Demographics and Real Interest Rates Across Countries and Over Time*

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AEA Session on The Secular Decline in Real Interest Rates

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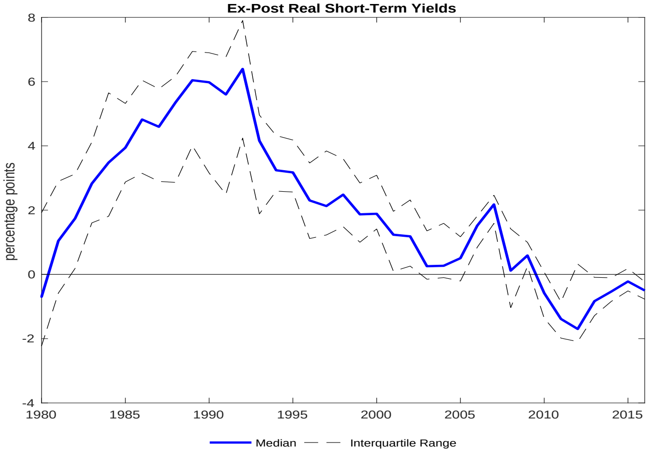
* *The views expressed in this paper do not necessarily reflect the position of the Central Bank of Brazil.*

Three Observations on Global Real Interest Rates



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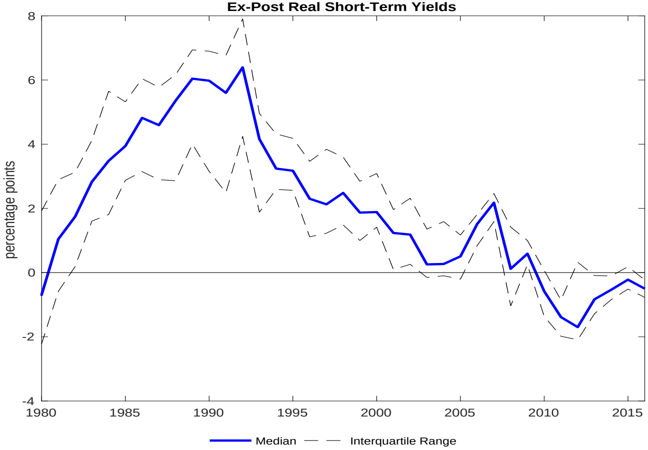

1. At very low levels (negative in many countries): Median in 2016 = -0.5%

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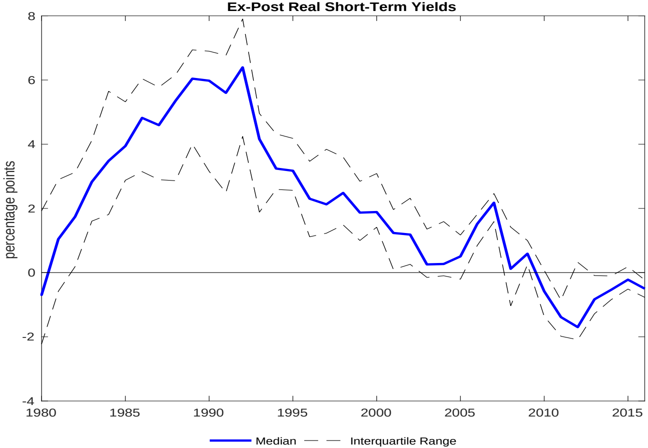

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2. Declining for almost three decades: Median above 6% in 1989

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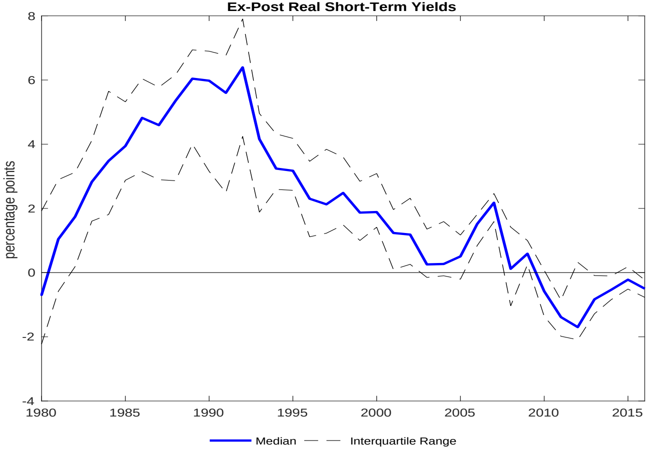

