1%/5%/10% levels
- FMOLS1=pooled, FMOLS2=weighted, DOLS1=pooled, DOLS2=weighted, PMG=ARDL(2,2)

Findings of the Baseline Model

General Comments on Long-run Relationship

1. n^{yng} strongly positive effects on residential property prices
2. n^{old} strongly negative effects on residential property prices
3. Unit impact of n^{old} is larger than that of n^{yng}
4. Current real GDP per worker (LY2WPOP) has positive effects as a proxy of real rents
5. Current nominal rate of return (NINT) has negative effects implying a statistically significant effect of credit conditions
6. Coefficient of CPI (LCPI) is close to unity (no money illusion)

Representative Result: FMOLS1

$$\widehat{\log P_{jt}^{rppi}} = 1.072 \log P_{jt}^{cpi} + 0.780 \log \left(\frac{Y_{jt}}{pop_{jt}^{wrk}} \right) - 2.876 i_{jt}$$

$$+ 0.847 \log pop_{jt}^{total} + 2.558(n_{jt}^{yng}) + 1.026(n_{jt}^{wrk}) - 3.584(n_t^{old}) + \text{others}$$

Robustness Check: Unbalanced 23 Economies Model

All Included: Unbalanced Panel of 23 Economies in Period 1971-2015

Eq Name:	FMOLS1	FMOLS2	DOLS1	DOLS2	PMG
LCPI	1.190	1.103	0.963	1.064	0.876
	(0.044)***	(0.006)***	(0.060)***	(0.045)***	(0.045)***
LY2WPOP	0.498	0.734	1.608	1.343	1.206
	(0.110)***	(0.007)***	(0.150)***	(0.107)***	(0.151)***
NINT	-2.808	-2.071	-1.364	-0.907	-3.219
	(0.606)***	(0.009)***	(0.711)*	(0.520)*	(0.570)***
LTPOP	0.889	0.896	-0.062	0.170	0.354
	(0.220)***	(0.002)***	(0.314)	(0.259)	(0.353)
NY_NW	3.496	3.487	2.660	3.124	0.057
	(0.595)***	(0.002)***	(0.747)***	(0.567)***	(0.664)
NO_NW	-2.860	-2.757	-3.850	-3.807	0.384
	(0.576)***	(0.001)***	(0.753)***	(0.625)***	(0.814)
Observations:	947	947	919	919	950
R^2:	0.933	0.935	0.995	0.995	NA

- ***/**/* indicate the estimates are significant at 1%/5%/10% levels
- FMOLS1=pooled, FMOLS2=weighted, DOLS1=pooled, DOLS2=weighted, PMG=ARDL(2,2)

Findings of Unbalanced 23 Economies Model

- Missing Data for ES, KR, HK, MA, TH, and FI —
  - Data (both RPPI and nominal interest rates) are available for ES only after 1979, KR after 1975, HK after 1990, MA after 1988, TH after 1991, and FI after 1988.
- Robust Results: All-included Models Produce Qualitatively the Same Results as the Baseline Model Except for PMG
- Possible Explanations of Weak Results in PMG Are —
  - PMG estimates not only long-run relationship but also short run error-correction terms. Although the balanced panel of the baseline model has a 45-years sample period, HK, MA, TH and others have only about 25 years of samples, which may not be sufficient to get a sharp result when prices and demographic factors move very slowly.

Extension: Synergetic Effects of Demography-Induced Optimism and Credit Conditions

- Nishimura (2016) pointed out evidence of synergetic effects of population-bonus-induced optimism and loose credit conditions on property prices, which often resulted in so-called property bubbles.
- To test whether his evidence represents a rule rather than mere coincidence, we add the cross-term of nominal interest rate and demographic factors.

