Demographics, Trade, and Growth

Yang Pei
University of Houston

December 5, 2023

Introduction

Motivation

- In recent decades, developing countries that experienced an increase in their working-age share of population also saw increases in trade openness, aggregate total factor productivity (TFP) growth, and real GDP growth ▸ Detail
  - However, in recent years, the working-age share in China and many other countries has declined

Research Question: How does demographics affect trade and GDP growth?

- Potential mechanisms
  - TFP growth (Age-dependent ability in generating new idea)
  - Capital accumulation (Age-dependent saving behavior)
  - Trade determined by comparative advantage (CA) regulates the allocation of production
    - ⋆ Ricardian CA: Differences in TFP
    - ⋆ Hecksher-Ohlin CA: Differences in K/L ratio

What I do

Today's focus

- Panel Regressions: provide empirical evidence on the relationship between
  - Demographic structure and TFP growth
  - Demographic structure and other variables
    - Investment and Consumption
    - Growth rate of K/L ratio (factor endowments)
- VARX: estimate the dynamics of demographic structure shock
- Develop a perfect foresight OLG trade model consistent with empirical findings
  - Demographic-induced TFP growth
  - Demographic structure affects capital accumulation
  - Trade based on Ricardian and Heckscher-Ohlin CA affect specialization
- Application: from the perspective of demographics and trade, explain China's past growth and do model-based projection for future Detail

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

CEPII

- Imports and Exports between two countries

World Development Indicators (WDI)

- Share of household consumption, capital formation, government consumption (% share of GDP), residents new patents application, residents new industrial design application

Panel Regression

Effect of Demographic structure on TFP growth

$$GRTFP_{it,t+4} = Constant + \alpha_1 Demographic_{it} + \alpha_2 Controls_{it} + f_i + f_t + \varepsilon_{it} \tag{1}$$

- 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)
- i means country; t means year
- Dependent variables, $GRTFP_{it,t+4}$: Investment K/L Ratio
  - Average TFP growth rate during the period t to $t+4$
  - Average number of new patents applications during the period t to $t+4$
  - Average number of new industrial design applications during the period t to $t+4$
- $Demographic_t$: Working age share [15-64/total] (%) ; Share of people at different age intervals (%)
- $Controls$: Initial log real GDP per capita; f_i and f_t: fixed effects

Panel VARX model

Capital accumulation, TFP, and economic growth

VARX model:

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

Endogenous variables:

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

Exogenous variables: Demographic Structure (age shares):

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

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

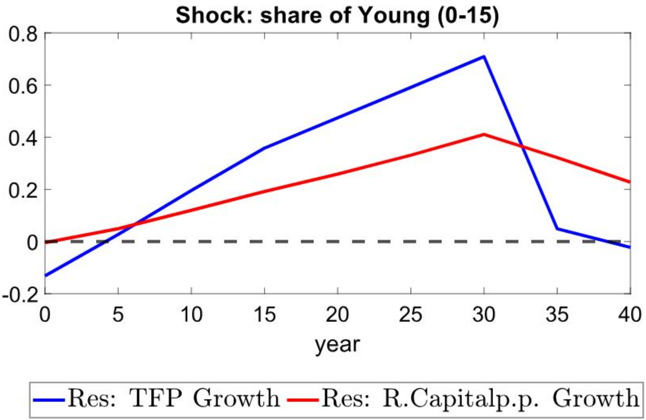
Panel Regression Results

	Average value in the future 4 years		
VARIABLES	TFP growth rate	Patent.Applications (per 1000 people)	Industrial.Design.Applications (per 1000 people)
(0-24)/ToT.	26.22***	-1.56***	-0.55***
	(4.24)	(-7.06)	(-3.87)
(25-49)/ToT.	34.48***	0.18	0.71***
	(4.28)	(0.46)	(2.87)
(50-74)/ToT.	43.60***	4.90***	1.08***
	(4.41)	(7.40)	(2.93)
(75+)/ToT.	13.47	-2.59	-1.85**
	(0.90)	(-1.59)	(-1.99)
Initial.Log.Dependent	-3.51***		
	(-4.49)		
Observations	732	395	215
R-squared	0.263	0.880	0.939
Time FE	YES	YES	YES
Country FE	YES	YES	YES