1. At very low levels (negative in many countries): Median in 2016 = -0.5%
2. Declining for almost three decades: Median above 6% in 1989
3. Decreasing dispersion across countries: IQR from 4.27 in 1991 to 0.54 in 2016

Are Low Real Rates Here to Stay?

Nominal Yields in % as of 29 April 2019

	US	UK	EMU	JP
2 year	2.30	0.74	-0.14	-0.60
5 year	2.30	0.87	-0.16	-0.43
10 year	2.52	1.16	-0.04	0.00

- Current expected medium/long-term real rates close to zero or negative
    - Assumption: Inflation on target over medium term (2-3 years out)

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- Current expected medium/long-term real rates close to zero or negative
  - Assumption: Inflation on target over medium term (2-3 years out)
- Low real rates present challenges and possible opportunities for policy
  - To the extent that they reflect low "natural" rates, constraint on monetary policy
  - Implications for fiscal policy and public finance

Why Are Real Interest Rates So Low?

- Various "structural" explanations

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- Demographic trends (Carvalho, Ferrero and Nechio, 2016)
  - Decline in growth rate of labor force and increase in life expectancy
  - Determine consumption-savings patterns and equilibrium real interest rate

Why Are Real Interest Rates So Low?

- Various "structural" explanations
- Demographic trends (Carvalho, Ferrero and Nechio, 2016)
  - Decline in growth rate of labor force and increase in life expectancy
  - Determine consumption-savings patterns and equilibrium real interest rate
- "Raising the bar"
  - If demographics indeed important factor, should expect patterns across countries and over time to accord with demographics
- Assessment complicated by:
  - Other determinants of real rates
  - With (some) capital mobility, a country's real rate should depend on own and global demographics

Our paper

- Two contributions
  - Structural model: Relevant channels in open-economy life-cycle model with imperfect capital mobility
  - Empirics: Panel error-correction models, with guidance from structural model

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  - Demographics can generate significant decline of real interest rates
  - The more financially integrated a country is and the smaller its size:
    - ★ The higher the sensitivity of its real interest rate to global developments
    - ★ The less its own real rate determinants matter
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- Empirics:
  - Evidence of importance of demographics – life expectancy, in particular
  - Financial integration correlated with decline of cross-country dispersion

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- Empirics:
  - Evidence of importance of demographics – life expectancy, in particular
  - Financial integration correlated with decline of cross-country dispersion
- Implication: Low real rates may be here to stay

Related Literature

- Quantitative models of demographics and real interest rates
  - Krueger and Ludwig (2006), Ikeda and Saito (2014), Gagnon, Johansen and Lopez-Salido (2016), Kara and Von Thadden (2016), Eggertsson, Merhotra and Robbins (2017), Sudo and Takizuka (2018), ...
- Empirical analysis of real interest rates dynamics
  - Hamilton, Harris, Hatzius and West (2016), Lunsford and West (2017), Rachel and Smith (2015), Favero, Gozluklu and Yang (2016), Yi and Zhang (2016), Fiorentini, Galesi, Perez-Quirós and Sentana (2018), Borio, Disyatat, Juselius and Rungcharoenkitkul (2017), ...
- Other determinants of low real interest rates
  - Caballero, Farhi and Gourinchas (2008), Lo and Rogoff (2015), Caballero and Farhi (2017), Del Negro, Giannone, Giannoni and Tambalotti (2017, 2018), ...

