Demography, Credits and Property Prices: Evidence from a Panel of Diverse Economies

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Organization of the Presentation

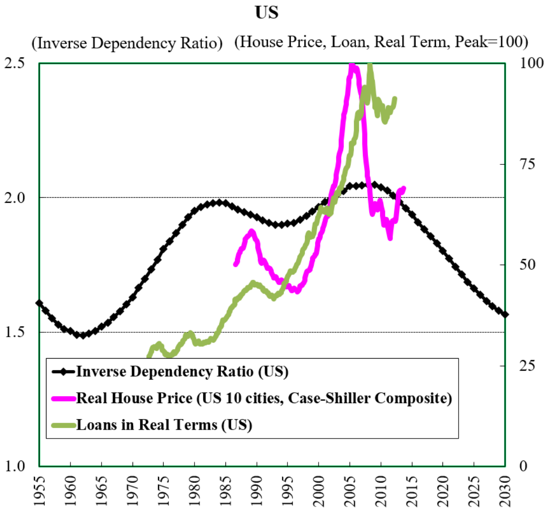
Motivation: Demography, Credits and Bubbles

- Casual Observation about the Past Episodes of Property Bubbles Suggests Strong Correlation between Demographic Composition and Property Bubbles (and Loose Credits).

Demography, Credits and "Property Bubbles": United States

A demographic bonus (more working age people) might trigger the bubble, with a help of loose credit conditions.(Nishimura 2011, 2016)

- Inverse Dependency Ratio = Non-Work-Age / Working Age population



Demography, Credits and "Property Bubbles": Ireland

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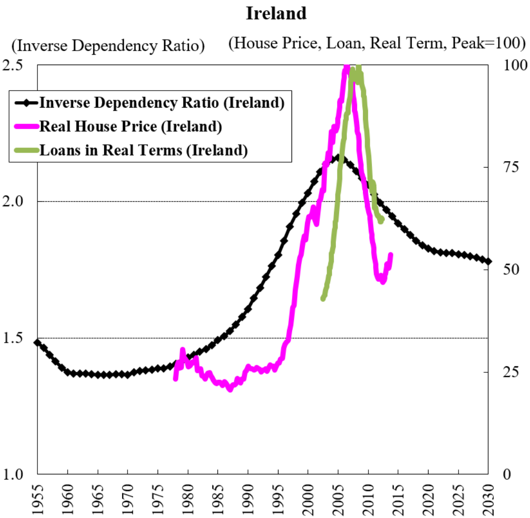

Demography, Credits and "Property Bubbles": Japan

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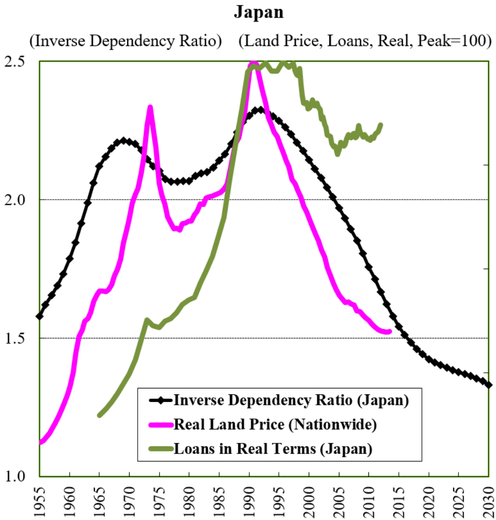

Demography, Credits and "Property Bubbles": Germany

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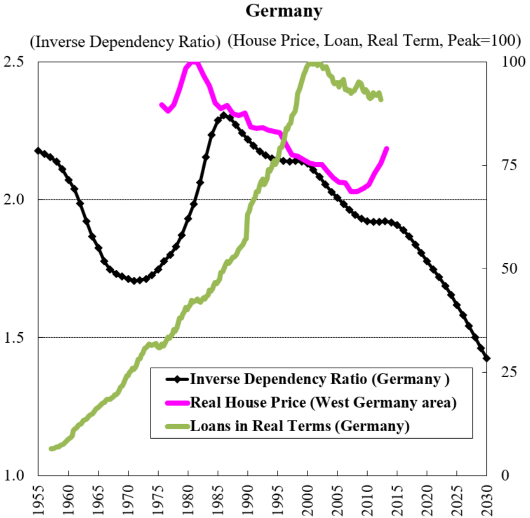


Economic Theory and Its Implications

- If Expectations are "Rational" or Perfect Foresight on the Average, and the Supply of the Assets Is Elastic, then CHANGE IN DEMOGRAPHY IS NOT LIKELY TO MATTER MUCH FOR THOSE ASSETS' PRICES
  - Implications of the 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 Is **Inelastic**, then DEMOGRAPHY MATTERS for Those Assets' Prices:
  - 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.
    - N&T and T+ found a sizable effect of aging on property prices.
- However, the theory based on generational portfolio choices are insufficient to explain often volatile property prices in the medium-run (say, 10 yrs) or in a business cycle (typically 2 yrs).

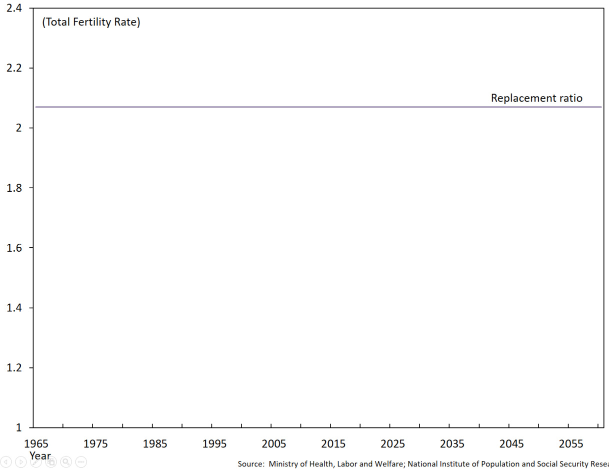
- However, are people's long-run forecasts such as those about demography are "Rational" Expectations (or Perfect Foresight on Average)? Especially when it takes long to realize expectation errors?

- In reality, they are not rational, as exemplified in the "expert forecasts" about Japanese fertility rates. Experts think
  - (1) the current unexpected change is transitory and short lived
  - (2) it will eventually return to their anticipated long run value which is closer to the "old normal"
  - (3) And when the actual value is persistently different from the their anticipated long-run value, they change the anticipated value, but very slowly, not immediately.

- Thus, forecasts about slow-moving factors are likely to be extrapolative in the long-run, wishful-thinking in the short-run, and very slow to adjust.

- Expert Forecasts about Slow-Moving Factors:
  Wishful Thinking in the Short Run (Unexpected Change is Temporary)
  and Extrapolative and Slow to Adjust in the Long Run

  (Assume to Return to "Normal", and Expected "Normal" Change only very gradually)
- Example: Total Fertility Rate Forecasts of Japanese Experts



Source: Ministry of Health, Labor and Welfare; National Institute of Population and Social Security Research

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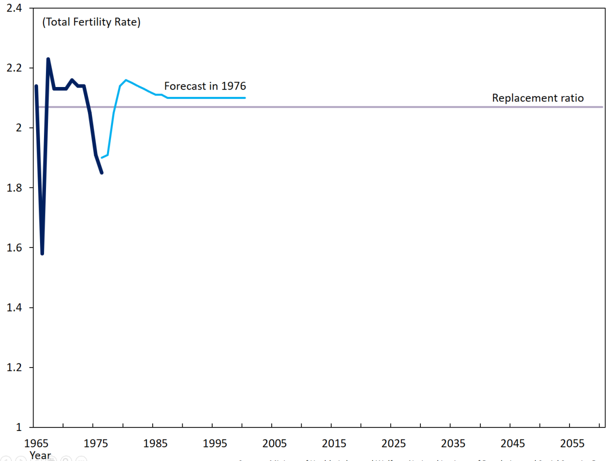

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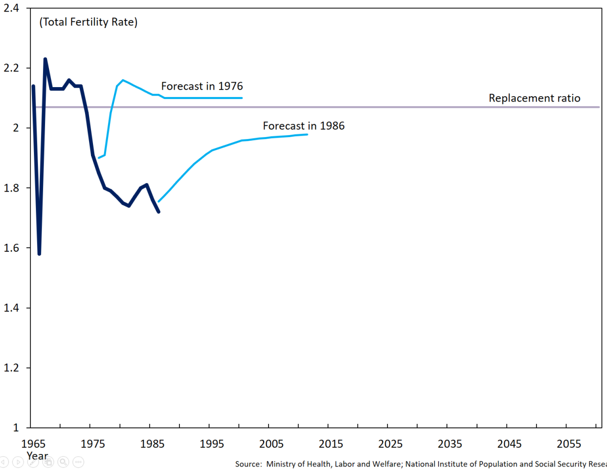

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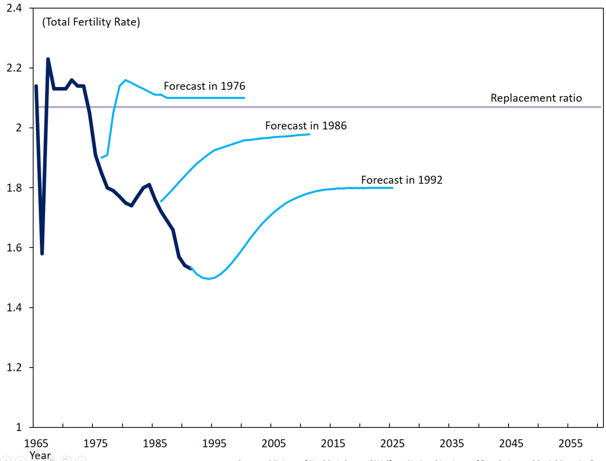

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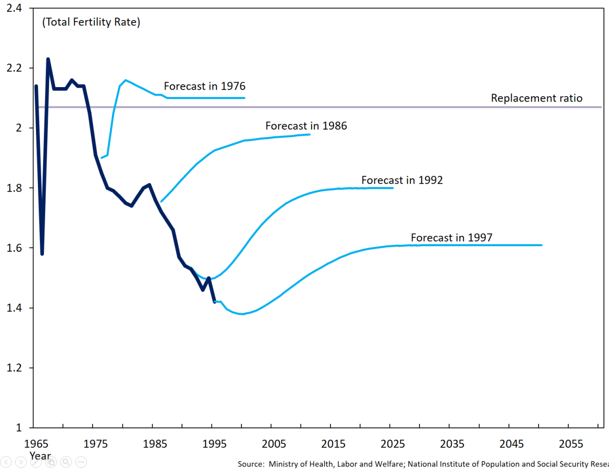

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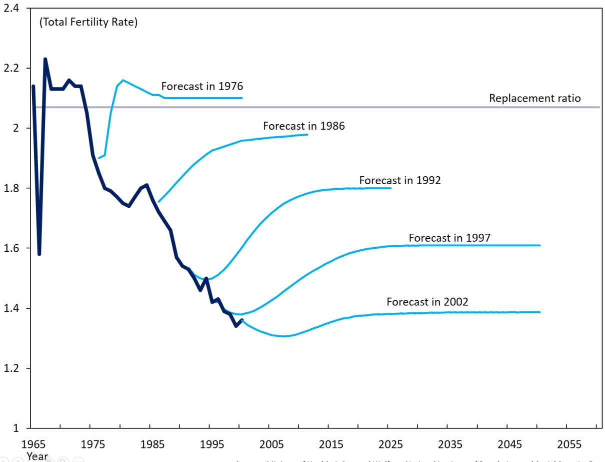

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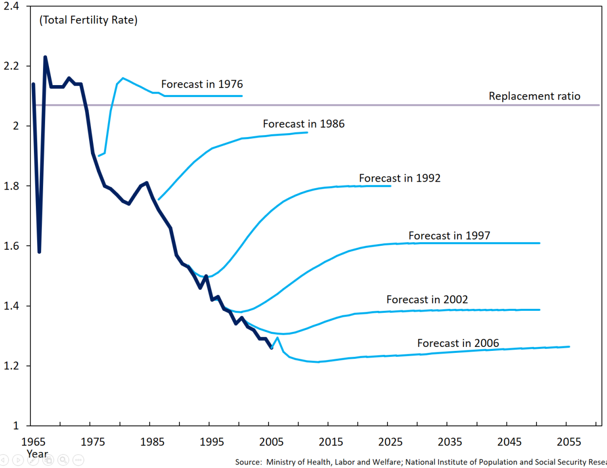

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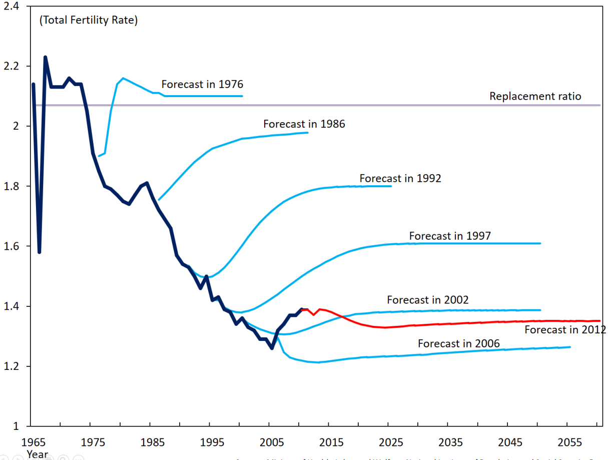

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- If people's expectations are extrapolative ("tomorrow is like today"), and suppliers (experts) forecasts are extrapolative, slow-to-adjust and wishful thinking, then DEMOGRAPHY MAKES a DIFFERENCE even in a shorter run. (Nishimura 2016)
- Population "Bonus" Period (Dominance of the Young)
  - Demand Side: excessive optimism
    - 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.
    - A vibrant economy and optimistic expectations.
    - If people extrapolate from their experience, a demographic bonus can nurture optimism and higher demand for properties.
    - When child mortality is down, more children imply more future working population, fostering optimism further.
  - Supply Side: persistent short supply
    - Supply of buildings will increase but not sufficient to satisfy the excessive optimism, because of resource constraints and practical conservatism in business ("return to past normal" forecasts)
  - Result: Significant Increases of Property Prices.

- Moreover, when population bonus is coupled with easy credit, the swing of property prices become significantly larger through a self-feeding process, because of excessive leveraging.
  - Excessive optimism leads to excessive leveraging and temporarily high growth; in turn, feeding on each other, excessive leveraging and high growth reinforce excessive optimism.
- Population "Onus" Period (Dominance of the Old)

  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" forecasts prevent rapid liquidation of the oversupply
  - Result: Significant decreases of property prices
  - People will switch from optimism to pessimism quite easily, while experts are likely to be the captive of own past. (Nishimura and Ozaki 2017)
- This "Leveraging and Subsequent Deleveraging" process—the alteration between bubbles and busts—is a key trait of Credit Cycles.

