Demographic, Trade, and Growth

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Introduction

- In recent decades (90s-10), we have seen developing countries growing, at the same time increase in share of working age people, trade openness, and large aggregate TFP growths
  - China, India, Vietnam, Philippines and more ▸ Detail

- In what degree demographics structure interact with trade driven these economic development?
  - Demographic structure:
    - ★ Self innovation and Technology diffusion
    - ★ Capital accumulation(or Saving)
  - Trade and Comparative Advantage (CA):
    - ★ Trade induced Technology diffusion
    - ★ Ricardian CA forces: Difference in Productivity
    - ★ Heckscher-Ohlin CA forces: Difference in Endowments

- In this study I want to understand/quantify how demographic structure interact with trade affect economic growth

This Paper

- Provide empirical evidence on the relationship between
  - Panel Regression: Age structure and productivity change
    - TFP growth
    - Trade-induced technology diffusion
  - Panel Regression: Age structure and other macroeconomic variables
    - Capital accumulation, Consumption, Growth rate of K/L ratio
  - VARX: The dynamic effects of demographics shock and trade cost shock

- Develop an perfect foresight OLG trade model consistent empirical results.
  - Demographic structure affect both self innovation and trade-induced technology diffusion process
  - Demographic structure affect capital accumulation
  - Both Heckscher-Ohlin and Ricardian trade affect distribution of economic activity

- Application: Study China's past growth and conduct a model-based projection for china's future from the perspective of demographics and trade.

China

Facts of China:

- R.GDP.pc growth has trended down since 2008
- Working-age share shrink since 2010
- Old before rich: At 2021, similar median age with U.S.: 37.9 v.s 37.7; but R.GDP.pc is only 27.91 % of US

Past Growth

- Demographic structure and open to trade is beneficial to TFP growth
- Demographic structure and open to trade stimulate capital accumulation
- Growing Comparative Advantage (CA) in labor-intensive goods

China

Future: Population is aging, and if no policy to further reduce trade friction:

- TFP growth slow down
- Capital accumulation slow down
- Gradually lose the CA in labor-intensive sectors
- Not have enough time to build CA in capital-intensive sectors

Interesting Question:

- Whether and how demographic interact with trade driven China's growth in the past?
- How demographic forces influence China's growth in the future?

Related literature

Evidence on demographic structure and/or productivity: (Rudik,et,al, 2023)

Trade and technology diffusion::

Dynamic trade model: (Sposi, 2022)

Heckscher-Ohlin and Ricardian trade: (Yi,et,al, 2022)

Quantitative spatial economics:

China's growth:

Roadmap

- Empirical evidence
  - ▶ Data
  - ▶ Empirical model and results

- Model
  - ▶ Technology process with demographic structure
  - ▶ OLG, factor demand and capital accumulation
  - ▶ Production and trade

- Application
  - ▶ Data
  - ▶ Calibration
  - ▶ Counterfactual
  - ▶ Results

Empirical Data source

The United Nations Statistics Division (UNSD)

- Age cohorts share for every 5 years, Dependence ratio, Old dependence ratio, Young dependence ratio, Total population

Penn World Table (PWT 10.01)

- Average annual hours worked by persons engaged, Number of persons engaged, Mean years of schooling, Capital stock, Real GDP, Average depreciation rate of the capital stock
- TFP calculated by PWT based on above variables

World Development Indicators (WDI)

- Share of household consumption, capital formation, government consumption (% share of GDP)

Panel Regression: technology change

$$GRTFP_{it,t+4} = Constant + Demographic_{it} + Control_{it} + f_i + f_t + \varepsilon_{it} \qquad (1)$$

- i mean country i; t means year t
- $GRTFP_{it,t+4}$: average TFP growth rate during the period t to $t+4$

$$GRTFP_{it,t+4} = \{\frac{TFP_{t+4}}{TFP_{t+0}}\}^{1/4} - 1$$

- $Demographic_t$: Dependency ratio [(0-14 65+)/15-64] (%); Young dependency ratio [(0-14) / 15-64] (%); Old dependency ratio [65+ /15-64] (%); Working age share [15-64/total] (%); Young population share[0-14 / total] (%); Old population share [65+ / total] (%)

- $Control$: initial log real GDP per capita; f_i and f_t: fixed effects.