Outline

- Introduction
- **Open economy life-cycle model**
  - Analytical framework
  - Demographics and financial integration
  - Other determinants of real interest rates
- Empirical analysis
  - Data description
  - Panel ECM regressions
  - Dispersion and projections

Model Overview

- Two countries
  - Large and old: Global economy
  - Small and young economy
- In each country, continuum of workers and retirees
  - Face idiosyncratic risk of retirement (for workers) and death (for retirees)
  - Consume one good and can save via three instruments
    - Capital, government bonds, claims on foreign assets
- Standard supply side (labor-augmenting productivity)
- Government funds spending and transfers with taxes and debt
- Friction: Portfolio holding costs

Demographics

- Simple life-cycle structure (Gertler, 1999)
  - Each period, $1 + n_{it} - \omega$ new workers are born in country i
  - Remain in labor force with probability ω, retire otherwise
  - Once retired, survive with probability γ_{it}

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- Growth rate of labor force

$$N_{it}^{w} = (1 + n_{it})N_{it-1}^{w}$$

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- Growth rate of labor force

$$N^w_{it} = (1 + n_{it}) N^w_{it-1}$$

- Dependency ratio

$$\psi_{it} \equiv \frac{N^r_{it}}{N^w_{it}} = \frac{(1-\omega) + \gamma_{it}\psi_{it-1}}{1 + n_{it}}$$

Retirees' Problem

- Retirees turn their wealth to mutual fund at beginning of each period
  - Mutual fund insures survivors against probability of death (Yaari, 1965)

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$$V_{it}^{r} = \max_{C_{it}^{r}, A_{iit}^{r}, A_{ijt}^{r}} \left[(C_{it}^{r})^{\frac{\sigma-1}{\sigma}} + \beta_i \gamma_{it+1} (V_{it+1}^{r})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

subject to

$$C_{it}^{r} + \left[1 + \frac{\Lambda_{ij}}{2} (\eta_{ijt}^{r} - \overline{\eta}_{ij})^2 \right] A_{it}^{r} = \frac{1}{\gamma_{it}} (R_{it-1} A_{iit-1}^{r} + R_{jt-1} A_{ijt-1}^{r}) + E_{it}^{r}$$

with $j \neq i$ and where

$$\eta_{ijt}^{r} \equiv \frac{A_{ijt}^{r}}{A_{iit}^{r} + A_{ijt}^{r}} = \frac{A_{ijt}^{r}}{A_{it}^{r}}$$

Retirees' Decision Rules

Workers' Problem

- Workers start their life with no assets
- No insurance available against probability of retirement (permanent disability)
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$$V_{it}^{w} = \max_{C_{it}^{w}, A_{iit}^{w}, A_{ijt}^{w}} \left\{ \left(C_{it}^{w} \right)^{\frac{\sigma-1}{\sigma}} + \beta_i \left[\omega V_{it+1}^{w} + (1-\omega) V_{it+1}^{r} \right]^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}}$$

subject to

$$C_{it}^{w} + \left[1 + \frac{\Lambda_{ij}}{2} \left(\eta_{ijt}^{w} - \overline{\eta}_{ij} \right)^2 \right] A_{it}^{w} = R_{it-1} A_{iit-1}^{w} + R_{jt-1} A_{ijt-1}^{w} + W_{it}^{w} - T_{it}^{w}$$

Workers' Decision Rules

Portfolio Shares

- Cross-country return differentials only depend on portfolio cost parameters
  - Retirees and workers optimally choose same portfolio shares

$$\eta_{ijt}^{r} = \eta_{ijt}^{w} = \eta_{ijt}$$

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- Let share of asset holdings accruing to retirees be

$$\lambda_{it} \equiv \frac{A_{ijt}^{r}}{A_{ijt}^{w} + A_{ijt}^{r}}$$

  - Sufficient statistic to summarize distribution of wealth over life cycle
  - Because of same η_{ijt} between workers and retirees

Aggregate Consumption

- Marginal propensity to consume independent of individual characteristics
  - Can aggregate within each group (retirees and workers)
    - ⋆ Retirees' consumption

$$C^r_{it} = \xi^r_{it}\left(R_{it-1}A^r_{iit-1} + R_{jt-1}A^r_{ijt-1} + S_{it}\right)$$