(Reinhart and Rogoff, Buttiglione et al 2014)

Our Research

- We investigate RPPI (Residential Property Price Index) to ask:
    - Would the observation ("demography matters on short-run property prices") be confirmed in the econometric analysis of diverse economies/countries? Or more specifically speaking, (1) How will the changes in population makeup (whether population bonus or onus) affect the property prices? (2) What is the interaction between demopgraphic factors and credit conditions? (3) Is there a confounding cyclical component in property prices?
- 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 diverse in their demographics and economic activities.
- Panel data from 20 economies for the period 1971-2015 are collected and used (Five Asia-Pacific, Twelve European, Two North American, One African)

Demography and Property Prices: A Literature Review
Rational Expectations, Elasticity of Supply, and Property Prices

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 run, 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"). Also see Takáts (2015) for a prediction based on the theory.
    - However, although it shows demography matters in the long run, the theory based on generational portfolio choices are insufficient to explain often volatile property prices in the medium-run (say, 10 yrs) or in a business cycle (typically 2 yrs) in many countries (see Saita et al. 2013 and Shimizu et al.2015) .

- 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: Long-run Relationship and Short-run Cyclical Effects

RPPI (residential property price index) Models

- Model:
  Long-run nominal RPPI model based on Present Value Relation
  - Assume that property prices P^{rppi} are equal to the present value of future nominal real rents $P^{cpi} \times (real\ Rent)$ in the long run,

$$P^{rppi} = \frac{P^{cpi} \times (real\ Rent)}{i - \pi^e - g^e}$$

    where i nominal interest rate, π^e expected CPI inflation, and g^e is expected real rent growth.
  - The long-run relationship is likely to be homogeneous, since it is the no-unexploited-arbitrage-opportunity condition of competitive equilibrium, common to all financial markets.
  - However, short-run adjustment may be heterogeneous. Because of country-specific institutions and transaction costs, the long run relationship is not immediately achieved but only partially and gradually.

- Demographic factors may influence:
  1. expected future rent growth factor g^e
     - Population bonus ⇒ optimistic
       ⇒ Higher expectations on future rent growth and *vice versa*
  2. expected inflation π^e
     - Population bonus ⇒ optimistic ⇒ demand outpaces supply
       ⇒ higher inflation and *vice versa*

- Real rent is approximated by a function of output per worker

$$\log(real\ Rent) = \beta_0 + \beta_1 \log\left(\frac{Real\ GDP}{Working\text{-}age\ Population}\right)$$

Long-run nominal RPPI regression model with demographic factors

$$\log P^{rppi}_{jt} = \mu_0 + \alpha_0 \log P^{cpi}_{jt} + \alpha_1 \underbrace{\log\left(\frac{Y_{jt}}{pop^{wrk}_{jt}}\right)}_{\approx \text{ current real rent}} + \alpha_2 \underbrace{i_{jt}}_{\approx \text{ current nominal rate}}$$

$$+ \left[\text{demographic factors (in levels)}\right]_{jt} + \epsilon_{jt}$$

- Alternative Model: Long-run Real RPPI model
  - It is sometimes assumed that the current real interest rate r_t is equal to the current nominal interest rate i_t minus the realized rate of inflation $\pi_t = \Delta \log P_t^{cpi} = \log P_t^{cpi} - \log P_{t-1}^{cpi}$.
  - This is equivalent to assume inflationary expectations π^e is equal to the actual inflation π_t from the previous period.
  - Defining real RPPI be $real\ P^{rppi} = P^{rppi}/P^{cpi}$, we have a "real RPPI model" in that all variables are all in "real terms".

$$real\ P^{rppi} = \frac{real\ Rent}{r - g^e}$$

  - Demography influences real RPPI through g^e only.

Long-run real RPPI regression model with demographic factors

$$\log real\ P_{jt}^{rppi} = \mu_0 + \alpha_1 \underbrace{\log\left(\frac{Y_{jt}}{pop_{jt}^{wrk}}\right)}_{\approx \text{current real rent}} + \alpha_2 \underbrace{r_{jt}}_{\approx \text{static expectation real rate}}$$
$$+ [\text{demographic factors (in levels)}]_{jt} + \epsilon_{jt}$$

- Short-run Adjustment: Modified Augmented Error Correction
  - The present-value relation determines the fundamental value of RPPI, which may not be achieved instantaneously because of large transaction costs and substantial imperfect information.
  - Moreover, property prices may be influenced by cyclical macro factors (GAPs) over business cycles, in addition to fundamentals (FDMs). Optimism is in upturns and pessimism in downturns.
  - This suggests (explained later) the "modified augmented" error correction model (below) as short-run adjustment of RPPI.

Short-run Nominal RPPI: Modified Augmented Error Correction ARDL(2,2,2-Lg)

$$\Delta \log P_{jt}^{rppi} = \phi_j \underbrace{(\log P_{j,t-1} - \theta_j \text{FDM}_{j,t-1})}_{\text{long run relation}} + \delta_{0,j} \Delta \log P_{j,t-1}^{rppi}$$

$$+ \delta_{1,j} \Delta \text{FDM}_{jt}^{*} + \delta_{2,j} \Delta \text{FDM}_{j,t-1}^{*} + \delta_{3,j} \text{GAP}_{j,t} + \delta_{4,j} + \epsilon_{jt}$$

$$\text{where FDM} = \left(\log P^{cpi}, \log\left(\frac{Y}{pop^{wrk}}\right), i, \text{demo factors}\right);$$

$$\text{GAP} = \text{Deviation from the HP Filter trend of} \left(\log\left(\frac{Y}{pop^{wrk}}\right), i\right);$$

$$\text{FDM}^{*} = \text{FDM excluding} \left(\log\left(\frac{Y}{pop^{wrk}}\right), i\right).$$

Variables in the RPPI Regression Model

- Three core variables in RPPI regression models
  1. RPPI index, logged ($lnrppi_{jt}$)
     - 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, in log ($nint_{jt}$)

$$\log\left(1 + \frac{rate}{100}\right)$$

     - Source: Annual "Interest Rates, Government Securities, Government Bonds, Percent per annum" (IFS).
  3. Real GDP per working population, logged ($ly2wpop_{jt}$)

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

     - 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. demographic factors$_{jt} = \delta_1 n_{jt}^{yng} + \delta_2 n_{jt}^{wrk} + \delta_3 n_{jt}^{old}$
2. Recall that all three population variables are ratios, thus

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

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

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

   then one can estimate δ_1 and δ_3 and their standard errors.
5. δ_2 is calculated from δ_1 and δ_3.

Complete List of Countries/Regions in Our Sample

Asia-Pacific (5)
Australia(AU) Hong Kong(HK) Japan(JP)
Korea(KR)
New Zealand(NZ)

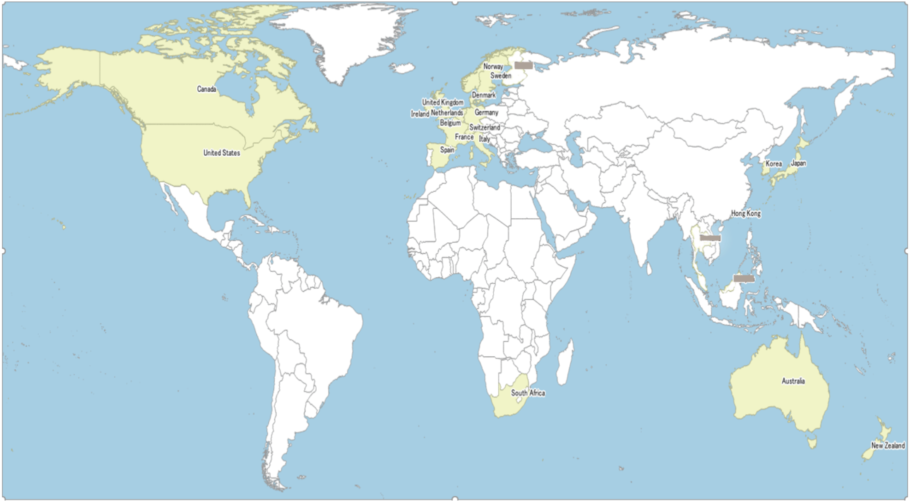
America (2)
Canada(CA) United States(US)

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

Europe (12)
Belgium(BE) Switzerland(CH)
Germany(DE) Denmark(DK)
Spain(ES)
France(FR) United Kingdom(GB)
Ireland(IE) Italy (IT)
Netherlands(NL) Norway(NO)
Sweden(SE)

- Twenty Countries: Five Asian Countries (Regions) and South Africa Are Included for Diversity
- Unbalanced Panel (Some Data Missing in Underlined Countries)
- Actual Data Used in Empirical Analysis Are Selected from This Set. Balanced Panel (17 Countries) and Total (20 Countries).

Map of Our Sample



Diagnostics

(Non-)Stationarity of Variables in the Panel

- Before proceeding with the regression analysis, we should examine stationarity (or non-stationarity) of the variables,
  - since inadvertent mixing of stationary and non-stationary variables in regressions may cause problems.
- We start with such tests for the panel of variables we consider.
- Pesaran's CIPS Panel Unit Root Tests.
  - Null Hypo. H_0: All panels contain unit roots.
  - Alternative Hypo. H_a: Some panels do not have unit roots.
  - Cross-sectional dependence of residuals are accounted for.
- Hadri's Stationarity Tests.
  - Null Hypo. H_0: All panels are stationary.
  - Alternative Hypo. H_a: Some panels are non-stationary.
  - Note: Hadri test works only for balanced data set.
- The balanced set of 17 countries, 1971 - 2015

Pesaran's CIPS and Hadri's Stationarity Tests

- Variables included in the Nominal RPPI Models

	level		1st difference		2nd difference	
	CIPS Z[t-bar]	Hadri LM	CIPS Z[t-bar]	Hadri LM	CIPS Z[t-bar]	Hadri LM
lnrppi	-4.02 ***	12.18 ***	-8.52 ***	0.68	-15.01 ***	-3.12
lcpi	-4.78 ***	19.39 ***	-8 ***	7.65 ***	-16.84 ***	-2.14
ly2wpop	2.84	16.44 ***	-7.23 ***	3.22 ***	-17.74 ***	-0.09
nint	-3.34 ***	10.36 ***	-12.25 ***	-1.68	-19.07 ***	-2.84
ltpop	-8.86 ***	19.88 ***	-9.49 ***	13.34 ***	-17.73 ***	-1.25
ny_nw	-5.42 ***	15.06 ***	-2.19 **	6.03 ***	-9.56 ***	0.12
no_nw	-2.17 **	18.56 ***	0.73	7.08 ***	-7.7 ***	-0.66
deterministic	trend+const		const		const	
lags	fixed 1		fixed 1		fixed 1	
long-run variance		QS w/ 2 lags		QS w/ 2 lags		QS w/ 2 lags

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

A note on the specifications

- In CIPS, a time trend and a constant are included in the estimated equation for level. Only constant is included for a first/second differenced series.
- Lag length of ADF regressions used in CIPS is fixed as one.
- Long-run variance, used to calculate Hadri statistic, is estimated by quadratic spectral kernel with 2 lags.

Summary Interpretation of CIPS and Stationarity Tests

- Level
  1. CIPS: H_0 cannot be rejected for $ly2wpop$ so that all countries are non-stationary. However, H_0 is rejected for others implying some countries are stationary.
  2. Stationarity Tests: H_0 are rejected for all, so that all variables in all countries are non-stationary.
- First differences
  1. CIPS: H_0 cannot be rejected for no_nw so that all countries are non-stationary. However, H_0 is rejected for others implying some countries are stationary.
  2. Stationarity Tests: H_0 cannot be rejected for $lnrppi$ and $nint$ so that they are stationary in all countries. For all others ,H_0 is rejected, implying they are non-stationary in all countries.
- Second differences
  1. CIPS: H_0 is rejected for all variables, implying some countries are stationary for all variables.
  2. Stationarity Tests: H_0 cannot be rejected for all variables, so that they are stationary in all countries.

Unit Root Tests for Individual Countries

- Although CIPS and Hadri tests showed all variables are stationary in the second differences, whether they are stationary in the first difference or in the level are difficult to determine. So, we proceed with country/region-wise unit root tests.
  - Max lag of ADF is one. The optimal length is chosen by AIC. Sample period: 1971-2015.