- 74 countries. I divide the entire period of 1970–2019 into 10 non-overlapping 5 year periods: period 1 (1970–1974), period 2 (1975–1979), period 3 (1980–1984), period 4 (1985–1989), period 5 (1990–1994),... and period 10 (2015–2019).

Panel Regression Results ▸ Robust: every non-overlapping 8 years

Table 1: The effect of demographic structure on technology change

VARIABLES	Average TFP growth rate in the future 4 years					
Initial.log.RGDP.p.c	-2.93***	-0.20***	-2.37***	-3.09***	-0.20***	-2.59***
	(-4.61)	(-2.70)	(-5.24)	(-4.82)	(-2.78)	(-5.40)
Dep.Ratio [0-14, 65+]/[15-64]	-3.31***	-2.47***	-5.68***			
	(-2.86)	(-3.73)	(-5.04)			
Work.Share [15-64]/ToT				11.43***	7.16***	18.01***
				(3.33)	(3.98)	(5.14)
Constant	28.56***	4.39***	25.01***	20.96***	-1.59**	12.30***
	(4.94)	(3.80)	(5.39)	(3.65)	(-2.29)	(3.70)
Observations	732	732	732	732	732	732
R-squared	0.254	0.085	0.182	0.259	0.085	0.188
Time FE	YES	YES	NO	YES	YES	NO
Country FE	YES	NO	YES	YES	NO	YES

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

1 unit increase of the dependence ratio (%) related to 0.03 p.p decrease of TFP growth rate;
1 unit increase of the working age share (%) related to 0.11 p.p increase of TFP growth rate.

Panel Regression Results

Table 3: The effect of demographic structure on technology change

VARIABLES	Average TFP growth rate in the future 4 years					
Initial.ln.RGDP.p.c	-3.09***	-2.73***	-3.22***	-3.43***	-2.81***	-3.46***
	(-4.71)	(-4.06)	(-4.62)	(-4.91)	(-4.02)	(-4.77)
Child.Dep.R [0-14]/[15-64]	-4.33***		-4.64***			
	(-3.24)		(-3.40)			
Old.Dep.R [65+]/[15-64]		3.34	5.83			
		(0.79)	(1.30)			
Child.Share[0-14]/ToT				-14.28***		-13.98***
				(-3.72)		(-3.68)
Old.Share [65+]/ToT					8.35	2.79
					(1.05)	(0.39)
Constant	30.15***	24.02***	30.82***	35.50***	24.48***	35.46***
	(4.99)	(4.11)	(4.91)	(5.18)	(4.07)	(5.19)
Observations	732	732	732	732	732	732
R-squared	0.259	0.244	0.262	0.266	0.246	0.266
Time FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Increasing elderly share has no significant effects on TFP growth rate;

Increasing young people share related to TFP growth rate decline

Empirical

2 Demographic structure and technology diffusion

$$GRTFP_{it,t+4} = Constant + Demographic_{it} + Techdist_{i,t} + Demographic_{it} \times Techdist_{i,t}$$
$$+ Control_{it} + f_i + f_t + \varepsilon_{it}$$

- $Techdist_{i,t}$: at time t, the technology distance between the home country i and the import-weighted foreign country.

$$Techdist_{i,t} = \sum_{j \neq i}^{n} \frac{imports_{i,j}}{Totalimports_i} TFP_{jt} - TFP_{it}$$