Results: Cross-Term Effects Between i and (n^{yng} and n^{old})

Balanced Panel of 17 Countries in Period 1971-2015

Eq Name:	FMOLS1	FMOLS2	DOLS1	DOLS2	PMG
LCPI	1.115	1.035	1.077	1.142	0.982
	(0.047)***	(0.006)***	(0.069)***	(0.044)***	(0.085)***
LY2WPOP	0.807	1.045	1.124	0.882	1.132
	(0.109)***	(0.012)***	(0.158)***	(0.113)***	(0.201)***
NINT	9.336	11.162	9.038	8.604	1.272
	(5.811)	(0.013)***	(6.062)	(4.270)**	(6.980)
LTPOP	0.744	0.867	0.075	0.213	0.815
	(0.213)***	(0.002)***	(0.283)	(0.194)	(0.359)**
NY_NW	3.442	2.958	3.112	2.799	1.148
	(0.812)***	(0.003)***	(0.979)***	(0.591)***	(1.581)
NO_NW	-4.795	-4.679	-6.229	-5.481	-0.454
	(0.736)***	(0.001)***	(0.895)***	(0.491)***	(1.171)
NINT*NY_NW	-9.261	-4.258	-3.680	-7.039	22.335
	(5.533)*	(0.003)***	(6.372)	(5.405)	(10.834)**
NINT*NO_NW	31.142	28.834	27.711	29.634	-11.297
	(10.551)***	(0.003)***	(10.249)***	(8.181)***	(9.722)
Observations:	765	765	748	748	765
R^2:	0.954	0.956	0.998	0.997	NA

Interpretation of the Results in the Extended Mode (1)I

Rearraigning the terms in a representative FMOLS2 result, we have

$$\log \widehat{P_{jt}^{rppi}} = 1.035 \log P_{jt}^{cpi} + 1.045 \left(\frac{Y_{jt}}{pop_{tj}^{wrk}} \right) + \left([-19.4 \sim -26.9]_j \right) i_t$$
$$+ \left(-4.258 \widetilde{n_{jt}^{yng}} - 24.576 \widetilde{n_{jt}^{wrk}} + 28.834 \widetilde{n_{jt}^{old}} \right) i_t$$
$$+ 0.867 \log pop_{jt}^{total} + 2.958 n_{jt}^{yng} + 1.721 n_{jt}^{wrk} - 4.679 n_{jt}^{old}$$
$$+ \text{other factors}$$

where (1) $[-19.4 \sim -26.9]_j$ is the coefficient of the credit condition i of country j when the country's demographic composition n^x ($x = yng, wrk, or\ old$) is at their historical average $\overline{n^x}$, and (2) $\widetilde{n_{jt}^x}$ indicates whether the economy is in a demographic bonus phase ($\widetilde{n_{jt}^{wrk}} > 0$) or onus one ($\widetilde{n_{jt}^{old}} > 0$)

Interpretation of the Results in the Extended Mode (2)I

The results of the extended model of cross-term effects between credit conditions and demographic factors in the last slide imply

- The credit condition's negative coefficient on property prices (that is, a positive effect of declining interest rates) is between -19.4 and -26.9, which is substantially greater in the absolute value than the baseline model of between -3.4 and -4.1.
- A demographic bonus ($\widetilde{n_{jt}^{wrk}} > 0$) substantially strengthens the positive effects on declining interest rates. In contrast, in a demographic onus phase ($\widetilde{n_{jt}^{old}} > 0$), increasing interest rates have even stronger negative effects on residential property prices.
- These results strongly support the hypothesis of Nishimura (2016).

Conclusion

Summing Up

- Major findings of this paper

  1. Demographic composition has significant impacts on residential property prices.
     1. n^{yng} strong positive effect on RPPI
     2. n^{old} strong negative effect on RPPI
  2. Unit impact of the increase in n^{old} is larger than that of n^{yng}
  3. When demographic bonus is coupled with easy credit, residential property prices are substantially higher than otherwise. The opposite is the case in a demographic onus phase.

Thank You for Your Kind Attention.