Table: ADF test

Variables	c.v.	AU	BE	CA	CH	DE	DK	FR	GB	IE	IT	JP	NL	NO	NZ	SE	US	ZA
lnrppi (with trend)	-3.45	-3.30	-5.80	-3.68	-2.21	-2.73	-3.14	-2.83	-2.04	-3.40	-2.32	-2.21	-3.56	-2.43	-3.11	-4.33	-3.61	-3.68
lnrppi (no trend)	-2.89	-1.82	-1.61	-2.05	-0.73	-1.64	-1.35	-2.27	-1.61	-2.20	-4.05	-2.40	-1.64	-1.03	-1.89	-0.71	-1.94	-0.82
Dlnrppi	-2.89	-4.70	-2.94	-3.36	-4.86	-2.65	-3.77	-2.43	-4.71	-2.80	-2.64	-5.32	-2.97	-4.13	-3.77	-3.67	-3.86	-3.62
DDlnrppi	-2.89	-8.03	-4.27	-6.07	-6.57	-3.94	-5.35	-5.49	-6.75	-4.86	-7.18	-7.68	-5.37	-6.40	-6.03	-5.38	-4.87	-5.18
lcpi (with trend)	-3.45	-3.94	-4.02	-3.64	-1.51	-2.64	-4.28	-3.80	-4.28	-3.40	-4.18	-7.20	-4.00	-2.43	-2.40	-1.83	-2.92	-0.85
lcpi (no trend)	-2.89	-5.03	-4.05	-4.62	-2.74	-2.47	-5.08	-4.51	-4.82	-4.18	-5.94	-7.79	-2.28	-3.70	-3.91	-3.96	-4.19	-3.16
Dlcpi	-2.89	-1.83	-2.18	-1.65	-3.11	-3.19	-1.30	-1.21	-1.77	-1.99	-1.26	-2.61	-2.37	-1.59	-1.36	-1.28	-2.39	-1.79
DDlcpi	-2.89	-6.78	-6.10	-5.83	-4.77	-4.99	-9.58	-6.24	-5.55	-5.76	-7.17	-10.83	-5.24	-5.80	-5.49	-6.57	-6.96	-6.55
ly2wpop (with trend)	-3.45	-2.13	-1.43	-3.05	-4.47	-3.51	-1.38	-2.35	-2.42	-3.03	-1.00	-1.24	-2.08	-0.96	-2.17	-3.10	-2.00	-1.13
ly2wpop (no trend)	-2.89	0.29	-1.54	-0.83	-0.34	-0.64	-1.22	-1.49	-0.61	0.80	-3.04	-2.25	-0.25	-2.23	0.40	-0.35	-0.76	-1.34
Dly2wpop	-2.89	-4.50	-4.53	-4.94	-5.55	-5.82	-4.66	-4.76	-5.26	-1.76	-4.30	-5.01	-3.92	-3.06	-3.53	-4.99	-4.83	-3.69
DDly2wpop	-2.89	-7.36	-7.06	-6.94	-7.02	-7.66	-7.38	-6.89	-7.56	-3.35	-8.69	-8.62	-6.69	-5.92	-5.91	-7.32	-6.68	-6.65
nint (with trend)	-3.45	-3.16	-2.95	-2.88	-3.19	-3.62	-3.19	-3.33	-6.05	-3.66	-3.57	-4.18	-4.07	-2.11	-2.35	-2.35	-2.92	-1.68
nint (no trend)	-2.89	-0.86	-0.43	-0.50	-0.94	-0.65	-0.14	-0.57	-0.47	-0.68	-1.15	-0.99	-0.38	-0.32	-1.01	0.22	-0.76	-1.23
Dnint	-2.89	-4.66	-4.00	-4.59	-5.29	-4.82	-3.97	-4.41	-5.02	-4.38	-4.10	-5.52	-4.71	-3.57	-3.78	-4.36	-5.13	-4.88
DDnint	-2.89	-7.05	-6.41	-7.84	-7.03	-6.10	-8.11	-7.43	-7.26	-7.58	-6.14	-6.88	-6.64	-6.07	-6.65	-7.70	-9.66	-8.71
ltpop (with trend)	-3.45	-8.39	-2.55	-2.64	-5.34	-9.17	-6.46	-9.42	-4.06	-9.45	-6.21	-0.04	-0.30	-3.06	-6.33	-5.22	-3.43	-0.46
ltpop (no trend)	-2.89	1.25	0.42	0.10	0.98	-3.93	1.71	0.89	-0.58	-1.87	-0.99	0.01	-0.71	3.43	0.55	0.69	-2.48	-1.81
Dltpop	-2.89	-5.34	-2.63	-5.90	-5.15	-5.25	-3.69	-12.40	-2.64	-5.98	-4.89	-2.92	-2.71	-3.76	-8.79	-5.18	-4.27	-1.40
DDltpop	-2.89	-3.91	-6.78	-5.21	-8.13	-4.37	-2.19	-8.49	-6.45	-5.08	-6.10	-9.27	-5.33	-4.71	-11.59	-5.07	-8.41	-10.66
ny_nw (with trend)	-3.45	-1.09	-4.81	-3.45	-6.90	-4.32	-5.67	-1.79	-5.22	-3.00	-5.25	-2.04	-6.30	-5.65	-2.23	-4.31	-3.53	-3.13
ny_nw (no trend)	-2.89	-2.92	-5.29	-2.07	-5.85	-4.44	-6.25	-3.26	-5.54	-3.17	-7.19	-3.11	-6.68	-4.35	-3.15	-4.26	-2.26	-0.05
Dny_nw	-2.89	-0.78	-1.20	-1.44	-1.64	-1.59	-1.20	-0.53	-1.35	-0.77	-1.29	-1.06	-1.31	-1.37	-0.70	-1.37	-1.98	-2.60
DDny_nw	-2.89	-5.52	-2.93	-3.17	-2.31	-3.24	-2.42	-3.96	-2.89	-3.61	-2.16	-4.30	-2.30	-2.31	-5.01	-3.52	-4.47	-3.79
no_nw (with trend)	-3.45	-0.77	-4.74	-1.42	-3.19	-3.99	-0.88	-2.96	-4.52	-3.07	-3.22	-2.06	-1.57	-3.16	-0.25	-3.29	-3.00	-3.60
no_nw (no trend)	-2.89	0.04	-2.56	-0.65	-0.98	-3.03	-0.88	-1.57	-5.19	-3.51	-0.65	0.27	-1.97	-5.35	-0.99	-0.10	-3.13	-0.34
Dno_nw	-2.89	-0.19	-2.73	-0.73	-2.01	-2.36	-0.47	-3.12	-1.87	0.24	-2.40	-0.22	-0.96	-0.83	0.14	-1.92	0.00	-2.93
DDno_nw	-2.89	-3.85	-2.88	-2.32	-2.95	-2.76	-3.03	-2.83	-2.96	-3.31	-2.68	-3.56	-2.55	-2.83	-4.64	-2.55	-3.13	-3.88

ADF Test

Note) "Shaded" means a unit root is rejected at the 5% level.

Table: Weighted-Symmetric DF test

Variables	c.v.	AU	BE	CA	CH	DE	DK	FR	GB	IE	IT	JP	NL	NO	NZ	SE	US	ZA
lnrppi (with trend)	-3.24	-1.79	-5.17	-1.85	-2.04	-1.72	-2.65	-2.17	-1.15	-3.21	-0.96	-0.53	-3.51	-2.46	-1.87	-4.05	-3.15	-3.96
lnrppi (no trend)	-2.55	1.09	-0.15	1.00	0.52	0.66	0.80	-0.20	1.13	-0.39	-0.02	0.11	-0.31	0.76	0.91	0.72	-0.08	0.11
Dlnrppi	-2.55	-4.66	-3.06	-3.32	-3.78	-2.37	-3.70	-2.65	-3.30	-3.08	-2.86	-2.92	-3.04	-4.40	-3.71	-3.94	-4.06	-3.89
DDlnrppi	-2.55	-8.19	-4.29	-5.60	-5.14	-4.20	-5.48	-5.63	-6.29	-4.98	-5.08	-7.81	-5.55	-6.65	-5.56	-5.67	-5.14	-5.46
lcpi (with trend)	-3.24	-1.36	-1.16	-1.58	-0.33	-0.90	-1.41	-2.00	-1.42	-1.50	-2.19	-1.25	-1.27	-1.00	-1.29	-0.90	-1.32	-1.40
lcpi (no trend)	-2.55	-0.34	0.04	-0.48	0.47	0.32	-0.42	-0.94	-0.35	-0.42	-1.32	0.03	0.42	0.11	-0.48	-0.25	-0.44	-0.81
Dlcpi	-2.55	-2.07	-2.31	-1.89	-2.21	-2.60	-1.40	-1.50	-2.02	-2.18	-1.64	-2.42	-1.74	-1.75	-1.71	-1.59	-2.67	-2.06
DDlcpi	-2.55	-5.48	-4.93	-4.82	-4.70	-5.10	-6.42	-4.04	-5.03	-5.50	-4.60	-6.13	-5.33	-5.95	-5.55	-6.55	-5.92	-6.46
ly2wpop (with trend)	-3.24	-1.74	-1.45	-3.22	-4.23	-3.67	-1.79	-1.99	-2.72	-3.05	-0.28	-0.53	-2.19	-0.79	-2.29	-3.33	-2.33	-1.55
ly2wpop (no trend)	-2.55	0.92	1.30	0.87	-0.01	1.24	0.72	1.16	0.69	1.06	1.05	1.58	0.39	0.58	0.56	1.14	0.85	-1.60
Dly2wpop	-2.55	-4.77	-3.60	-4.94	-5.65	-5.68	-4.66	-4.24	-4.92	-2.02	-3.93	-3.96	-4.02	-3.06	-3.53	-5.15	-4.84	-3.96
DDly2wpop	-2.55	-7.70	-7.39	-7.24	-7.30	-7.84	-7.33	-7.23	-6.99	-3.59	-9.00	-7.42	-7.02	-6.19	-6.21	-7.66	-6.42	-6.71
nint (with trend)	-3.24	-1.54	-1.97	-1.43	-3.28	-3.54	-1.63	-2.15	-2.75	-2.16	-2.47	-3.91	-3.03	-1.16	-1.28	-0.71	-1.70	-1.15
nint (no trend)	-2.55	-1.13	-0.86	-0.95	-1.10	-0.82	-0.66	-1.00	-0.94	-1.11	-1.48	-1.07	-0.77	-0.80	-1.21	-0.42	-1.18	-1.19
Dnint	-2.55	-4.93	-4.27	-4.81	-5.54	-4.85	-4.20	-4.65	-5.03	-4.17	-4.36	-5.80	-4.92	-3.83	-4.04	-4.62	-5.36	-5.15
DDnint	-2.55	-6.81	-6.49	-8.11	-7.01	-6.28	-7.79	-7.34	-6.54	-7.56	-6.00	-6.62	-6.40	-6.27	-6.97	-8.05	-10.05	-9.02
ltpop (with trend)	-3.24	-8.68	-3.40	-2.39	-5.40	-9.51	-6.59	-8.19	-4.99	-9.45	-5.64	-1.36	-2.10	-4.92	-6.09	-5.57	-3.85	-1.80
ltpop (no trend)	-2.55	0.71	0.03	1.20	0.26	-4.18	0.53	1.04	-0.46	-1.75	-0.76	0.47	0.89	1.82	0.38	0.29	-2.05	-0.97
Dltpop	-2.55	-5.41	-2.87	-4.90	-5.46	-5.55	-3.59	-9.32	-2.91	-6.19	-4.42	-0.83	-1.81	-3.90	-8.04	-5.48	-4.40	-1.28
DDltpop	-2.55	-3.48	-6.98	-5.30	-8.09	-4.46	-2.26	-8.12	-6.41	-5.25	-6.41	-9.25	-5.42	-4.75	-11.34	-5.23	-8.85	-11.16
ny_nw (with trend)	-3.24	-0.90	-4.05	-2.98	-6.04	-3.57	-5.39	-2.25	-5.01	-3.47	-5.55	-2.66	-5.22	-5.22	-1.88	-4.70	-2.21	-1.99
ny_nw (no trend)	-2.55	-0.73	-3.60	-0.86	-4.45	-2.50	-5.06	-2.38	-4.29	-3.19	-5.62	-3.10	-3.90	-3.36	-1.17	-4.33	-0.45	-0.58
Dny_nw	-2.55	-1.09	-1.51	0.12	-1.93	-1.94	-1.56	-1.03	-1.58	-0.97	-1.50	-1.15	-1.67	-1.66	-1.09	-1.48	0.01	-2.43
DDny_nw	-2.55	-5.72	-2.57	-3.42	-2.12	-3.25	-2.55	-4.11	-2.61	-3.88	-2.25	-4.57	-2.17	-2.23	-5.11	-3.72	-4.70	-4.04
no_nw (with trend)	-3.24	-1.62	-4.44	-3.44	-3.69	-3.90	-2.94	-3.22	-5.39	-3.32	-3.45	-2.89	-2.92	-3.82	-1.21	-4.37	-3.88	-3.70
no_nw (no trend)	-2.55	-0.06	-2.66	-1.96	-1.28	-3.16	-1.08	-1.50	-5.44	-3.61	-0.79	-0.06	-1.57	-5.24	-1.23	-1.18	-3.79	-0.14
Dno_nw	-2.55	-0.49	-3.01	0.34	-2.12	-2.65	-0.74	-3.36	-1.92	-0.39	-2.68	-0.81	-1.37	-0.97	-0.12	-1.78	0.22	-3.10
DDno_nw	-2.55	-4.06	-2.99	-2.60	-3.03	-2.93	-3.11	-3.06	-2.93	-3.58	-2.93	-3.83	-2.53	-2.94	-4.77	-2.76	-3.38	-4.10

WSDF Test

Note) "Shaded" means a unit root is rejected at the 5% level.

A note on WSDF test

- WSDF test is the weighted symmetric estimation of ADF type regressions, proposed by Park and Fuller (1995).
- WSDF test exploits the time reversibility of stationary autoregressive processes in order to increase their power performance.

Summary Interpretation of Individual URTs for Nominal RPPI

- Except for CPI and demographic ratios, most variables can be regarded as $I(1)$.
- CPI: ADF Tests (WSDF tests) suggest Switzerland and Germany (Germany and US) are $I(1)$ and others are $I(2)$.
- Demographic ratios: Results are mixed but largely $I(1)$ or $I(0)$.
- Note: Results should be interpreted with caution, since:
  1) the sample period is short, and
  2) they are sensitive w.r.t. the choice of deterministic components.

- In sum, CPI's order of integration is hard to determine. Thus for empirical analysis, we should examine two cases, i.e., $I(1)$ and $I(2)$.

Tests of Real Variables

- Finally, we examine two real variables (real RPPI and "static expectation" real interest rate).
- (Non)Satationarity Tests of Panel Variables

	level		1st difference		2nd difference	
	CIPS	Hadri	CIPS	Hadri	CIPS	Hadri
	Z[t-bar]	LM	Z[t-bar]	LM	Z[t-bar]	LM
lrrppi	-3.81 ***	11.83 ***	-8.35 ***	-0.69	-15.21 ***	-3.31
rint	-7.92 ***	5.06 ***	-17.82 ***	-2.39	-19.14 ***	-1.41
deterministic	trend+const		const		const	
lags	fixed 1		fixed 1		fixed 1	
long-run variance		QS w/ 2 lags		QS w/ 2 lags		QS w/ 2 lags

*** significant at 1% level. See slide 31 for the setting of test regressions.

- Summary
  - CIPS rejects H_0 for $lrrpi$ and $rint$ in levels, 1st differences and 2nd differences, implying there are some countries which do not have unit roots in levels, 1st differences, and 2nd differences.
  - Stationarity Tests cannot reject H_0 in 1st differences and 2nd differences for $lrrpi$ and $rint$ and are rejected in levels, implying $lrrpi$ and $rint$ are $I(1)$.