    - ⋆ Workers' consumption

$$C^w_{it} = \xi^w_{it}\left(R_{it-1}A^w_{iit-1} + R_{jt-1}A^w_{ijt-1} + H_{it} + Z_{it}\right)$$

where

- ⋆ S_{it} = PDV of pensions for retirees
- ⋆ Z_{it} = PDV of pensions for workers
- ⋆ H_{it} = PDV of wages net of taxes

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- Aggregate consumption

$$C_{it} = \xi^w_{it}\left\{\left[1-\left(1-\frac{\xi^r_{it}}{\xi^w_{it}}\right)\lambda_{it-1}\right]\left(R_{it-1}A_{iit-1} + R_{jt-1}A_{ijt-1}\right) + \frac{\xi^r_{it}}{\xi^w_{it}}S_{it} + H_{it} + Z_{it}\right\}$$

where $C_{it} \equiv C^w_{it} + C^r_{it}$

Distribution of Wealth

- Retirees' assets

$$\left[1+\frac{\Lambda_{ij}}{2}(\eta_{ijt}-\overline{\eta}_{ij})^2\right]A_{it}^r = R_{it-1}A_{iit-1}^r + R_{jt-1}A_{ijt-1}^r + E_{it} - C_{it}^r$$
$$+(1-\omega)\left(R_{it-1}A_{iit-1}^w + R_{jt-1}A_{ijt-1}^w + W_{it}N_{it}^w - T_{it} - C_{it}^w\right)$$

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- Workers' assets

$$\left[1+\frac{\Lambda_{ij}}{2}(\eta_{ijt}-\overline{\eta}_{ij})^2\right]A^w_{it}$$
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- Evolution of wealth distribution

$$[\lambda_{it}-(1-\omega)]\left\{\left[1+\frac{\Lambda_{ij}}{2}(\eta_{ijt}-\overline{\eta}_{ij})^2\right]A_{it}\right\}$$
$$=\omega\left[(1-\xi^r_{it})\lambda_{it-1}(R_{it-1}A_{iit-1}+R_{jt-1}A_{ijt-1})+E_{it}-\xi^r_{it}S_{it}\right]$$

Production

- Perfectly competitive firms produce homogenous consumption good

- Labor-augmenting Cobb-Douglas technology

$$Y_{it} = (X_{it} N_{it}^{w})^{\alpha} K_{it-1}^{1-\alpha},$$

where

$$X_{it} = (1 + x_{it}) X_{it-1}$$

- Law of motion of capital

$$K_{it} = (1 - \delta) K_{it-1} + I_{it}$$

Fiscal Policy

- Flow budget constraint

$$G_{it} + E_{it} + R_{it-1}B_{it-1} = B_{it} + T_{it} + \frac{\Lambda_{ji}}{2}(\eta_{jit} - \bar{\eta}_{ji})^2 A_{jt}$$

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- Assume spending, debt, and pensions are exogenous fraction of GDP

$$G_{it} = g_{it}Y_{it} \qquad E_{it} = e_{it}Y_{it} \qquad B_{it} = b_{it}Y_{it}$$

- Government budget constraint pins down taxes

Balance of Payments

- Domestic assets

$$A_{iit} = K_{it} + B_{it} - A_{jit}$$

Balance of Payments

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- Net foreign assets

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Balance of Payments

- Domestic assets

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- Net foreign assets

$$F_{it} \equiv A_{ijt} - A_{jit}$$

- Evolution of net foreign asset position

$$\begin{aligned} F_{it} = F_{it-1} &+ (R_{jt-1} - 1)A_{ijt-1} - (R_{it-1} - 1)A_{jit-1} \\ &+ \frac{\Lambda_{ji}}{2}(\eta_{jit} - \bar{\eta}_{ji})^2 A_{jt} - \frac{\Lambda_{ij}}{2}(\eta_{ijt} - \bar{\eta}_{ij})^2 A_{it} + NX_{it} \end{aligned} \tag{1}$$

where

$$NX_{it} = Y_{it} - (C_{it} + I_{it} + G_{it})$$

with

$$F_{it} + F_{jt} = 0$$

Calibration

- Two (fictitious) countries:
  - "Old" (global economy): Relatively low population growth rate and high dependency ratio
  - "Young": Relatively high population growth rate and low dependency ratio