Results: Demographic structure and technology change

VARIABLES	Average TFP growth rate in the future 7 years			
Dep.Ratio	-0.00002			
	(-0.17415)			
Young.Dep.Ratio		-0.00008		-0.00005
		(-0.47479)		(-0.30184)
Old.Dep.Ratio			0.00002	0.00052
			(0.04805)	(0.88597)
Tech.Dist	0.09530***	0.08222***	0.03969***	0.10944***
	(4.76807)	(4.99920)	(2.81098)	(3.15615)
Tech.Dist $\times Dep.Ratio$	-0.00060**			
	(-2.52246)			
Tech.Dist $\times Young.Dep.Ratio$		-0.00051**		-0.00066**
		(-2.43402)		(-2.25013)
Tech.Dist $\times Old.Dep.Ratio$			0.00082	-0.00164
			(0.69556)	(-0.99732)
Initial.log.R.GDPpc	-0.01529***	-0.01624***	-0.01465***	-0.01616***
	(-2.89739)	(-2.82717)	(-2.80783)	(-2.71824)
Constant	0.14695***	0.15797***	0.13756***	0.14956***
	(2.81695)	(2.76867)	(3.15787)	(2.64825)
Observations	389	389	389	389
R-squared	0.521	0.521	0.507	0.523
Time FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES

1 unit increase of the working age share (%) related to 0.08 unit increase of TFP growth rate (%) which is due to technology diffusion process

Panel Regression
Investment and consumption

Effect of Demographic structure on saving, capital formation and consumption

$$Ave.Y_{it,t+4} = Constant + Demographic_{it} + f_i + f_t + \varepsilon_{it} \tag{2}$$

- Y: domestic saving, investment, or consumption share of GDP
- $Ave.Y_{it,t+4}$: average investment, saving or consumption share of GDP during the period t to $t+4$:

$$Ave.Y_{it,t+4} = \sum_{s=t+0}^{t+4} \frac{Y_{i,s}}{5}$$

Panel Regression Results

Capital accumulation, investment, saving and economic growth ▸ Robust: every non-overlapping 8 years

Table 6: The effect of demographic structure on Investment, Saving and Consumption

VARIABLES	Average value (% GDP) in the future 4 years			
	Dom.Saving	Cap.Formation	Fix.Cap.Formation	Consumption
Dep.Ratio $[0\text{-}14, 65+]/[15\text{-}64]$	-9.93*	-10.20**	-11.07**	9.93*
	(-1.68)	(-2.13)	(-2.38)	(1.68)
Constant	28.26***	28.24***	27.39***	71.74***
	(6.74)	(7.87)	(7.91)	(17.11)
Observations	725	724	716	725
R-squared	0.751	0.575	0.539	0.751
Time FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES

Robust t-statistics in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

a country with more working-age people saves and invests more, consumes less

Panel Regression
Investment and consumption

Effects of demographic structure and trade cost change on capital/labor ratio

$$GR.K/L_{it,t+4} = Constant + \beta_1 Demographic_{it} + \beta_2 TradeCost_{it} + \beta_3 Control_{it} + f_i + f_t + \varepsilon_{it}$$
$$(3)$$

- The variable $GR.K/L_{it,t+4}$ means average capital per person (k) growth rate (%) for country i during the period from t to $t+4$, and calculated as follows:

$$GR.K/L_{it,t+4} = [\frac{k_{i,s+4}}{k_{i,s}}]^{\frac{1}{4}} - 1$$

- The trade cost for country i at time t $TradeCost_{it}$ are constructed as the Head-Ries (HR) index . I calculated it as follows:

$$TradeCost_{it} = (\frac{\pi_{i,row}}{\pi_{row,row}} \frac{\pi_{row,i}}{\pi_{ii}})^{-\frac{1}{2\theta}}$$

Panel Regression Results

Effects of demographic structure and trade cost change on capital/labor ratio

VARIABLES	Average K/L (%) growth rate in the future 4 years			
Trade Cost	-0.83**	-0.82**	-0.87**	-0.83**
	(-2.13)	(-2.06)	(-2.27)	(-2.13)
Dep.Ratio	-4.39**			
	(-2.22)			
Child.Dep.R		-3.25		
		(-1.27)		
Old.Dep.R		-11.37		
		(-1.66)		
Work.Share			13.34**	
			(2.49)	
Child.Share				-11.22*
				(-1.82)
Old.Share				-24.65**
				(-2.38)
Initial.ln.K/L	-2.13***	-1.93***	-2.24***	-1.99***
	(-3.90)	(-3.41)	(-4.12)	(-3.45)
PoP.Growth	-28.85	-34.06*	-28.93	-33.14*
	(-1.53)	(-1.90)	(-1.55)	(-1.84)
Constant	31.86***	29.96***	22.19***	32.98***
	(5.77)	(5.31)	(3.63)	(5.32)
Observations	758	758	758	758
R-squared	0.585	0.588	0.586	0.589
Time FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES

a country with a larger share of working-age people (or lower trade costs) is associated with a higher growth rate of capital per person; a country with is associated with a higher growth rate of capital per person