- Country-by-country unit root tests

ADF Test

Table: ADF test

Variables	c.v.	AU	BE	CA	CH	DE	DK	FR	GB	IE	IT	JP	NL	NO	NZ	SE	US	ZA
lrrppi (with trend)	-3.45	-1.94	-3.40	-2.28	-2.83	-2.70	-2.64	-3.11	-3.89	-3.53	-3.82	-1.75	-3.00	-2.44	-2.71	-1.46	-4.71	-2.14
lrrppi (no trend)	-2.89	0.31	-1.34	-0.65	-2.15	-1.84	-1.28	-1.35	-0.71	-1.86	-2.64	-1.56	-1.88	-0.17	-0.41	-0.17	-2.30	-1.71
Dlrrppi	-2.89	-5.75	-3.19	-3.50	-4.33	-2.74	-3.95	-3.28	-5.17	-3.51	-3.58	-5.69	-3.24	-3.98	-3.91	-2.88	-4.09	-3.50
DDlrrppi	-2.89	-8.85	-4.30	-5.97	-6.98	-4.36	-5.56	-5.50	-6.70	-5.02	-5.86	-9.09	-5.35	-6.00	-5.68	-5.13	-5.30	-5.75
rint (with trend)	-3.45	-1.58	-1.80	-1.54	-2.96	-2.12	-1.92	-1.21	-2.14	-2.51	-2.16	-2.78	-2.02	-1.28	-1.82	-1.75	-2.72	-3.26
rint (no trend)	-2.89	-1.75	-1.75	-1.59	-3.12	-1.26	-1.23	-1.37	-2.18	-2.53	-2.07	-2.82	-1.63	-1.53	-1.75	-1.91	-2.75	-2.55
Drint	-2.89	-5.28	-4.56	-4.88	-5.28	-5.87	-6.89	-4.46	-5.55	-4.69	-6.33	-7.13	-4.80	-5.25	-5.47	-6.68	-5.61	-6.61
DDrint	-2.89	-9.67	-7.74	-6.83	-8.09	-7.65	-11.33	-7.69	-7.43	-6.25	-10.19	-11.10	-7.91	-8.27	-7.36	-10.49	-8.20	-7.39

WSDF Test

Table: Weighted-Symmetric DF test

Variables	c.v.	AU	BE	CA	CH	DE	DK	FR	GB	IE	IT	JP	NL	NO	NZ	SE	US	ZA
lrrppi (with trend)	-3.24	-2.03	-3.65	-2.56	-3.16	-2.71	-2.76	-3.33	-4.05	-3.79	-3.63	-1.74	-3.28	-2.41	-2.97	-1.66	-4.91	-2.24
lrrppi (no trend)	-2.55	0.44	-1.20	0.03	-2.40	-2.02	-1.51	-1.22	-0.42	-1.73	-1.16	-1.86	-1.58	-0.22	-0.20	-0.48	-1.82	-2.01
Dlrrppi	-2.55	-5.86	-3.43	-3.57	-4.21	-2.96	-4.09	-3.54	-4.35	-3.77	-3.78	-4.23	-3.46	-4.24	-3.91	-3.15	-4.32	-3.76
DDlrrppi	-2.55	-9.25	-4.57	-5.94	-5.49	-4.61	-5.42	-5.79	-5.90	-5.29	-4.83	-6.79	-5.59	-6.17	-5.52	-5.40	-5.49	-6.05
rint (with trend)	-3.24	-1.90	-2.05	-1.91	-2.79	-1.91	-2.03	-1.62	-2.39	-2.77	-2.36	-3.07	-1.13	-1.52	-2.10	-1.99	-2.99	-3.29
rint (no trend)	-2.55	-1.90	-2.03	-1.93	-2.50	-1.56	-1.59	-1.69	-2.38	-2.67	-2.38	-3.10	-1.17	-1.56	-1.59	-1.98	-3.03	-2.83
Drint	-2.55	-5.29	-4.62	-4.38	-5.37	-6.16	-6.84	-4.59	-5.78	-4.95	-5.77	-7.09	-5.07	-5.47	-5.69	-6.99	-5.87	-6.64
DDrint	-2.55	-9.91	-7.79	-7.17	-8.42	-7.86	-11.71	-7.48	-7.48	-6.51	-10.38	-10.53	-8.19	-8.64	-7.18	-10.59	-7.99	-7.74

Note) "Shaded" means a unit root is rejected at the 5% level.

- Summary
  - Results show that both real RPPI and "static-expectation" real interests are almost all $I(1)$.
  - Exceptions are: Germany and Sweden in the ADF test of real RPPI, and Ireland, Japan, United States, and South Africa in the WSDF test and Switzerland in the ADF test of the static expectation real interest rate.

Estimation Results

1. Long-run nominal RPPI models with demographic factors

- We first consider the case that CPI is $I(1)$ like other variables.
- Then, the following long-run nominal RPPI model is an appropriate model to be estimated, which is homogeneous among countries.

Long-run nominal RPPI models with demographic factors

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

Panel Cointegration Tests and Estimation Methods

1. We first apply Panel Cointegration Tests examining whether a long run relationship exists.
2. Then, Panel Cointegrating Regressions of Homogeneous Long-Run Relations are estimated by:
    1. Fully-Modified OLS (pooled FMOLS and weighted FMOLS)
    2. Dynamic OLS (pooled DOLS and weighted DOLS)

	Homogeneous long run variance of innovation vectors for all countries	Heterogeneous long run variance of innovation vectors for each country
Fully-Modified OLS	pooled FMOLS	weighted FMOLS
Dynamic OLS	pooled DOLS	weighted DOLS

    3. We also report the long run part of Pooled Mean Group Estimates allowing Heterogeneous Short-run Adjustment (details are given later) for comparison purposes.

Summary of Panel Cointegration Tests

- Pedroni's Panel Cointegration Tests (1999,2004)

within-dimension			between-dimension	
	stats	weighted stats		stats
Panel v	1.614*	1.482*		
Panel ρ	2.329	2.378	Group ρ	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)

	stats
ADF	-6.284***

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

Comments on the Panel Cointegration Tests

1. Among the 11 test statistics by Pedroni (1999,2004), panel v-stat (both) and panel ADF-stat (both) reject the null of no cointegration 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. In our case, 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 can conclude that there exists a significant long run relationship between the variables. That said, we estimate the long-run coefficients in the next slides.

Panel Cointegrating Regression: Setup

- Consider a fixed effect panel cointegrating regression, which assumes homogeneous long run relations except for intercepts (i.e., the deterministic trend terms consist only of cross-section dummy variables).

$$y_{it} = \alpha_i + x_{it}'\beta + u_{it} \qquad \text{where} \qquad \Delta x_{it} = \epsilon_{it}$$

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

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

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

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

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

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

where $\tilde{x}_{it} = x_{it} - \bar{x}_i$ and $\tilde{y}_{it} = y_{it} - \bar{y}_i$ are the demeaned variables, and

$$\hat{y}_{it}^{+} = \tilde{y}_{it} - \hat{\Omega}_{u\epsilon}\hat{\Omega}_{\epsilon}^{-1}\Delta x_{it} \quad \text{and} \quad \hat{\Delta}_{\epsilon u}^{+} = \hat{\Delta}_{\epsilon u} - \hat{\Delta}_{\epsilon}\hat{\Omega}_{\epsilon}^{-1}\hat{\Omega}_{\epsilon u}$$

(See slide 43 for definitions of $\Omega_{\epsilon u}, \Omega_{\epsilon}, \Omega_{u\epsilon}, \Delta_{\epsilon u}$ and Δ_{ϵ}.)

- 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:

$$\tilde{y}_{it} = \tilde{x}_{it}'\beta + \sum_{j=-q}^{q} c_{ij}\Delta\tilde{x}_{i,t+j} + v_{it}$$

where $\tilde{x}_{it} = x_{it} - \bar{x}_i$ and $\tilde{y}_{it} = y_{it} - \bar{y}_i$ are the data purged of the individual deterministic trends. In our application, we consider only the individual specific intercepts.

- Note that the short-run coefficients c_i are panel-specific.
- The limiting distribution of $\hat{\beta}_D$ is

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

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

Robustness Checks

- We have conducted FMOLS, weighted FMOLS, DOLS, weighted DOLS, in various sample periods (1971-2015, 1972-2015, 1973-2015, 1974-2015, 1975-2015).
- The results are stable and have right signs of coefficients in all sample periods we consider.
- We will report the result of the longest sample period (1971-2015) later in the "result" part.

Demography and RPPI -''Nominal'' Formulation

Baseline Nominal RPPI: Balanced Panel of 17 Countries 1971-2015

ES(Spain), HK(Hong Kong), and KR(Korea) are excluded due to missing observations

Eq Name:	FMOLS1	FMOLS2	DOLS1	DOLS2	PMG
$\log P^{cpi}$	1.072	0.989	0.987	1.053	1.1006
	(0.047)***	(0.006)***	(0.070)***	(0.058)***	(0.0530)***
$\log(Y/pop^{wrk})$	0.780	1.064	1.577	1.386	1.1445
	(0.110)***	(0.010)***	(0.170)***	(0.150)***	(0.1191)***
i	-2.876	-1.968	-1.731	-1.960	-2.3885
	(0.594)***	(0.011)***	(0.818)**	(0.648)***	(0.4610)***
$\log pop^{total}$	0.847	0.966	-0.146	-0.022	1.2239
	(0.213)***	(0.002)***	(0.343)	(0.268)	(0.2999)***
$n^{yng} - n^{wrk}$	2.558	2.601	2.839	2.817	4.9896
	(0.640)***	(0.002)***	(0.925)***	(0.774)***	(0.6201)***
$n^{old} - n^{wrk}$	-3.584	-3.432	-4.128	-4.152	-3.3787
	(0.534)***	(0.001)***	(0.914)***	(0.719)***	(0.6880)***
Observations:	765	765	748	748	731
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(2,2,2-Lg) for 1973-2015 (for comparison, discussed later)

Findings of the "Nominal" Baseline Model

Representative "Nominal" Result: FMOLS2

$$\log P_{jt}^{rppi} = 0.989 \log P_{jt}^{cpi} + 1.064 \log \left(\frac{Y_{jt}}{pop_{jt}^{wrk}} \right) - 1.968\, i_{jt}$$

$$+ 0.966 \log pop_{jt}^{total} + 2.601 (n_{jt}^{yng} - n_{jt}^{wrk}) - 3.432 (n_{t}^{old} - n_{jt}^{wrk}) + \text{others}$$

General Comments on "Nominal" Long-run Relationship

1. $n^{yng} - n^{wrk}$ (young dependency ratio) has strongly positive effects on residential property prices *) A baby boom implies optimism
2. $n^{old} - n^{wrk}$ (old dependency ratio) has strongly negative effects on residential property prices *) Aging implies pessimism
3. Current real GDP per worker ($\log(Y/pop^{wrk})$) has positive effects as a proxy of real rents (as expected)
4. Current nominal rate of return (i) has negative effects implying a statistically significant effect of credit conditions (as expected)
5. Present-value relation explains long-run RPPI very well (high R^2).
6. Coefficient of CPI ($\log P^{cpi}$) is close to unity (no money illusion)

Robustness Checks

All Included: Unbalanced Panel of 20 Economies in Period 1971-2015

Eq Name:	FMOLS1	FMOLS2	DOLS1	DOLS2	PMG
$\log P^{cpi}$	1.185	1.101	0.961	1.053	1.1020
	(0.050)***	(0.006)***	(0.063)***	(0.048)***	(0.0521)***
$\log(Y/pop^{wrk})$	0.456	0.711	1.605	1.416	1.0995
	(0.118)***	(0.008)***	(0.161)***	(0.143)***	(0.1182)***
i	-2.991	-2.276	-1.421	-1.436	-2.7307
	(0.652)***	(0.010)***	(0.759)*	(0.606)**	(0.4700)***
$\log pop^{total}$	0.868	0.899	-0.063	0.057	1.1210
	(0.245)***	(0.002)***	(0.330)	(0.266)	(0.2951)***
$n^{yng} - n^{wrk}$	3.261	3.280	2.576	2.999	4.6870
	(0.655)***	(0.002)***	(0.796)***	(0.661)***	(0.6417)***
$n^{old} - n^{wrk}$	-2.697	-2.751	-3.817	-3.926	-3.3627
	(0.611)***	(0.001)***	(0.790)***	(0.637)***	(0.6961)***
Observations:	867	867	844	844	808
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(2,2,2-Lg) for 1973-2015 (for comparison, discussed later)
- Data (both RPPI and nominal interest rates) are available for ES (Spain) only after 1979, KR (Korea) after 1975, HK (Hong Kong) after 1990.

Findings about Unbalanced 20 Economies

Representative "Nominal" Result: FMOLS2 for 20 Economies

$$\log P_{jt}^{rppi} = 1.101 \log P_{jt}^{cpi} + 0.711 \log \left(\frac{Y_{jt}}{pop_{jt}^{wrk}} \right) - 2.276\, i_{jt}$$
$$+ 0.899 \log pop_{jt}^{total} + 3.280(n_{jt}^{yng} - n_{jt}^{wrk}) - 2.751(n_{t}^{old} - n_{jt}^{wrk}) + \text{others}$$

Robust results:

- All-Included Models produce qualitatively similar results to the Baseline Model including strong negative effects of aging (n^{old})
- However, the young dependency ratio has bigger positive effects in the absolute term than the old ratio's negative effects in FMOLS and DOLS.
- This might be the result of these three countries/regions' substantial population bonus and significant increases in their property prices.

2. Long-run real RPPI models with demographic factors

- When CPI is $I(2)$, the nominal RPPI model is not valid since nominal RPPI which is $I(1)$ cannot have a long run relation with $I(2)$-CPI.
- The real-real formulation here avoids this problem.
- However, there emerges a problem in cointegration tests.

Long-run real RPPI model with demographic factors

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

Panel Cointegration Tests and Regressions

1. The results of Panel Cointegration Tests become weaker in the real RPPI models than in the nominal RPPI models.
    1. Although the Kao (1999) test rejects the null of no cointegration at 1%, only two (Panel ADF at 5% and Group ADF at 10%) out of eleven Pedroni (1999,2004) tests reject the null of no cointegration. See the next slide.
    2. Exact causes are not clear, but the fact that real RPPI is constructed by dividing nominal RRPI (which is $I(1)$) by CPI (which is $I(2)$) might have some relevance.
2. However, Panel Cointegrating Regressions (estimated in the same way as in the nominal RPPI models) produce results very similar to those of nominal RPPI models, showing a significant impact of demographic variables on real RPPI.