◂ Hump shape for the coefficients

Panel VARX model

IRF of exogenous shock on
I.TFP growth; **II**. Growth rate of real capital stock per person



The IRF of $+1\%$ young people share shock is hump shape

Other IRFs

Panel regression

- TFP growth
  - Hump shape for the relation of age and TFP growth
    - ★ same for new patents application or new industry design application
  - Higher working age share showing a larger growth rate of K/L ratio

VARX

- The IRF of $+1\%$ young people share shock is hump shape
  - Shock will pass down as people grow up

Model

Goal

- Understand mechanisms for empirical results in general equilibrium framework

- From perspective of demographics and trade
  - Explain China's past growth
  - Do projection for future

Model

Overview of Model

- Age structure influence
  - TFP growth (idea generation)
  - Capital accumulation

- Trade determined by comparative advantage regulates the allocation of production

- Economy consists of many countries $n, i \in [1, \cdots, N]$ and sectors $j, k \in [1, \cdots, J]$

Model

Production

Demographic-induced TFP change

- From t to $t+h$, unit interval of people draws new ideas from knowledge frontier (a.k.a CDF of productivity) $F^j_{n,t}(z)$
  - The arrival rate of new ideas for people in country n, sector j at age g is $\alpha^j_{n,g,t}$
  - The share of age g people at time t in country n is $\Omega_{n,g,t}$
  - Aggregate idea arrival rate: $A^j_{n,t} = \sum_g \Omega_{n,g,t}\alpha^j_{n,g,t}$
- At time $t+h$, the technology frontier is

$$F^j_n(z, t+h) = F^j_n(z,t) \times Pr\left\{all\ A^j_{n,t}h\ draws \leq z\right\} = F^j_n(z,t)\left(F^j_n(z,t)\right)^{A^j_{n,t}h} \tag{2}$$

- Assume $F^j_{n,t}(z)$ follows Fréchet distribution with mean $\lambda_{n,t}$, Equation 2 implies

$$\frac{d\lambda^j_{n,t}}{\lambda^j_{n,t}dt} = A^j_{n,t} \tag{3}$$

- Linear relation

$$A^j_{n,t} = \underbrace{\sum_g \Omega_{n,g,t}\alpha^j_{n,g,t}}_{Demographic-induced} + \underbrace{\vartheta^j_{n,t}}_{Adjusted\ for\ errors} \tag{4}$$

Model

Households

OLG and capital accumulation

An age g individual that was born in period t choose lifetime consumption $\{c_{n,g,t+g-1}\}_{g=E+1}^{E+G}$ and savings $\{b_{n,g+1,t+g}\}_{g=E+1}^{E+G-1}$ to maximize lifetime utility :

$$\max_{\{c_{n,g,t+g-1}\}_{g=E+1}^{E+G}\{b_{n,g+1,t+g}\}_{g=E+1}^{E+G-1}} \sum_{g=E+1}^{E+G} \beta^{g-E-1}\mathcal{U}\left(c_{n,g,t+g-1}\right)$$

$$P_{n,C}c_{n,g} + P_{n,I}b_{n,g+1} = (1+\frac{R_n}{P_{n,I}} - \delta)P_{n,I}b_{n,g} + W_n l_g + \frac{TRS_n}{\bar{L}_n} + \frac{D_n}{\bar{L}_n} \quad \forall g \geq E+1$$

$$b_{n,E+1,t} = b_{n,E+G+1,t} = 0 \quad \forall\ t$$

$$c_{n,E+g,t} > 0 \quad \forall g, t$$

- $i_{g,t} = b_{g+1,t+1} - (1-\delta)\, b_{g,t}$
- $TRS_{n,t}$ is defined as transfer which is due to net death or net immigrant
- $D_{n,t}$ is the trade deficit, a.k.a the trade-relevant transfer.
- Transfers are equally distributed across the economically relevant population