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  - "Old" (global economy): Relatively low population growth rate and high dependency ratio
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- Period is one year, individuals born workers at 20

Parameters and Fixed Exogenous Variables

Parameter value	Target	
$\omega = 0.9778$	Average employment duration	$= 45$ years
$\alpha = 0.67$	Labor share	$= 2/3$
$\delta = 0.1$	Depreciation rate	$= 10\%$
$\sigma = 0.5$	Elasticity of intertemporal substitution	
$g = 0.2$	Government spending / GDP	$= 20\%$
$b = 0.4$	Government debt / GDP	$= 40\%$
$x = 0$	Productivity growth	$= 0\%$

Initial Steady State

- Associate two countries with 25^{th} and 75^{th} percentiles of empirical distributions of labor force growth dependency ratios and real rates

Parameter	Old Country	Young Country
n	0.59%	1.13%
ψ	24%	21%
R	3.1%	6.2%

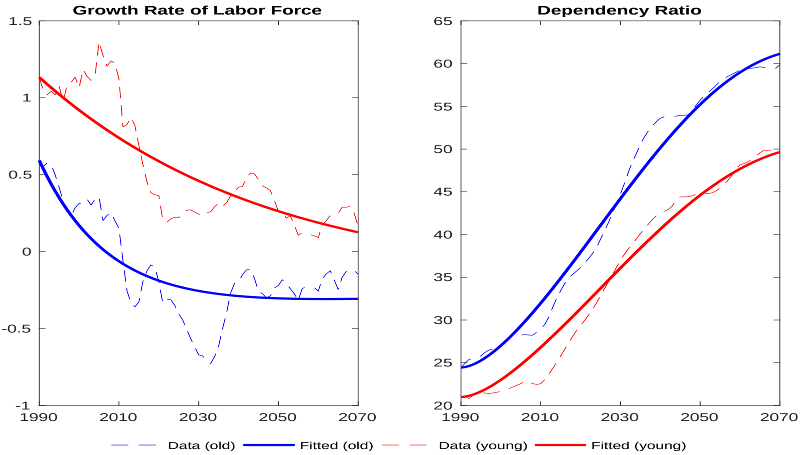
  - Fit smooth n_{it}, n_{jt} paths directly to data
  - Pick smooth paths for γ_{it}, γ_{jt} to fit paths of dependency ratio in the data

$$\psi_i = \frac{1-\omega}{1+n_i-\gamma_i}$$

  - Calibrate $\Lambda_{ij} = \Lambda_{ji} = \Lambda$ to yield an average current account deficit for small economy that matches time-average of 25^{th} percentile of current account-to-GDP ratios in the data
  - Calibrate β_i, β_j to match observed real rates in initial steady state (1990)

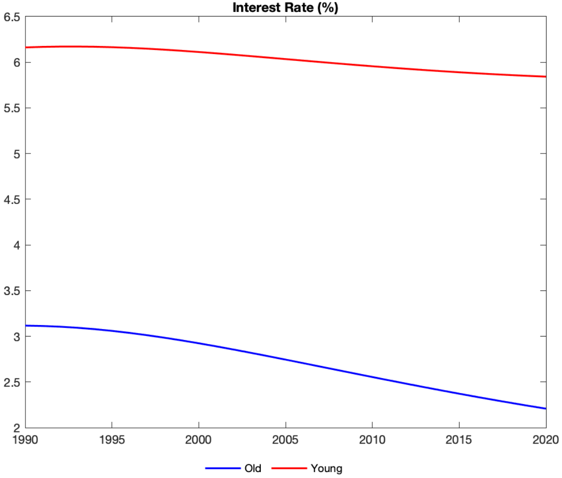
Experiment

- What happens in response to changes in demographic variables?
  - Transition driven by changes in population growth and life expectancy