Summary of Panel Cointegration Tests

- Pedroni's Panel Cointegration Tests (1999,2004)

within-dimension			between-dimension	
	stats	weighted stats		stats
Panel v	1.059	0.875		
Panel ρ	1.224	1.693	Group ρ	3.227
Panel PP	0.147	0.931	Group PP	2.219
Panel ADF	-2.410***	-1.487*	Group ADF	-1.895**

- Kao's Panel Cointegration Tests (1999)

	stats
ADF	-3.106***

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

Demography and RPPI -"Real" Formulation

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

ES(Spain), HK(Hong Kong), and KR(Korea) are excluded due to missing observations

Eq Name:	FMOLS1	FMOLS2	DOLS1	DOLS2	PMG
$\log(Y/pop^{wrk})$	0.985	1.128	1.112	1.190	1.0381
	(0.094)***	(0.006)***	(0.131)***	(0.117)***	(0.0917)***
r	-2.572	-2.142	-2.323	-2.588	-1.3020
	(0.538)***	(0.015)***	(0.606)***	(0.423)***	(0.3522)***
$\log pop^{total}$	1.016	1.003	0.748	0.656	2.8789
	(0.186)***	(0.001)***	(0.253)***	(0.194)***	(0.2687)***
$n^{yng} - n^{wrk}$	1.390	1.756	1.839	1.695	5.4630
	(0.628)**	(0.002)***	(0.809)**	(0.604)***	(0.5406)***
$n^{old} - n^{wrk}$	-3.098	-3.125	-2.786	-3.029	-3.6290
	(0.536)***	(0.001)***	(0.813)***	(0.577)***	(0.6754)***
Observations:	765	765	748	748	714
R^2:	0.820	0.822	0.969	0.969	NA

- ***/**/* indicates the estimates are significant at 1%/5%/10% levels
- FMOLS1=pooled, FMOLS2=weighted, DOLS1=pooled, DOLS2=weighted, PMG=ARDL(2,2,2-Lg) for 1974-2015 (for comparison, discussed later)

Findings of the "Real" Baseline Model

Representative "Real" Result: FMOLS2

$$\log real\ P_{jt}^{rppi} = 1.128 \log\left(\frac{Y_{jt}}{pop_{jt}^{wrk}}\right) - 2.142 r_{jt} + 1.003 \log pop_{jt}^{total} + 1.756(n_{jt}^{yng} - n_{jt}^{wrk}) - 3.125(n_t^{old} - n_{jt}^{wrk}) + \text{others}$$

General Comments on "Real" Long-run Relationship

1. "Real" results are qualitatively quite similar to "nominal" results
2. In particular, nominal interest rates and "static expectation" real interest rates have qualitatively the same effects on the prices.
3. To examine whether demo. factors influence through rent growth expectations only, compare the "real" and "nominal".
    - The coeff. of young-to-working, and old-to-working age ratios are smaller both in FMOLS and DOLS in reals than nominals, suggesting demo ratios also affect inflationary expectations.

3. Interaction of Demography and Credit Conditions on Property Prices

- Demography-Induced Optimism/Pessimism and Credit Conditions during Bubbles and Busts
  - Introductory slides taken from Nishimura (2016) suggest sizable synergetic effects of population-bonus- induced optimism and loose credit conditions on property prices, which often resulted in so-called property bubbles.
  - In contrast, post-property bubble experiences of Japan, US and Ireland indicate that the effectiveness of nominal interest rate cuts (monetary policy) may severely limited in the population onus (aging) period and country.
  - To test whether these casual observations found in three countries represents a rule rather than mere coincidence, we add the cross-term of nominal interest rate and demographic factors in the nominal RPPI model.

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
$\log P^{cpi}$	1.115	1.035	1.077	1.142
	(0.047)***	(0.006)***	(0.069)***	(0.044)***
$\log(Y/pop^{wrk})$	0.807	1.045	1.124	0.882
	(0.109)***	(0.012)***	(0.158)***	(0.113)***
i	9.336	11.162	9.038	8.604
	(5.811)	(0.013)***	(6.062)	(4.270)**
$\log pop^{total}$	0.744	0.867	0.075	0.213
	(0.213)***	(0.002)***	(0.283)	(0.194)
$n^{yng} - n^{wrk}$	3.442	2.958	3.112	2.799
	(0.812)***	(0.003)***	(0.979)***	(0.591)***
$n^{old} - n^{wrk}$	-4.795	-4.679	-6.229	-5.481
	(0.736)***	(0.001)***	(0.895)***	(0.491)***
$i \times (n^{yng} - n^{wrk})$	-9.261	-4.258	-3.680	-7.039
	(5.533)*	(0.003)***	(6.372)	(5.405)
$i \times (n^{old} - n^{wrk})$	31.142	28.834	27.711	29.634
	(10.551)***	(0.003)***	(10.249)***	(8.181)***
Observations:	765	765	748	748
R^2:	0.954	0.956	0.998	0.997

- ***/**/* indicate the estimates are significant at 1%/5%/10% levels;
- FMOLS1=pooled, FMOLS2=weighted, DOLS1=pooled, DOLS2=weighted

Demography and Credits: Interpretation (1)

Rearranging the terms in a representative FMOLS2 result, we have

$$\begin{aligned}\log P_{jt}^{rppi} &= 1.035 \log P_{jt}^{cpi} + 1.045 \left(\frac{Y_{jt}}{pop_{tj}^{wrk}} \right) \\ &+ \left(-2.34 - 4.258 \widetilde{n_{jt}^{yng}} - 24.576 \widetilde{n_{jt}^{wrk}} + 28.834 \widetilde{n_{jt}^{old}} \right) i_{jt} \\ &+ 0.867 \log pop_{jt}^{total} + 2.958 n_{jt}^{yng} + 1.721 n_{jt}^{wrk} - 4.679 n_{jt}^{old} \\ &+ \text{other factors}\end{aligned}$$

where (1) -2.34 is the coefficient of the nominal interest rate (credit condition) i of country j when the country's demographic composition n^x ($x = yng, wrk, or\ old$) is at the (cross-sectional) 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 ($\widetilde{n_{jt}^{old}} > 0$)

Demography and Credits: Interpretation (2)

The results (of this extended model with 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 -2.34, which is in line with the baseline models' results.
- A demographic bonus ($\widetilde{n_{jt}^{wrk}} \uparrow$) substantially strengthens the positive effects on declining interest rates (loose monetary policy).
- In contrast, a demographic onus ($\widetilde{n_{jt}^{old}} \uparrow$) makes decreasing interest rates (monetary easing) have substantially less positive effects on residential property prices.
- These results strongly support the hypothesis of a strong interaction between demographics and credit conditions in Nishimura (2011, 2016).

4. Short-Run Property Price Dynamics

- Short-run RPPI model: (1) Augmented Error Correction of RPPI
  - The fundamental value may not be achieved instantaneously because of transaction costs and imperfect information.
  - Moreover, property prices may be influenced by cyclical macro factors over business cycles, in addition to fundamentals.
  - This suggests the following "augmented" error correction process.
    - Let y_{jt} be RPPI, which gradually incorporates the changes in macro fundamentals x_{jt}, for example, in a ARDL(1, 1) way:
      $$y_{jt} = \delta_{0,j} + \lambda_j y_{j,t-1} + \beta_{0j} x_{jt} + \beta_{1j} x_{j,t-1} + \varepsilon_{jt}$$
    - The traditional error correction process of this ARDL(1,1) is
      $$\Delta y_{jt} = \phi_j (y_{j,t-1} - \theta_j x_{j,t-1}) + \delta_{0,j} + \beta_{0j} \Delta x_{jt} + \varepsilon_{jt}$$
      where $\phi_j = -(1 - \lambda_j)$ and θ_j is the coefficient of the long run relationship.
    - We augment this error correction process with the possible effect of cyclical macro factors z_{jt} (whose long-run effects are nil) :
  - $$\Delta y_{jt} = \phi_j (y_{j,t-1} - \theta_j x_{j,t-1}) + \delta_{0,j} + \beta_{0j} \Delta x_{jt} + \beta'_{0j} z_{jt} + \varepsilon_{jt}$$

- We consider cyclical macro factors in the form of GAPs:
  - For a macro variable x_{jt}, we regard the deviation z_{jt} from the HP filter trend x_{jt}^{HP} as the GAP (cyclical part) of this variable.
  - In particular, we examine "Real-GDP-per-working-age-population GAP" and "Interest-Rate GAP" in the subsequent analysis.
  - Hamilton (2016) argues against the use of the HP filter to get "cyclical components" in dynamic models such as, for example, DSGE models, especially for prediction purposes. (In particular, HP-filter-detrended cyclical variables often produce "reasonable" impulse response functions which are in fact artifact of the HP-filter detrending.) This paper uses the HP filter to get a proxy of the cyclical position of macro variables only, and thus less prone to the criticism. Moreover, in a preliminary analysis, we have tried the Hamilton's alternative and also the 1-sided filter he recommended instead of the 2-sided filter, but the results are unstable. Also, it is desirable to apply the same procedure to get GAPs, and possibly more sophisticated approaches are not applicable to a very diverse set of countries of this study. So, we stick to use this filter.

- Short-run RPPI Model (2) Coping with Multicollinearity
  - A confounding factor exists. There is a severe multicollineartiy problem involving concurrent (and lagged) difference Δx_{jt} in the conventional Error Correction Model in the ARDL framework.
  - Preliminary analysis shows that when Δx_{jt} is in the conventional error correction equation (without GAPs), estimation results become unstable w.r.t. sample periods and produce wrong signs for x_{jt} in the long run relationship, indicating multicollinearity.
  - In contrast, contemporaneous GAP z_{jt} is added in the augmented error correction model and Δx_{jt} dropped, there is no symptom of multicollinearity.
  - To cope with this multicollinearity problem, we replace macro variables' differences (Δx_{jt}) with their approximation based on concurrent GAPs (z_{jt}), in the augmented Error Correction equation (next slide).

- We assume that GAP z_{jt} can be approximated linearly by Δx_{jt}. In the ARDL(1,1) case, we assume $z_{jt} = \mu_j + \omega_j \Delta x_{jt} + \varepsilon^x_{jt}$. Then,

Short-run RPPI: Modified Augmented Error Correction ARDL(1,1-Lg) example

$$\Delta y_{jt} = \phi_j (y_{j,t-1} - \theta_j x_{j,t-1}) + \delta''_{0,j} + \beta''_{0j} z_{jt} + \varepsilon''_{jt} \quad \text{(EC-M)} \qquad (1)$$

where $\delta''_{0,j} = \delta_{0,j} - \frac{\beta_{0j}}{\omega_j}\mu_j$; $\beta''_{0j} = \beta'_{0j} + \frac{\beta_{0j}}{\omega_j}$; $\varepsilon''_{jt} = \varepsilon_{jt} - \frac{\beta_{0j}}{\omega_j}\varepsilon^z_{jt}$

- Here, the EC model has a lagged macro x_{jt} in the "long run relation" part, but has its GAP term z_{jt} in the EC part. We may denote this modified, augmented ARDL(1,1)-EC relation as ARDL(1, 1-Lg), where L indicates lagged macro x_{jt} in the long run relation and g its gap z_{jt} in the short-run error correction.
- To impose the exact linear relation amounts to assume a specific dynamics of the gap z_{jt}. In the following formal analysis, we use ARDL(2,2) for macro variables, and a linear approximation of z_{jt} by current difference Δx_{jt} and lagged one $\Delta x_{j,t-1}$, which implies AR(2) process of z_{jt}. These approximations may mimic a cyclical behavior of actual z_{jt} reasonably well. See the Appendix for these approximations.

- Using this Modified Augmented Structural Error Correction Model framework, we will examine the characteristics of property price movement which are shared among the diverse economies of our sample.

- Specifically, we ask
    - Is property price dyanmics smooth (that is, are shocks gradually waned down), or bumpy, hump-shaped (are they amplified initially then reversed sharply)?
    - Are there significant influences of short-run macro cyclical factors on property prices?
    - Are there any differences between nominal interest gaps and (stationary expectation) real interest gaps?

Estimation of Short-Run RPPI Model

- An ARDL (2, 2 [Demographics], 2 [Macros]) model is assumed:
  - RPPI y_{jt}; Macro Variables x_{jt}; Demographic Variables n_{jt};
  - Fundamentals follow ARDL(2,2,2) :

$$
\begin{aligned}
y_{jt} &= \delta_{0,j} + \lambda_{1j} y_{j,t-1} + \lambda_{2j} y_{j,t-2} \\
&\quad + \beta_{0j} x_{jt} + \beta_{1j} x_{j,t-1} + \beta_{2j} x_{j,t-2} \\
&\quad + \gamma_{0j} n_{jt} + \gamma_{1j} n_{j,t-1} + \gamma_{2j} n_{j,t-2} + \varepsilon_{jt}
\end{aligned}
$$

- Cyclical factors z_{jt} are augmented in error correction, and taking account of multicollinearity involving Δx_{jt}, the modified augmented error correction [ARDL(2,2,2-Lg)] is to be estimated

(by using approximation $z_{jt} = \mu_j + \omega_j \Delta x_{jt} + \varepsilon^{x}_{jt}$ and $z_{jt} = \mu^*_j + \omega^*_j \Delta x_{j,t-1} + \varepsilon^{x*}_{jt}$).

$$
\begin{aligned}
\Delta y_{jt} &= \phi_j (y_{j,t-1} - \theta_j x_{j,t-1} - \eta_j n_{j,t-1}) \\
&\quad + \delta_{0,j} - \lambda_{2j} \Delta y_{j,t-1} + \delta'_{0j} \Delta n_{jt} + \delta'_{1j} \Delta n_{j,t-1} \\
&\quad + \delta'_{2,j} z_{jt} + \varepsilon'_{jt}
\end{aligned}
$$

where $\phi_j = -(1 - \lambda_{1j} - \lambda_{2j})$

PMG Framework

- Adapted from Shin, Pesaran, and Smith (1999)
- Impose Long-run Homogeneity: $\theta_j = \theta$ and $\eta_j = \eta \quad \forall\ j$
- However, Short-run Heterogeneity is allowed: ϕ_j; δ_{*j}; λ_{2j}; δ'_{*j}
- Then the PMG model is

$$\begin{aligned}\Delta y_{jt} = \phi_j(y_{j,t-1} - \theta x_{j,t-1} - \eta n_{j,t-1}) + \delta_{0,j} - \lambda_{2j}\Delta y_{j,t-1} \\ + \delta'_{0j}\Delta n_{jt} + \delta'_{1j}\Delta n_{j,t-1} + \delta'_{2,j} z_{jt} + \varepsilon'_{jt}\end{aligned}$$

- Thus, long-run homogeneity assumption that we have made so far can be tested in this framework.

Diagnostics: Tests about the Stationarity of GAP variables

- Before proceeding with the PMG framework, we examine the unit root property of GAP variables, to confirm our procedure (assuming GAP variables are $I(0)$) is appropriate.
- Pesaran's CIPS and Hadri's Stationarity Tests

	level		1st difference		2nd difference	
	CIPS Z[t-bar]	Hadri LM	CIPS Z[t-bar]	Hadri LM	CIPS Z[t-bar]	Hadri LM
ly2wpop_gap	-5.74 ***	-2.04	-11.98 ***	-2.22	-18.19 ***	0.4
nint_gap	-7.09 ***	-2.63	-15.79 ***	-3.49	-19.21 ***	-2.77
rint_gap	-12.39 ***	-3.01	-18.24 ***	-3.01	-19.13 ***	-1.35
deterministic	trend+const		const		const	
lags	fixed 1		fixed 1		fixed 1	
long-run variance		QS w/ 2 lags		QS w/ 2 lags		QS w/ 2 lags

*** significant at 1% level. See slide 31 for the setting of test regressions.

- Results show that all GAP variables are $I(0)$.