Trade

- "Iceberg" trade costs: One unit of a tradable good in sector j shipped from region i to region n require $\kappa^j_{ni,t} \geq 1$ units in i
- The unit price of an input bundle is given by:

$$c^j_{n,t} \equiv \Upsilon^j_n \left[\left(W^j_{n,t} \right)^{\beta^j_n} \left(R^j_{n,t} \right)^{1-\beta^j_n} \right]^{\gamma^j_n} \prod_{k=1}^{J} {P^k_{n,t}}^{\gamma^{k,j}_n} \tag{5}$$

- Following Eaton and Kortum (2002), the fraction of country n's expenditures in sector j goods source from country i is:

$$\pi^j_{ni,t} = \frac{\lambda^j_{i,t} \left(c^j_{i,t} \kappa^j_{ni,t} \right)^{-\theta}}{\sum_{m=1}^{N} \lambda^j_{m,t} \left(c^j_{m,t} \kappa^j_{nm,t} \right)^{-\theta}} \tag{6}$$

Detail

Future Plan

- Do small experiments to quantify the main mechanism
  - Model without trade and capital accumulation
  - Model without trade
  - Model without capital accumulation

- Application: Answer China's question
  - Data and Calibration
  - Counterfactual
  - Findings

Thank You

Panel Regression

Effect of Demographic structure on investment and consumption

$$Ave.Y_{it,t+4} = Constant + \beta_1 Demographic_{it} + f_i + f_t + \varepsilon_{it} \tag{7}$$

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

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

Back

Panel Regression

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

$$GR.K/L_{it,t+4} = Constant + \beta_1 Demographic_{it} + \beta_2 TradeCost_{it} + \beta_3 Control_{it} + f_i + f_t + \varepsilon_{it} \tag{8}$$

- $GR.K/L_{it,t+4}$: Average capital per person (k) growth rate (%) for country i during the period t to $t+4$:

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

- $TradeCost_{it}$: The trade cost for country i at time t, which is constructed as the Head-Ries (HR) index (Head and Mayer, 2004):

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

Back

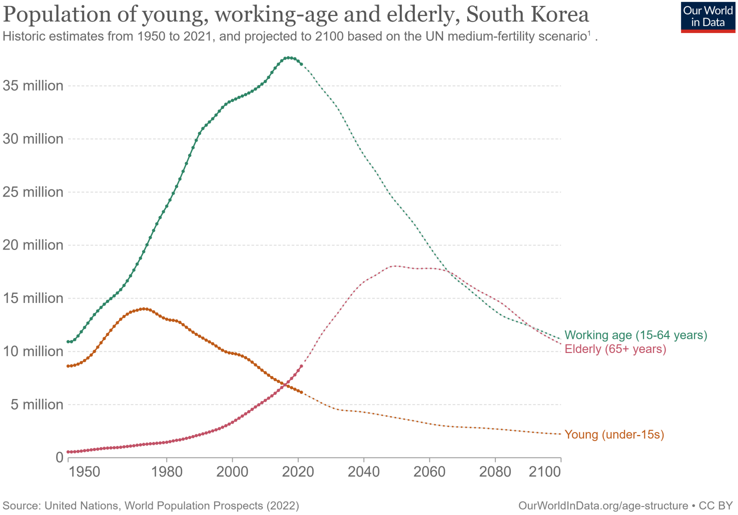
Panel Regression Results

Robust: every non-overlapping 8 years

	Average value in the future 4 years		
VARIABLES	Cap.Formation(% GDP)	Gross.Consumption(% GDP)	K/L growth rate
(0-24)/ToT.	16.69***	92.44***	24.08***
	(2.64)	(14.84)	(4.50)
(25-49)/ToT.	29.11***	60.55***	39.21***
	(4.14)	(5.58)	(5.36)
(50-74)/ToT.	37.83**	59.95***	19.18
	(2.05)	(3.23)	(1.66)
(75+)/ToT.	-124.60***	150.74***	4.22
	(-2.77)	(3.21)	(0.24)
Trade Cost			-0.83**
			(-2.11)
Initial.Log.Dependent			-1.98***
			(-3.21)
PoP.Growth			-35.31**
			(-2.08)
Observations	724	725	758
R-squared	0.972	0.996	0.787
Time FE	YES	YES	YES
Country FE	YES	YES	YES