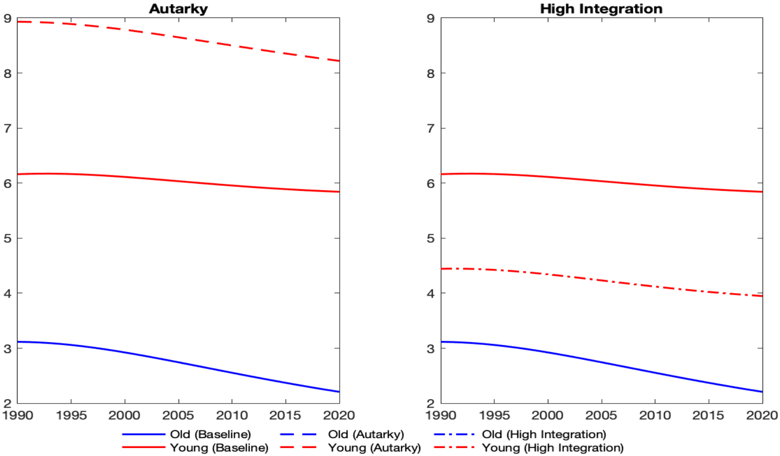
Demographic Trends and Real Interest Rates

- Real rates and financial integration



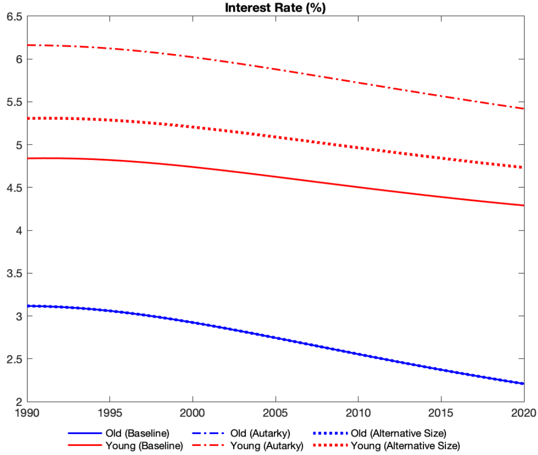
Demographic Trends and Real Interest Rates

- Different degrees of financial integration



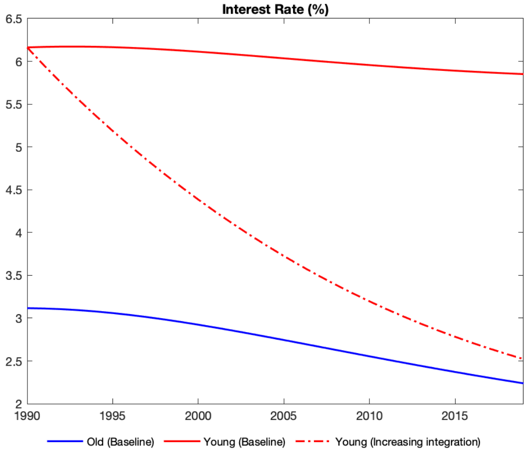
Demographic Trends and Real Interest Rates

- Role of country size



Demographic Trends and Real Interest Rates

- Increasing financial integration over time



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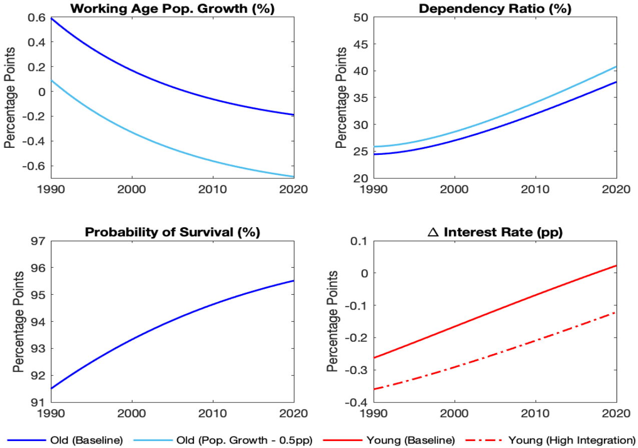
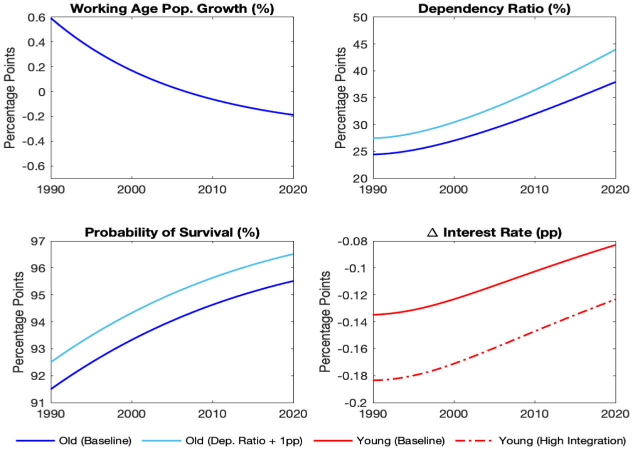