- Country-by-country unit root tests

ADF Test

Table: ADF test

Variables	c.v.	AU	BE	CA	CH	DE	DK	FR	GB	IE	IT	JP	NL	NO	NZ	SE	US	ZA
ly2wpop_gap (with trend)	-3.45	-4.09	-3.33	-4.15	-4.91	-4.42	-4.43	-3.96	-4.50	-3.30	-4.26	-4.13	-4.08	-4.91	-3.86	-3.93	-4.94	-4.48
ly2wpop_gap (no trend)	-2.89	-4.16	-3.34	-4.21	-5.01	-4.48	-4.50	-4.00	-4.61	-3.61	-4.29	-4.17	-4.13	-4.98	-3.94	-3.99	-5.01	-4.56
Dly2wpop_gap	-2.89	-5.75	-5.42	-5.52	-5.67	-6.20	-5.61	-5.32	-5.89	-1.84	-6.40	-6.38	-5.36	-5.14	-4.20	-5.66	-5.48	-5.53
DDly2wpop_gap	-2.89	-7.58	-7.45	-7.16	-7.21	-7.83	-7.55	-7.20	-7.75	-3.68	-9.02	-8.76	-7.08	-6.17	-6.30	-7.61	-6.80	-6.95
nint_gap (with trend)	-3.45	-5.86	-4.29	-4.61	-4.83	-4.84	-3.56	-4.52	-6.07	-4.39	-4.85	-5.91	-4.89	-3.77	-3.75	-4.49	-4.22	-4.54
nint_gap (no trend)	-2.89	-5.95	-4.37	-4.68	-4.89	-4.88	-3.59	-4.59	-5.92	-4.45	-4.97	-5.94	-4.97	-3.82	-3.81	-4.56	-4.27	-4.60
Dnint_gap	-2.89	-6.40	-4.90	-5.84	-5.63	-4.95	-5.09	-5.29	-5.91	-4.94	-5.23	-5.98	-5.17	-5.32	-5.35	-6.12	-6.55	-7.35
DDnint_gap	-2.89	-7.13	-6.57	-8.02	-7.18	-6.23	-8.37	-7.61	-7.40	-7.76	-6.30	-6.98	-6.77	-6.24	-6.88	-7.83	-9.99	-8.92
rint_gap (with trend)	-3.45	-3.96	-4.01	-4.38	-3.73	-4.80	-5.07	-4.33	-4.66	-4.36	-5.61	-5.62	-3.99	-4.78	-5.52	-4.46	-4.99	-6.69
rint_gap (no trend)	-2.89	-3.85	-3.95	-4.27	-3.79	-4.83	-5.03	-4.20	-4.65	-4.40	-5.26	-5.42	-4.03	-4.79	-5.50	-4.47	-5.01	-6.69
Drint_gap	-2.89	-6.38	-5.21	-5.64	-5.46	-6.56	-8.16	-5.82	-6.22	-5.18	-7.49	-7.93	-6.35	-6.30	-6.30	-7.68	-6.21	-7.20
DDrint_gap	-2.89	-10.10	-8.06	-7.00	-8.24	-7.71	-11.61	-7.95	-7.52	-6.34	-10.52	-11.54	-8.06	-8.40	-7.45	-10.67	-8.41	-7.45

WSDF Test

Table: Weighted-Symmetric DF test

Variables	c.v.	AU	BE	CA	CH	DE	DK	FR	GB	IE	IT	JP	NL	NO	NZ	SE	US	ZA
ly2wpop_gap (with trend)	-3.24	-4.08	-3.60	-4.35	-4.70	-4.64	-4.62	-4.20	-4.72	-3.65	-4.46	-4.34	-4.30	-5.16	-4.12	-4.20	-5.23	-4.76
ly2wpop_gap (no trend)	-2.55	-4.09	-3.59	-4.40	-4.70	-4.66	-4.68	-4.20	-4.76	-3.71	-4.51	-4.38	-4.32	-5.23	-4.18	-4.26	-5.28	-4.83
Dly2wpop_gap	-2.55	-6.02	-5.27	-5.62	-5.88	-6.40	-5.77	-5.50	-5.71	-2.13	-6.60	-6.04	-5.61	-5.42	-4.10	-5.93	-5.49	-5.77
DDly2wpop_gap	-2.55	-7.92	-7.80	-7.47	-7.53	-8.06	-7.54	-7.54	-7.25	-3.91	-9.32	-7.73	-7.41	-6.42	-6.62	-7.94	-6.57	-6.93
nint_gap (with trend)	-3.24	-6.00	-4.54	-4.82	-5.10	-5.11	-3.75	-4.72	-5.64	-4.20	-5.08	-6.08	-5.03	-4.03	-3.99	-4.75	-4.43	-4.75
nint_gap (no trend)	-2.55	-6.08	-4.60	-4.87	-5.16	-5.16	-3.79	-4.78	-5.65	-4.25	-5.16	-6.14	-5.10	-4.08	-4.03	-4.80	-4.48	-4.80
Dnint_gap	-2.55	-6.67	-5.16	-6.14	-5.92	-5.11	-5.32	-5.57	-6.19	-5.02	-5.32	-6.28	-5.46	-5.52	-5.62	-6.39	-6.87	-7.51
DDnint_gap	-2.55	-6.93	-6.67	-8.31	-7.12	-6.39	-8.05	-7.54	-6.63	-7.73	-6.19	-6.71	-6.51	-6.47	-7.21	-8.19	-10.40	-9.24
rint_gap (with trend)	-3.24	-4.03	-4.04	-3.94	-3.76	-4.86	-4.80	-4.14	-4.92	-4.64	-5.15	-5.38	-4.01	-4.92	-5.81	-4.72	-5.00	-6.83
rint_gap (no trend)	-2.55	-4.02	-4.07	-3.99	-3.71	-4.78	-4.85	-4.16	-4.92	-4.67	-5.07	-5.35	-3.90	-4.97	-5.78	-4.74	-5.05	-6.87
Drint_gap	-2.55	-6.52	-5.32	-5.21	-5.57	-6.88	-7.93	-6.07	-6.36	-5.40	-7.19	-7.95	-6.67	-6.57	-6.37	-7.98	-6.50	-7.36
DDrint_gap	-2.55	-10.31	-8.05	-7.33	-8.59	-7.94	-11.98	-7.68	-7.55	-6.60	-10.69	-10.85	-8.38	-8.78	-7.22	-10.75	-8.16	-7.80

Note) "Shaded" means a unit root is rejected at the 5% level.

- Results show that (almost) all GAP variables are $I(0)$.

Testing Long-run Homogeneity

- 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 (Mean Group Estimator) and the classical FE (Fixed Effect Estimator)
    - The MG allows both the slopes and the intercepts to differ across countries
    - The FE allows only the intercepts to vary
- Given this formulation, we have applied a Hausman Test to assess whether PMG is more appropriate than MG (or equivalently, whether the long-run homogeneity assumption is appropriate or not). The Test is applied to three time periods (1973-2015, 1974-2015, 1975-2015), for nominals and reals.
- All tests indicate PMG is more appropriate than MG (the long-run homogeneity assumption is appropriate). - Next slide.

Hausman Tests: PMG versus MG

- $\boldsymbol{\theta}$ is a set of long-run coefficients
- Hypotheses
  - H_0: Difference in coefficients $\boldsymbol{\theta}$ is not systematic
  - H_a: Difference in coefficients $\boldsymbol{\theta}$ is systematic
- $\hat{\boldsymbol{\theta}}_{\text{MG}}$ is consistent under H_0 and H_a
- $\hat{\boldsymbol{\theta}}_{\text{PMG}}$ is inconsistent under H_a, but efficient under H_0
- Test statistic is formed as

$$(\hat{\boldsymbol{\theta}}_{\text{MG}} - \hat{\boldsymbol{\theta}}_{\text{PMG}})'[var(\hat{\boldsymbol{\theta}}_{\text{MG}}) - var(\hat{\boldsymbol{\theta}}_{\text{PMG}})]^{-1}(\hat{\boldsymbol{\theta}}_{\text{MG}} - \hat{\boldsymbol{\theta}}_{\text{PMG}}) \sim \chi^2(g)$$

where g is the number of long-run coefficients

	nominal		real	
estimation period	test stat	p value	test stat	p value
1973-2015	3.48	0.7464	1.99	0.8510
1974-2015	3.97	0.6802	3.60	0.6089
1975-2015	4.63	0.5927	6.75	0.2402
g	6		5	

PMG Estimates of Long Run and Short Run: Nominal Models, 17 Countries

	(1)	(2)	(3)
sample period	1973-2015	1974-2015	1975-2015
Long-run relation			
$\log P_{-1}^{cpi}$	1.1006***	1.1491***	1.2268***
	[0.0530]	[0.0585]	[0.0625]
$\log(Y/pop^{wrk})_{-1}$	1.1445***	1.0112***	0.9416***
	[0.1191]	[0.1216]	[0.1182]
i_{-1}	-2.3885***	-1.8586***	-1.8829***
	[0.4610]	[0.4261]	[0.4171]
$\log pop_{-1}^{total}$	1.2239***	1.8966***	1.7949***
	[0.2999]	[0.3138]	[0.2927]
$n_{-1}^{yng} - n_{-1}^{wrk}$	4.9896***	6.3661***	5.9575***
	[0.6201]	[0.5725]	[0.5629]
$n_{-1}^{old} - n_{-1}^{wrk}$	-3.3787***	-4.9326***	-4.5608***
	[0.6880]	[0.5953]	[0.6130]
N	731	714	697
ll	1521.31	1519.54	1512.00

Standard errors in brackets
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

sample period	1973-2015	1974-2015	1975-2015
Short-run adjustment			
error-correction term$_{-1}$	-0.2671***	-0.2726***	-0.2688***
	[0.0612]	[0.0621]	[0.0662]
$\Delta \log P^{rppi}_{-1}$	0.4285***	0.3799***	0.3697***
	[0.0537]	[0.0580]	[0.0502]
$\Delta \log P^{cpi}$	0.3331	0.3106	0.4651
	[0.2282]	[0.2340]	[0.2868]
$\Delta \log P^{cpi}_{-1}$	0.1081	0.0717	0.1328
	[0.2711]	[0.2589]	[0.2729]
$\log(Y/pop^{wrk})^{gap}$	0.7971***	0.7476***	0.8459***
	[0.2428]	[0.2596]	[0.2595]
i^{gap}	-1.0409***	-0.7727*	-0.9669**
	[0.3891]	[0.4230]	[0.4093]
$\Delta \log pop^{total}$	8.6058	10.8411*	11.0746
	[5.3123]	[5.8608]	[6.9054]
$\Delta \log pop^{total}_{-1}$	-0.1481	-2.4309	-2.0754
	[3.7146]	[4.0073]	[4.8909]
$\Delta(n^{yng} - n^{wrk})$	1.3625	1.5434	-0.3383
	[2.6520]	[3.5197]	[3.1533]
$\Delta(n^{yng} - n^{wrk})_{-1}$	-8.9339**	-9.6837**	-9.2687**
	[3.8793]	[4.5995]	[4.5543]
$\Delta(n^{old} - n^{wrk})$	-0.2041	-0.3420	1.9306
	[3.3976]	[3.7556]	[3.9765]
$\Delta(n^{old} - n^{wrk})_{-1}$	5.9597	7.4681	6.4423
	[4.6045]	[5.0327]	[5.1481]
constant	-8.6089***	-9.9574***	-9.2693***
	[1.9517]	[2.2134]	[2.2270]

Standard errors in brackets
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

PMG Estimates of Long Run and Short Run: Real Models, 17 Countries

	(1) 1973-2015	(2) 1974-2015	(3) 1975-2015
Long-run relation			
$\log(Y/pop^{wrk})_{-1}$	1.0487***	1.0381***	0.9825***
	[0.0977]	[0.0917]	[0.0806]
r_{-1}	-1.7017***	-1.3020***	-1.2636***
	[0.3940]	[0.3520]	[0.2998]
$\log pop^{total}_{-1}$	2.7473***	2.8789***	3.2393***
	[0.3045]	[0.2687]	[0.2862]
$n^{yng}_{-1} - n^{wrk}_{-1}$	4.9127***	5.4630***	6.2617***
	[0.5872]	[0.5406]	[0.4340]
$n^{old}_{-1} - n^{wrk}_{-1}$	-2.7678***	-3.6290***	-4.7135***
	[0.7652]	[0.6754]	[0.5367]
N	731	714	697
ll	1413.69	1403.91	1402.84

Standard errors in brackets
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	1973-2015	1974-2015	1975-2015
Short-run adjustment			
error-correction term$_{-1}$	-0.2276***	-0.2529***	-0.2577***
	[0.0572]	[0.0581]	[0.0631]
$\Delta \log realP^{rppi}_{-1}$	0.4987***	0.4703***	0.4612***
	[0.0668]	[0.0660]	[0.0624]
$\log(Y/pop^{wrk})^{gap}$	0.5992***	0.5362**	0.6059***
	[0.2310]	[0.2485]	[0.2279]
r^{gap}	0.6570***	0.6258***	0.5718**
	[0.2153]	[0.2115]	[0.2622]
$\Delta \log pop^{total}$	13.7890*	17.1636**	17.7216**
	[7.1102]	[6.7906]	[7.5650]
$\Delta \log pop^{total}_{-1}$	-7.1566	-9.7351*	-10.0908*
	[5.2126]	[4.9824]	[5.5447]
$\Delta(n^{yng} - n^{wrk})$	0.9786	1.2187	-0.4231
	[2.9889]	[3.2043]	[3.0770]
$\Delta(n^{yng} - n^{wrk})_{-1}$	-5.8289*	-7.1970*	-6.4518
	[3.4944]	[3.8368]	[4.0698]
$\Delta(n^{old} - n^{wrk})$	0.8340	1.6175	2.4921
	[3.4753]	[3.1820]	[3.5127]
$\Delta(n^{old} - n^{wrk})_{-1}$	1.5507	2.6746	3.0097
	[3.6302]	[3.7572]	[4.0420]
constant	-9.9244***	-11.4564***	-12.3064***
	[2.4397]	[2.5281]	[2.8899]

Standard errors in brackets
$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Findings about the Short-Short Run Adjustment I

- Short-run property price adjustment is "bumpy" or "hump-shaped".
  - The PMG estimate of the property price adjustment shows that a shock will overshoot prices initially and then the change is reversed.
  - A typical autoregressive part (as in the nominal RPPI 1973-2015 case) is $y_{jt} = 1.161 y_{j,t-1} - 0.428 y_{j,t-2} + \cdots$ (see the next "footnote" slide)
- Cyclical factors influence property prices significantly. .
  - In the upturn, both long-run fundamentals and short-run cyclical factors push property prices higher, and *vice versa*.
  - The effects of Real-GDP-per-working-age-population GAP is most visible, and its magnitude is close to the long-run effects.
  - A monetary policy cycle factor (nominal interest rate gap) has similar effects in reverse, though not as much as real GDPpwkap.