Panel VARX model
Capital accumulation, investment, saving and economic growth

VARX model:

$$Y_{n,t} = C + AY_{n,t-1} + BX_{n,t} + \varepsilon_{n,t}$$

Endogenous variables:

$$Y_{nt} = \begin{bmatrix} \text{the 5 year growth rate of TFP } (\%) \\ \text{the 5 year growth rate of the real GDP per capita } (\%) \\ \text{the 5 year growth rate of capital per person } (\%) \end{bmatrix}_{Country\ n,time\ t}$$

Exogenous variables: Demographic Structure (age shares):

$$X_{nt} = \begin{bmatrix} \text{young people share } (\%),\ (0-14) \\ \text{old people share } (\%),\ (65+) \\ \text{trade cost change } (\%) \\ \text{the 5 year growth rate of population}(\%) \end{bmatrix}_{Country\ n,time\ t}$$

Time interval: 1 unit of time = 5 years. e.g. t = 1 means first 5 years

IRF of exogenous demographic shock
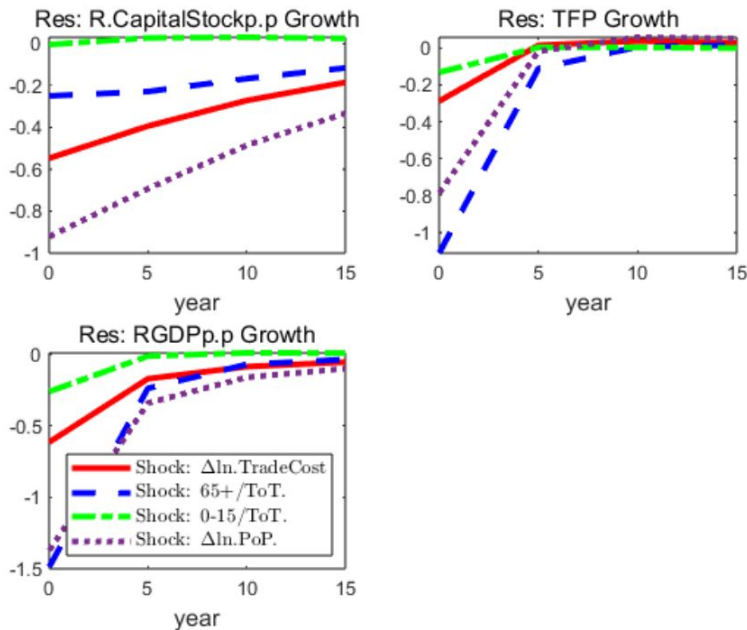
The effect of elderly share shock is larger and lasting than young people

Empirical Summary

- TFP growth
  - Country with higher working age share (or lower dependency ratio) showing a higher TFP growth rate
  - Elder share has no significant effects on TFP growth rate
  - Higher young people share (0-14/TOT) related to lower TFP growth rate

- Capital accumulation, investment, saving and economic growth
  - Country with more working-age people saves and invests more, consumes less
  - The effect of elderly share shock is stronger and lasting than young people