Back

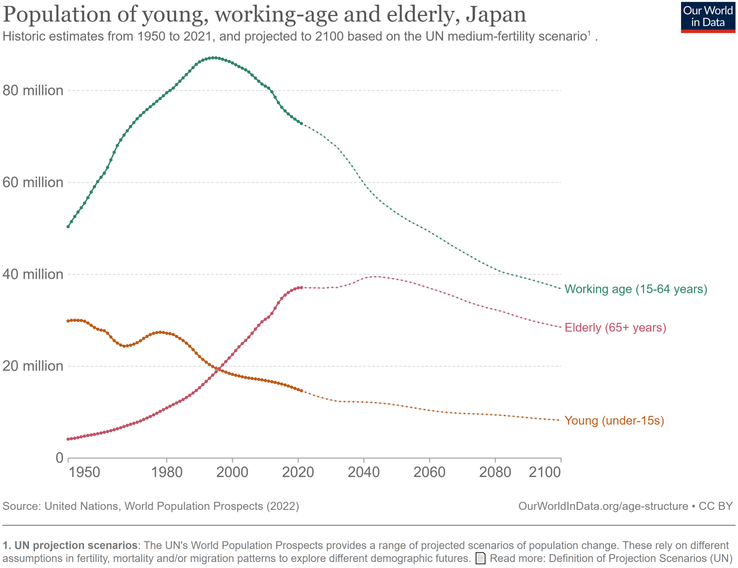
Motivation



1. UN projection scenarios: The UN's World Population Prospects provides a range of projected scenarios of population change. These rely on different assumptions in fertility, mortality and/or migration patterns to explore different demographic futures. Read more: Definition of Projection Scenarios (UN)