A footnote to the previous slide: Derivation

$$\begin{aligned}
\Delta y_t &= 0.4285\Delta y_{t-1} - 0.2671(y_{t-1} - \cdots) \\
y_t - y_{t-1} &= 0.4285(y_{t-1} - y_{t-2}) - 0.2671(y_{t-1} - \cdots) \\
y_t &= (1 + 0.4285 - 0.2671)y_{t-1} - 0.4285 y_{t-2} - \cdots \\
&= 1.161 y_{t-1} - 0.4285 y_{t-2} - \cdots
\end{aligned}$$

Findings about the Short-Short Run Adjustment II

- Contrastive effects between nominal interest GAP and real interest GAP.
    - Although real interest hikes reduce real RPPI in the long run,
    - a widening real interest GAP raises property prices.
    - One explanation is that real interest rates in the long run relation is the cost of funds (supply side), while real interest GAP in the short run indicates a higher demand for properties (demand side).

Conclusion

Summing Up

- Property prices of diverse economies during past 44 years
- Time series properties of variables in question are scrutinized and used to construct and estimate appropriate models
- Major findings of this paper are
  1. Demographic composition has significant impacts on residential property prices.
  2. The young dependency ratio $n^{yng} - n^{wrk}$ has strong positive effects on Residential Property Prices RPPI
  3. The old dependency ratio $n^{old} - n^{wrk}$ has strong negative effects on Residential Property Prices RPPI
  4. The present value relation has a very high explanatory power (very high R^2) for long-run residential property prices RPPI.

Summing Up - Continued

- Major findings of this paper - Continued
  1. When demographic bonus (young's dominance) is coupled with easy credit, RPPI are substantially higher than otherwise.
  2. The opposite is the case in a demographic onus (aging) phase, though to a lesser extent.
  3. In the short-run movement of RPPI, a sizable effect of cyclical factors is found, in addition to the effect of the change in long run fundamentals.
  4. Short-run movement of RPPI is "bumpy" or hump-shaped in the sense that a shock is first amplified then dampened.
  5. However, short-run RPPI dynamics differ considerably among countries. The next two slides show the heterogeneity in RPPI's short-run response to shocks.

- Heterogeneity of Price Adjustment:
  Nominal Residential Property Price Index (RPPI)

  - Three sample periods are displayed.
  - The first two columns are the coefficients of the error correction estimations:

    Dlnrrpi(-1) $= \Delta \log P^{rrpi}_{-1}$, ECT(-1) $=$ error correction term with one lag.
  - The third and fourth columns are the coefficients of the autoregressive parts: $y_t = \log P^{rppi}_t$

	1973-2015				1974-2015				1975-2015			
	Dlnrppi(-1)	ECT(-1)	y_{t-1}	y_{y-2}	Dlnrppi(-1)	ECT(-1)	y_{t-1}	y_{y-2}	Dlnrppi(-1)	ECT(-1)	y_{t-1}	y_{y-2}
AU	0.576	-0.508	1.068	-0.576	0.546	-0.441	1.105	-0.546	0.507	-0.444	1.062	-0.507
BE	0.529	-0.262	1.267	-0.529	0.510	-0.259	1.250	-0.510	0.466	-0.332	1.133	-0.466
CA	0.129	-0.214	0.915	-0.129	0.082	-0.241	0.841	-0.082	0.090	-0.161	0.929	-0.090
CH	0.560	0.043	1.603	-0.560	0.403	0.079	1.482	-0.403	0.408	0.078	1.485	-0.408
DE	0.571	-0.012	1.559	-0.571	0.572	-0.021	1.550	-0.572	0.571	-0.011	1.560	-0.571
DK	0.145	-0.980	0.165	-0.145	0.095	-1.015	0.080	-0.095	0.155	-1.059	0.096	-0.155
FR	0.784	-0.070	1.714	-0.784	0.743	-0.051	1.692	-0.743	0.550	-0.088	1.462	-0.550
GB	0.068	-0.134	0.934	-0.068	0.002	-0.113	0.890	-0.002	0.050	-0.121	0.929	-0.050
IE	0.422	-0.603	0.819	-0.422	0.459	-0.535	0.923	-0.459	0.525	-0.599	0.926	-0.525
IT	0.393	-0.218	1.175	-0.393	0.360	-0.325	1.035	-0.360	0.348	-0.131	1.217	-0.348
JP	0.554	-0.203	1.351	-0.554	0.215	-0.262	0.952	-0.215	0.205	-0.269	0.936	-0.205
NL	0.363	-0.243	1.120	-0.363	0.193	-0.257	0.936	-0.193	0.197	-0.266	0.930	-0.197
NO	0.276	-0.406	0.870	-0.276	0.276	-0.418	0.859	-0.276	0.267	-0.451	0.817	-0.267
NZ	0.225	-0.291	0.934	-0.225	0.220	-0.370	0.850	-0.220	0.249	-0.393	0.857	-0.249
SE	0.437	-0.312	1.125	-0.437	0.436	-0.304	1.133	-0.436	0.408	-0.228	1.180	-0.408
US	0.874	-0.001	1.873	-0.874	0.905	0.003	1.908	-0.905	0.866	-0.002	1.863	-0.866
ZA	0.379	-0.129	1.250	-0.379	0.442	-0.105	1.336	-0.442	0.423	-0.090	1.333	-0.423

- Countries and sample periods with overshooting (coeff of $y_{t-1} > 1$) where both Dlnrrpi(-1) and ECT(-1) are statistically significant (p<0.05): AU (73-, 74-, 75-); BE (73-, 74-, 75-); CH (74-, 75-); FR (75-); IT (73-, 74-); JP (73-, 74-): NL (73-); SE (73-, 74-, 75-); ZA (73-, 74-, 75-).

- Heterogeneity of Price Adjustment:
  Real Residential Property Price Index (RPPI)
  - Three sample periods are displayed
  - The first two columns are the coefficients of the error correction estimations:

    Dlrrrpi(-1) $= \Delta \log realP^{rrpi}_{-1}$, ECT(-1) = error correction term with one lag.
  - The third and fourth columns are the coefficients of the autoregressive parts: $y_t = \log realP^{rppi}_t$

	1973-2015				1974-2015				1975-2015			
	Dlrrppi(-1)	ECT(-1)	y_{t-1}	y_{y-2}	Dlrrppi(-1)	ECT(-1)	y_{t-1}	y_{y-2}	Dlrrppi(-1)	ECT(-1)	y_{t-1}	y_{y-2}
AU	0.416	-0.325	1.091	-0.416	0.424	-0.345	1.080	-0.424	0.386	-0.363	1.024	-0.386
BE	0.777	-0.279	1.498	-0.777	0.755	-0.276	1.479	-0.755	0.745	-0.260	1.486	-0.745
CA	-0.063	-0.252	0.685	0.063	-0.060	-0.302	0.638	0.060	-0.058	-0.271	0.671	0.058
CH	0.787	-0.027	1.760	-0.787	0.728	-0.028	1.700	-0.728	0.753	-0.027	1.725	-0.753
DE	0.416	-0.056	1.359	-0.416	0.424	-0.068	1.356	-0.424	0.442	-0.086	1.357	-0.442
DK	0.131	-0.999	0.132	-0.131	0.094	-1.041	0.053	-0.094	0.112	-1.099	0.013	-0.112
FR	0.801	-0.123	1.678	-0.801	0.823	-0.113	1.710	-0.823	0.634	-0.115	1.519	-0.634
GB	0.276	-0.146	1.131	-0.276	0.262	-0.133	1.129	-0.262	0.544	-0.121	1.424	-0.544
IE	0.737	-0.279	1.458	-0.737	0.734	-0.327	1.407	-0.734	0.723	-0.448	1.275	-0.723
IT	0.311	-0.059	1.252	-0.311	0.304	-0.073	1.231	-0.304	0.317	0.013	1.331	-0.317
JP	0.757	-0.005	1.753	-0.757	0.414	-0.179	1.235	-0.414	0.262	-0.220	1.042	-0.262
NL	0.675	-0.326	1.349	-0.675	0.637	-0.336	1.301	-0.637	0.591	-0.372	1.218	-0.591
NO	0.333	-0.321	1.013	-0.333	0.341	-0.329	1.012	-0.341	0.331	-0.294	1.037	-0.331
NZ	0.213	-0.291	0.922	-0.213	0.160	-0.347	0.813	-0.160	0.158	-0.300	0.858	-0.158
SE	0.558	-0.327	1.231	-0.558	0.557	-0.331	1.227	-0.557	0.533	-0.361	1.172	-0.533
US	0.879	-0.042	1.837	-0.879	0.911	-0.040	1.871	-0.911	0.909	-0.038	1.872	-0.909
ZA	0.473	-0.012	1.461	-0.473	0.485	-0.031	1.454	-0.485	0.458	-0.021	1.437	-0.458

- Countries and sample periods with overshooting (coeff of $y_{t-1} > 1$) where both Dlrrrpi(-1) and ECT(-1) are statistically significant ($p<0.05$): AU (73-, 74-, 75-); BE (73-, 74-, 75-); DE (73-, 74-, 75-); FR (73-,74-, 75-); IE (73-, 74-, 75-); JP (74-, 75-): NL (73-, 74-, 75-); NO (73-, 74-, 75-); SE(73-, 74-, 75-).

Thank You for Your Kind Attention.

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GAP z_{jt} and Differences Δx_{jt} and $\Delta x_{j,t-1}$

Appendix

- We have used the following linear approximations in the texts.
    - $z_{jt} = \mu_j + \omega_j \Delta x_{jt} + \varepsilon_{jt}$
    - $z_{jt} = \mu_j^* + \omega_j^* \Delta x_{j,t-1} + \varepsilon_{j,t-1}^*$
- In this appendix, we present these approximations for each of 17 countries in the balanced panel, and for each of three macro variables.

GAP z_{jt} and Concurrent Difference Δx_{jt}

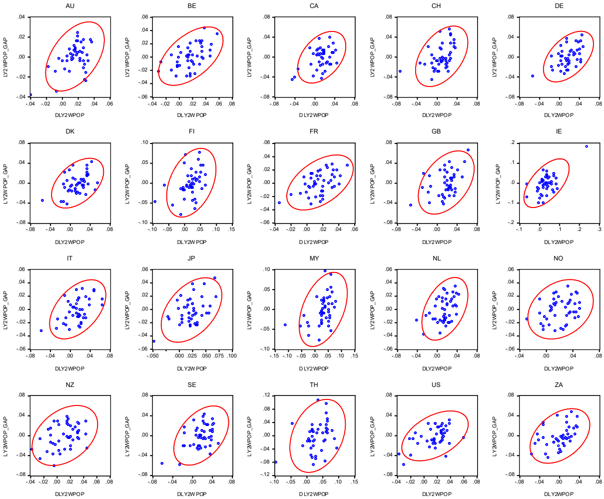
- Table: Individual Country's ω_j

	ly2wpop	nint	rint
AU	0.449 ***	0.414 ***	0.450 ***
BE	0.489 ***	0.489 ***	0.489 ***
CA	0.455 ***	0.455 ***	0.455 ***
CH	0.530 ***	0.530 ***	0.530 ***
DE	0.509 ***	0.509 ***	0.509 ***
DK	0.444 ***	0.444 ***	0.444 ***
FI	0.437 ***	0.437 ***	0.437 ***
FR	0.496 ***	0.496 ***	0.496 ***
GB	0.491 ***	0.491 ***	0.491 ***
IE	0.644 ***	0.644 ***	0.644 ***
IT	0.383 ***	0.383 ***	0.383 ***
JP	0.388 ***	0.388 ***	0.388 ***
MY	0.453 ***	0.453 ***	0.453 ***
NL	0.445 ***	0.445 ***	0.445 ***
NO	0.258 *	0.258 ***	0.258 ***
NZ	0.453 **	0.453 ***	0.453 ***
SE	0.486 ***	0.486 ***	0.486 ***
TH	0.408 **	0.408 ***	0.408 ***
US	0.469 ***	0.469 ***	0.469 ***
ZA	0.369 ***	0.369 ***	0.369 ***

***/**/* indicate the estimates are significant at 1%/5%/10% levels.

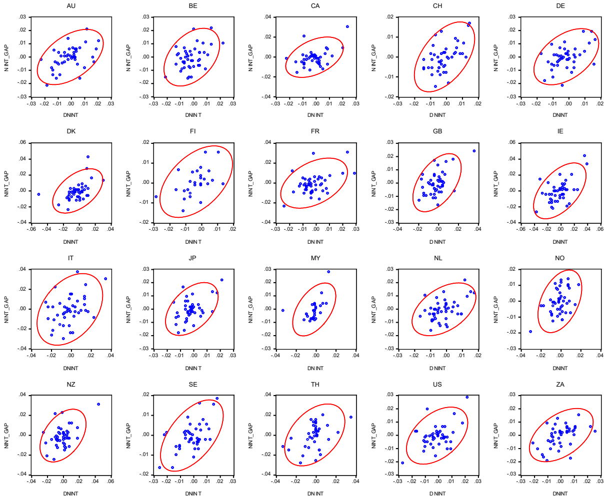
GAP z_{jt} and Concurrent Difference Δx_{jt}

- Scattered Diagram: Real GDP per Working-Age Population



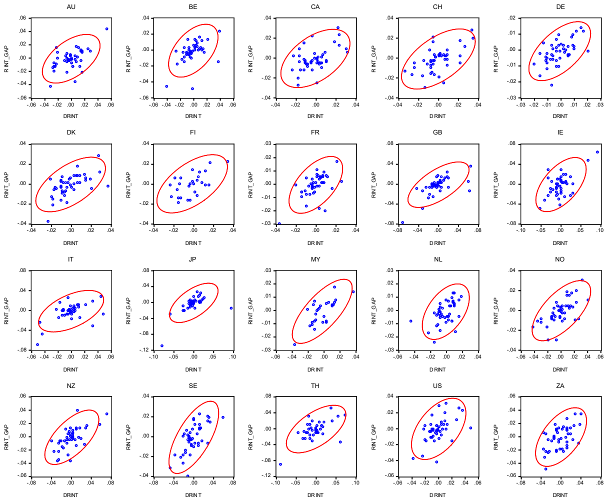
GAP z_{jt} and Concurrent Difference Δx_{jt}