Thank You

Motivation
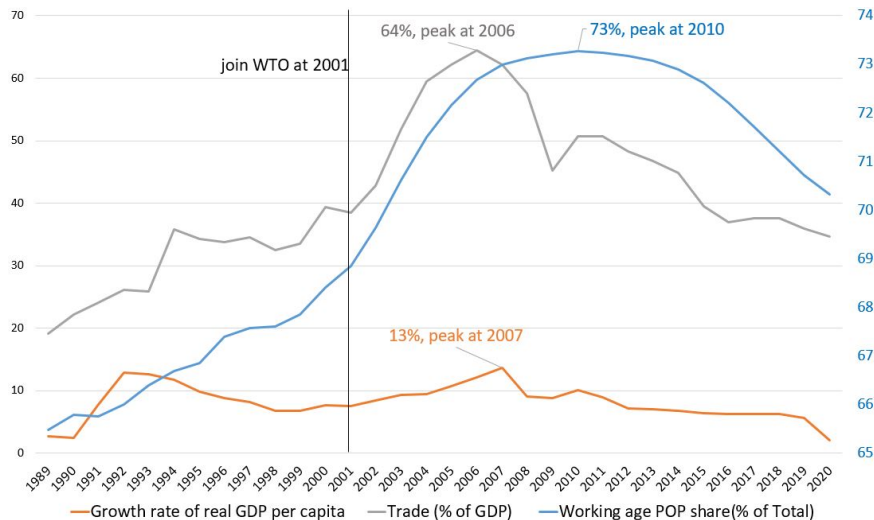
Source: Author's calculations from data from WDI, World Bank

Demographics and TFP

Table 2: The effect of demographic structure on technology change

VARIABLES	Average TFP growth rate in the future 7 years					
Initial.ln.RGDP.p.c	-2.78***	-0.17**	-1.96***	-2.93***	-0.18***	-2.19***
	(-4.32)	(-2.53)	(-4.66)	(-4.55)	(-2.64)	(-4.92)
Dep.Ratio [0-14, 65+]/[15-64]	-2.11*	-2.58***	-5.32***			
	(-1.88)	(-3.90)	(-4.89)			
Work.Share [15-64]/ToT				8.31***	7.61***	17.12***
				(2.76)	(4.20)	(5.50)
Constant	25.75***	3.48***	20.85***	20.69***	-2.80***	9.08***
	(4.44)	(3.37)	(4.83)	(3.53)	(-3.91)	(2.88)
Observations	439	439	439	439	439	439
R-squared	0.361	0.090	0.271	0.367	0.091	0.280
Time FE	YES	YES	NO	YES	YES	NO
Country FE	YES	NO	YES	YES	NO	YES

Robust t-statistics in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

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Demographics and TFP

Table 4: The effect of demographic structure on technology change

VARIABLES	Average TFP growth rate in the future 7 years					
Initial.ln.RGDP.p.c	-2.86***	-2.63***	-2.92***	-3.11***	-2.66***	-3.10***
	(-4.37)	(-3.80)	(-4.17)	(-4.49)	(-3.71)	(-4.28)
Child.Dep.R [0-14]/[15-64]	-2.58**		-2.70**			
	(-2.05)		(-2.08)			
Old.Dep.R [65+]/[15-64]		0.93	2.45			
		(0.22)	(0.55)			
Child.Share[0-14]/ToT				-9.31***		-9.41***
				(-2.72)		(-2.80)
Old.Share [65+]/ToT					3.06	-1.02
					(0.41)	(-0.14)
Constant	26.51***	22.79***	26.77***	30.40***	22.96***	30.42***
	(4.42)	(3.80)	(4.30)	(4.53)	(3.73)	(4.56)
Observations	439	439	439	439	439	439
R-squared	0.363	0.355	0.364	0.370	0.355	0.370
Time FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

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Demographics and TFP

Table 7: The effect of demographic structure on Investment, Saving and Consumption

VARIABLES	Average value (% GDP) in the future 7 years			
	Dom.Saving	Cap.Formation	Fix.Cap.Formation	Consumption
Dep.Ratio $[0\text{-}14, 65+]/[15\text{-}64]$	-7.63	-9.79*	-9.80*	7.63
	(-1.26)	(-1.91)	(-1.94)	(1.26)
Constant	26.65***	28.48***	27.36***	73.35***
	(6.18)	(7.44)	(7.33)	(17.00)
Observations	432	431	427	432
R-squared	0.792	0.627	0.587	0.792
Time FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES

Robust t-statistics in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

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