Demographic Trends and Real Interest Rates

- Sensitivity of small economy's real rate to global life expectancy



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- Open economy life-cycle model
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  - Demographics and financial integration

- **Empirical analysis**
  - Data description
  - Panel ECM regressions
  - Dispersion and projections

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- Regress real interest rates on demographic variables and controls, interacted with measures of openess and/or size as suggested by model
  - Demographic variables: labor force growth rate and life expectancy
  - Controls:
    - TFP growth
    - Fiscal variables (debt, government spending, pensions) % of GDP
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    - Others
- Complementary role of model and empirics $\Rightarrow$ Potential missing variables
  - Safe assets, private debt, relative price of investment, convenience yield
  - Introduce as additional controls (although with some data limitations)

Data

- Annual frequency, various sources
  - OECD, IFS, WB, UN WPP, PWT, Ameco, National agencies

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- Demographic variables:
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- Controls:
  - Direct measures for TFP growth and fiscal variables
  - Debt/GDP: From WB or Ameco
  - Financial integration: (Foreign Assets + Foreign Liabilities) / GDP
  - Other controls following existing literature

Ex-Ante Real Interest Rates

- Construct following Hamilton et al. (2016)
  - Using rolling windows of 20 years, estimate

$$\pi_{it} = \alpha_i + \beta_i \pi_{it-1} + \varepsilon_{it}$$

  - Ex-ante real rate is $r_{it} = i_{it} - \mathbb{E}_t \pi_{it+1}$, where

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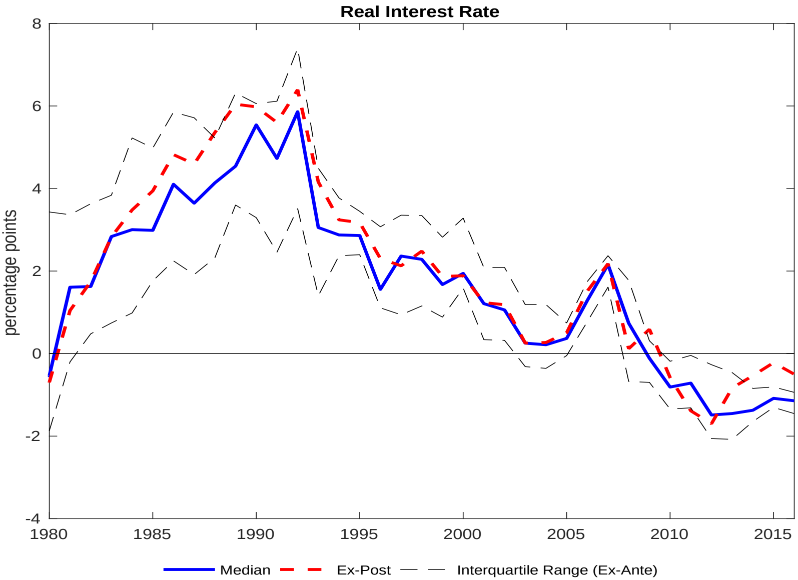
- Unbalanced panel of 20 OECD countries between 1980 and 2016
  - Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom, and United States
  - Exclude countries with inflation above 25% between 1970 and 2016