- Scattered Diagram: Nominal Interest Rates



GAP z_{jt} and Concurrent Difference Δx_{jt}

- Scattered Diagram: Static Expectation Real Interest Rates



GAP z_{jt} and Lagged Difference $\Delta x_{j,t-1}$

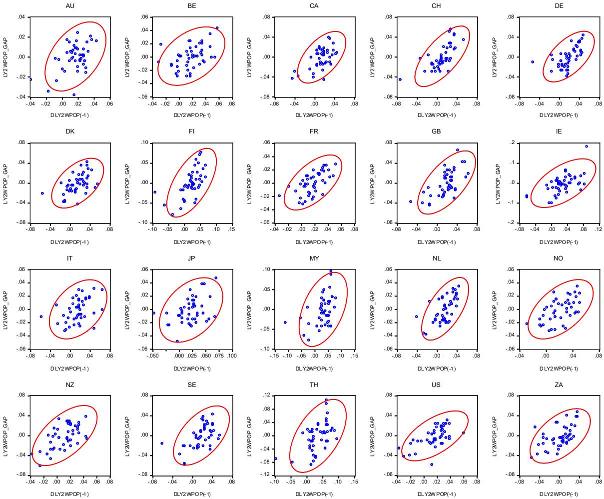
- Table: Individual Country's ω_j^*

	ly2wpop	nint	rint
AU	0.428 ***	0.482 ***	0.259 **
BE	0.489 ***	0.489 ***	0.489 **
CA	0.455 ***	0.455 ***	0.455 **
CH	0.530 ***	0.530 ***	0.530
DE	0.509 ***	0.509 ***	0.509 ***
DK	0.444 ***	0.444 **	0.444
FI	0.437 ***	0.437	0.437
FR	0.496 ***	0.496 ***	0.496 **
GB	0.491 ***	0.491 ***	0.491
IE	0.644 ***	0.644 ***	0.644 ***
IT	0.383 ***	0.383 ***	0.383 ***
JP	0.388 ***	0.388 ***	0.388 ***
MY	0.453 ***	0.453 ***	0.453
NL	0.445 ***	0.445 ***	0.445 *
NO	0.258 ***	0.258 ***	0.258
NZ	0.453 ***	0.453 ***	0.453 ***
SE	0.486 ***	0.486 *	0.486
TH	0.408 ***	0.408 ***	0.408
US	0.469 ***	0.469 ***	0.469 ***
ZA	0.369 ***	0.369 ***	0.369 ***

***/**/* indicate the estimates are significant at 1%/5%/10% levels.

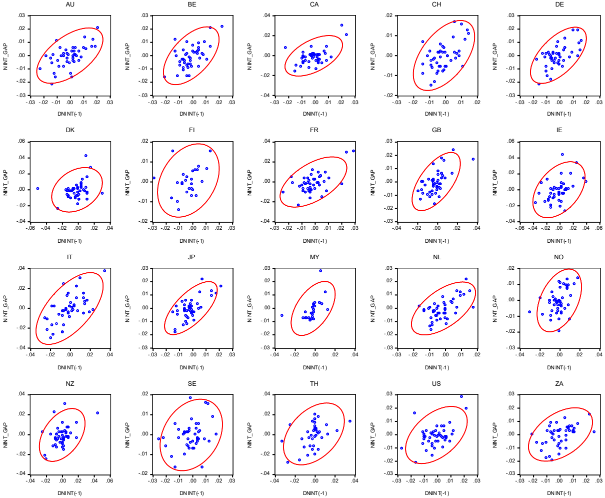
GAP z_{jt} and Lagged Difference $\Delta x_{j,t-1}$

- Scattered Diagram: Real GDP per Working-Age Population



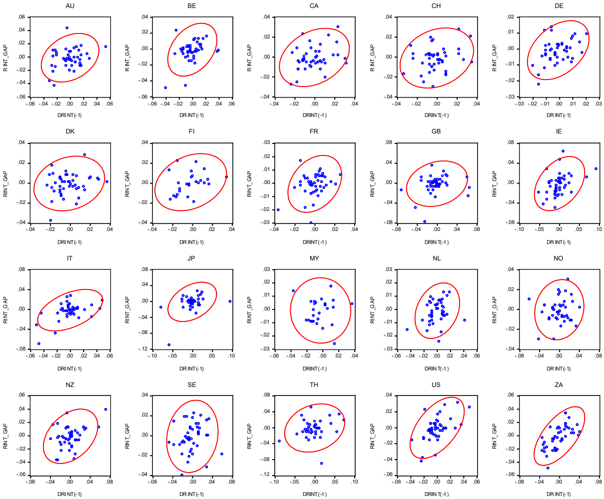
GAP z_{jt} and Lagged Difference $\Delta x_{j,t-1}$

- Scattered Diagram: Nominal Interest Rates



GAP z_{jt} and Lagged Difference $\Delta x_{j,t-1}$

- Scattered Diagram: Static Expectation Real Interest Rates



DATA

- Nominal interest rates (IFS): Description.

AU: Yield on 15-year treasury bonds. Beginning in July 1969, assessed secondary market yield on 10-year non-rebate bonds. Yield is calculated before brokerage and on the last business day of the month.
BE: Yield on 10-year government bonds. Beginning September 1963, refers to yield on government bonds of more than 5 years. Beginning January 1980, refers to secondary market yields of government bonds with a 10-year maturity. This rate is used to measure long-term interest rates for assessing convergence among the European Union member states.
CA : Average yield to maturity. Long-term series refers to issues with original maturity of 10 years and over.
CH: Beginning in January 1998, data refer to spot interest rate on government bonds with 10-year maturity. Prior to that data, data cover government bonds with maturity of up to 20 years.
DE: Bonds issued by the Federal government, the railways, the postal system, the Lander governments, municipalities, specific purpose public associations, and other public associations established under special legislation. Average yields on all bonds with remaining maturity of more than 3 years, weighted by amount of individual bonds in circulation. For additional information, refer to the section on interest rate in the introduction to IFS and the notes on the euro area page. Beginning January 1980, refers to yields on listed federal securities which can be delivered on the German Financial Futures and Options Exchange (DTB) with a remaining maturities of nine- to- ten years. This rate is used measure long-term interest rates for assessing convergence among the European Union member states.
DK: Yield on five-year government bonds. Beginning June 1983, refers to secondary market yields of government bonds with a ten-year maturity. This rate is used to measure long-term interest rates for assessing convergence among the European Union member states.
FR: Average yield to maturity on public sector bonds with original maturities of more than five years. Monthly yields are based on weighted average of weekly data. For additional information, refer to the introduction to IFS and the notes on the euro area page. Beginning January 1980, refers to secondary market yields of government bonds with a ten-year maturity. This rate is used to measure long-term interest rates for assessing convergence among the European Union member states.
GB: Bank of England. These are theoretical gross redemption bond yields. Beginning June 1976, the calculations are based on a method described by Bank of England, June 1976. Long-Term: Issue at par with 20 years to maturity.

- Nominal interest rates (IFS):Description - continued.

IE: Representative yield on government securities with 15-year maturities. For additional information, refer to the section on interest rates in the introductions to IFS and the notes on the euro area page. Beginning August 1988, refers to secondary market is used to measure long-term interest rates for assessing convergence among the European Union member states.
IT: Average yields to maturity on bonds with original maturities of 15 to 20 years, issued on behalf of the Treasury by the Consortium of Credit for Public Works. Beginning January 1980, average yields to maturity on bonds with residual maturities between 9 and 10 years. From January 1999 onward, monthly data are arithmetic averages of daily gross yields to maturity of the fixed-coupon ten-year treasury benchmark bond (last issued bond beginning from the date when it becomes the most traded issue among government securities with residual maturities between nine and ten years), based on prices in the official wholesale market. This rate is used to measure long-term interest rates for assessing convergence among the European Union member states.
JP: Arithmetic average yield on newly issued government bonds with ten-year maturity.
NL: The data refer to secondary market yields of the most recent 10-year government bond. For additional information, refer to the section on interest rate in the introduction to IFS and on the euro area page. This rate is used to measure long-term interest rates for assessing convergence among the European Union member states.
NO: Yields to maturity on five-year government bonds.
NZ: Yields on government bonds. Beginning in January 1987, rate on the five-year 'benchmark' bond, a specific bond selected by the Reserve Bank to provide a representative five-year government bond rate.
SE: Data refer to yields on government bonds maturing in 15 years. Beginning January 1987, data refer to secondary market yields on bonds maturing in 10 years. This rate is used to measure long-term interest rates for assessing convergence among the European Union member states.
US: Yield on actively traded treasury issues adjusted to constant maturities. Yields on treasury securities at constant maturity are interpolated by the U.S. Treasury from the daily yield curve. This curve, which relates the yield on a security to its time to maturity, is based on the closing market bid yields on actively traded treasury securities in the over-the-counter market. These market yields are calculated from composites of quotations obtained by the Federal Reserve Bank of New York. Long-term rate refers to ten-year constant maturities.
ZA: Yield on bonds with maturities of ten years and longer traded on the bond exchange.

- Nominal Residential Property Prices (BIS): Description.

AU: From 2003 Q3 onwards: residential property prices, all dwellings (eight cities), pure price, NSA 1986 Q3-2003 Q2: residential property prices, all detached houses (eight cities), pure price, NSA 1970 Q1-1986 Q2: median dwelling prices, state capital Source: Australian Bureau of Statistics Real Estate Institute of Australia
BE: From 2005 Q1 onwards: residential property prices, all dwellings, pure price, NSA 1973 Q1-2004 Q4: residential property prices, existing dwellings, per dwelling, NSA 1970 Q1-1972 Q4: index of small- and medium-sized dwellings Source: STATBEL Stadim Guide de valeurs immobilieres
CA: From 2005 Q1onwards MLS ® Home Price Index 1980 Q1-2004 Q4: national residential average price, NSA. 1970 Q1-1979 Q4: average price of existing homes Source: CREA: The Canadian Real Estate Association Multiple Listing Service
CH: From 1970 Q1onwards: unweighted average of owner occupied flats and houses nationwide Source: Wuest und Partner
DE: From 2006 Q1 onwards: residential property prices, all owner occupied dwellings, pure price, NSA; 1995 Q1-2005 Q4: terraced houses and owner-occupied apartments in 125 cities; 1990 Q1-1994 Q4: terraced houses and owner-occupied apartments in 100 towns in western Germany, including West Berlin; 1975 Q1-1989 Q4: new terraced houses and owner-occupied apartments in 50 towns in western Germany, including West-Berlin 1970 Q1-1974 Q4: construction prices of new residential buildings for western Germany. Source: BIS calculation based on Deutsche Bundesbank data
DK: From 2002 Q1 onwards: all types of dwellings nationwide 1970 Q1-2001 Q4: residential property prices, single-family houses, pure price, NSA Source: Statistics Denmark
ES: From 2007 Q1 onwards: residential property prices, all dwellings, pure price, NSA 1987 Q1-2006 Q4: residential property prices, all dwellings, per m2, NSA 1975 Q1-1986 Q4: house prices in the capital city Madrid area 1971 Q1-1974 Q4: OECD historical statistics Source: Instituto Nacional de Estadistica Ministerio de Fomento Bank of Spain Banco Hipotecario OECD
FR: From 2006 Q2 onwards: residential property prices, all dwellings, pure price, Q-All, NSA 1996 Q1-2006 Q1:residential property prices, existing dwellings, pure price, Q-All, NSA 1970 Q1-1995 Q4: J Friggit, "Produits derives, un sous-jacent immobilier", Ministere de l'Equipement, February 1999 Source: INSEE
GB: From 2005 Q1onwards: residential property prices, all dwellings (ONS), per dwelling, NSA 1968 Q2-2004 Q4: residential property prices, all dwellings (ONS), per dwelling, NSA (historical data) Source: Office for National Statistics

HK: From 1979 Q4 onwards: residential property prices, all dwellings, pure price, NSA Source: Hong Kong Monetary Authority

- Nominal Residential Property Prices (BIS): Description - Continued.

IE: From 2005 Q1 onwards: residential property prices, all dwellings, pure price,NSA 1970 Q1-2004 Q4: price index, new houses Source: Central Statistics Office Department of Environment, Community and Local Government
IT: From 1990 Q1onwards: residential property prices, all dwellings, pure price, NSA 1971 Q1-1989 Q4: Bank of Italy historical residential property price index 1929 Q1-1970 Q4: Bank of Italy Occasional Paper Source: Bank of Italy BIS calculation based on Bank of Italy Occasional Paper: I prezzi delle abitazioni in Italia, 1927-2012
JP: From 2008 Q2 onwards: residential property prices, all dwellings, pure price, NSA 1955 Q1-2008 Q1:land prices, residential, urban areas, per m2, NSA Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan Real Estate Institute
KR: From 1986 Q1 onwards: residential property prices, all dwellings, pure price, NSA; 1975 Q1-1985 Q4: land prices (residential and non-residential) Source: Bank of Korea, Korea Appraisal Board
NL: From 2005 Q1 onwards: residential property prices, all dwellings, pure price 1995 Q1-2004 Q4: residential property prices, all existing dwellings, pure price, NSA From 1976 Q1-1995 Q4: existing dwellings. 1970 Q1-1975 Q4: sales of houses and flats brokered by real estate agents Source: Statistics Netherlands Nederlandse Vereniging van Makelaars
NO: From 1992 Q1 onwards: residential property prices, all (only existing from 2012) dwellings, pure price, NSA 1970 Q1-1991 Q4: house prices, from Eitrheim and Erlandsen, "House price indices for Norway, 1819-2003", pp 349-76, 2004. Source: Statistics Norway Central Bank of Norway
NZ: From 1979 Q4 onwards: residential property prices, all dwellings, per dwelling, NSA 1970 Q1-1979 Q3: quarterly house price index - main urban areas; Quotable Value Limited, New Zealand Limited Source: Quotable Value Limited, New Zealand
SE: From 2005 Q1 onwards: all types of dwellings nationwide 1986 Q1-2004 Q4: residential property prices, all owner-occupied houses, per dwelling, NSA 1970 Q1-1985 Q4: index of owner-occupied one- and two-dwelling buildings Source: Statistics Sweden
US: From 1975 Q4 onwards: residential property prices, existing dwellings, per dwelling, SA 1970 Q1-1975 Q3: average sale price of existing single-family homes Source: Federal Reserve, based on CoreLogic data National Association of Realtors

ZA: 1966 Q1-2000 Q4: Residential property prices, all middle segment dwelling, per dwellings From 2001 Q1:

Residential property prices all dwellings Source: ABSA GROUP, First National Bank