Ex-Ante vs. Ex-Post Real Rates



Empirical Specification

- Panel error-correction model

$$
\begin{aligned}
\Delta r_{m,t} = \alpha_m + \gamma r_{m,t-1} + \theta \Theta_{m,t-1} r^*_{m,t-1} + \sum_j \psi_j (1 - \Theta_{m,t-1}) Dmg_{m,j,t-1} \\
+ \sum_k \Psi_k (1 - \Theta_{m,t-1}) X_{m,k,t-1} \\
+ \lambda \Delta(\Theta_{m,t} r^*_{m,t}) \\
+ \sum_j \phi_j \Delta((1 - \Theta_{m,t}) Dmg_{m,j,t}) + \sum_k \chi_k \Delta((1 - \Theta_{m,t}) X_{m,k,t}) + \epsilon_{m,t}, \quad (2)
\end{aligned}
$$

where α_m is country fixed effect, $r_{m,t}$ is ex-ante real interest rate of country m, $\Theta_{m,t}$ is financial openess, $Dmg_{m,\bullet,t}$ are demographic variables, $r^*_{m,t-1}$ is foreign real interest rate faced by country m, and $X_{m,\bullet,t}$ are control variables and other potential determinants of real rates. Regressions weighted regressions by working age population, robust standard errors (cluster at country level)

3: Panel Error-Correction regressions. Global Rates weighted by population size and openess. Lane and Milesi-Ferretti (2017) measu

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Country LE-equiv. Rate	0.502**	-0.133	-0.087	1.307*	3.421***	1.961	2.344***	2.769*	1.188***	2.916
	0.252	0.405	0.417	0.717	1.104	1.965	0.699	1.607	0.381	1.921
Global Rate	1.054***	0.961***	0.941**	1.113***	1.029***	0.819**	1.420***	1.324**	1.365***	1.345*
	0.310	0.371	0.376	0.173	0.231	0.379	0.471	0.631	0.189	0.812
Population Growth		4.949	4.605	7.624**	-0.689	0.037	0.492	2.575	11.271***	2.361
		3.331	3.444	3.040	3.810	3.777	6.583	7.268	2.775	6.790
TFP			0.390	0.159	0.829	1.288	0.673	0.489	-0.182	0.439
			0.375	0.357	1.235	1.286	0.989	1.809	0.333	2.086
Govt. Debt				0.045**	0.151***	0.152**	0.156	0.178	0.078*	0.174
				0.021	0.058	0.074	0.120	0.119	0.047	0.129
Government Spending				-0.022	0.052	0.052	0.553**	0.592	-0.095	0.583
				0.095	0.300	0.288	0.239	0.424	0.135	0.519
Pension Spending				3.269***	-0.448	-1.409	-1.647	-1.725	2.654***	-1.561
				0.625	1.671	2.345	1.844	2.154	0.636	3.388
Retirement Age				-0.601***	-0.471*	-0.483	-0.556	-0.792*	-0.609***	-0.779
				0.098	0.250	0.449	0.589	0.448	0.113	0.716
Rel. Price of Invest. (PWT)						0.191				-0.029
						0.299				0.424
Private Debt					-0.011	-0.008	0.067	0.099		0.099
					0.034	0.042	0.092	0.097		0.097
Convenience yields							-16.269**	-11.543**	-4.190	-11.941
							6.636	5.534	2.685	8.355
Long Term Bonds over GDP					0.101	0.060		0.340	-0.049	0.341
					0.206	0.225		0.345	0.063	0.358
R2	0.333	0.350	0.361	0.589	0.618	0.627	0.728	0.765	0.691	0.765
Observations	683	683	663	430	219	217	126	103	142	103
Clusters	20	20	20	20	17	17	7	7	7	7
RMSE	1.215	1.201	1.210	0.915	0.792	0.784	0.598	0.618	0.863	0.618

Demographic Projections and Real Rates

- How do real interest rate will look based on demographic projections?
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  - But life expectancy projected to continue to increase

Demographic Projections and Real Rates

- How do real interest rate will look based on demographic projections?
  - Population growth projected to remain relatively stable
  - But life expectancy projected to continue to increase
- Further downward pressure on real interest rates