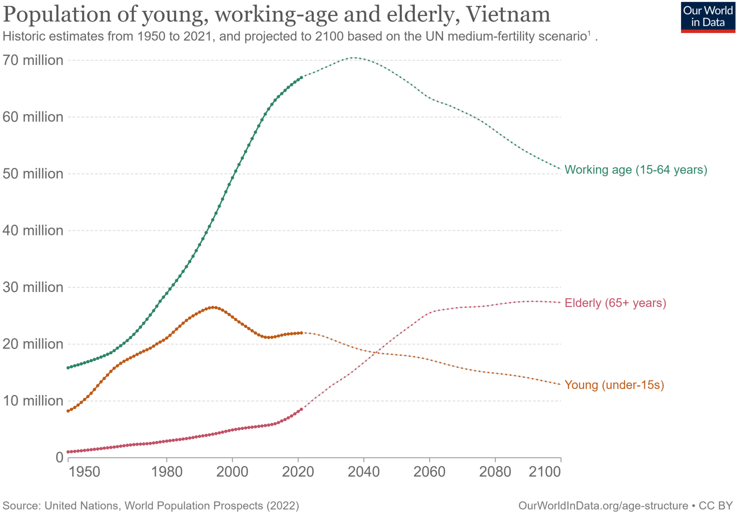
Back

Motivation



Back

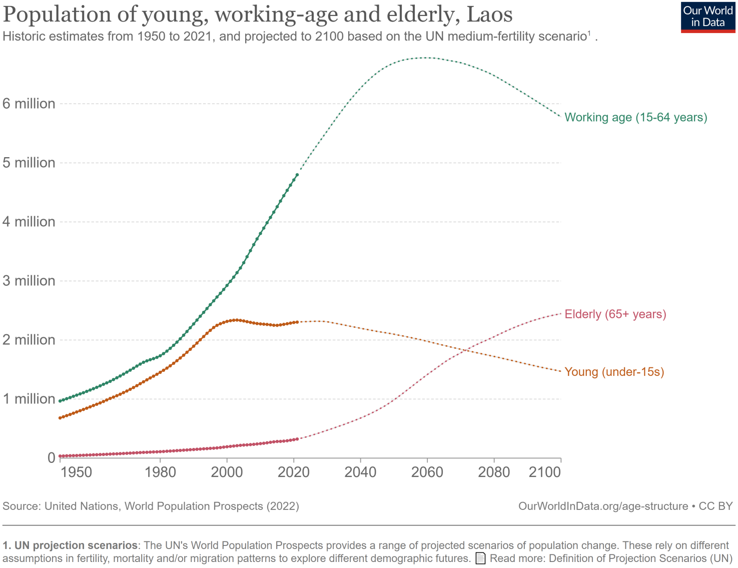
Motivation



1. UN projection scenarios: The UN's World Population Prospects provides a range of projected scenarios of population change. These rely on different assumptions in fertility, mortality and/or migration patterns to explore different demographic futures. Read more: Definition of Projection Scenarios (UN)

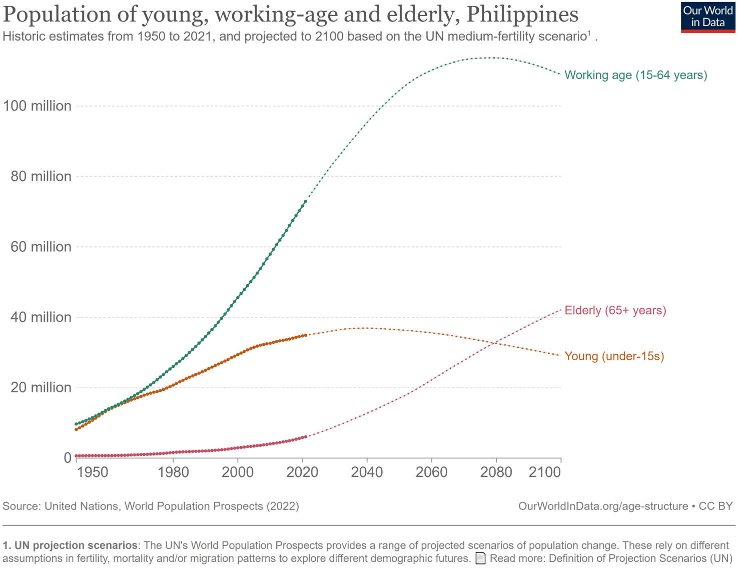
Back

Motivation



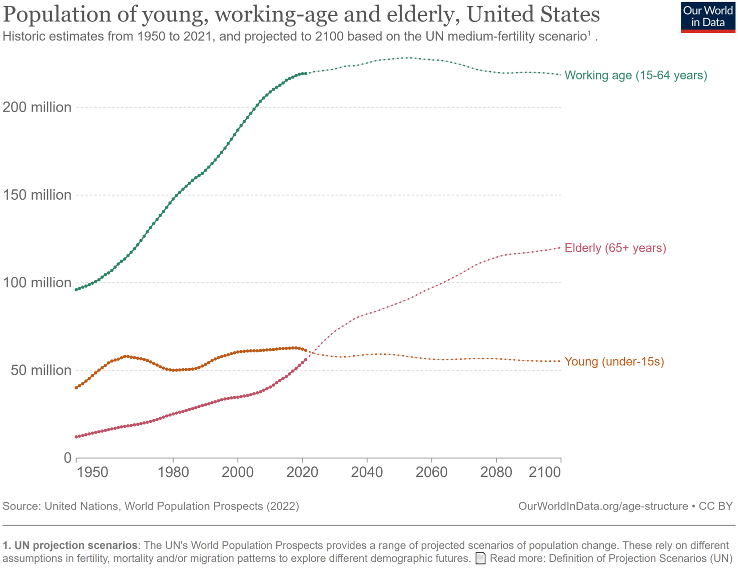
Back

Motivation



Back

Motivation

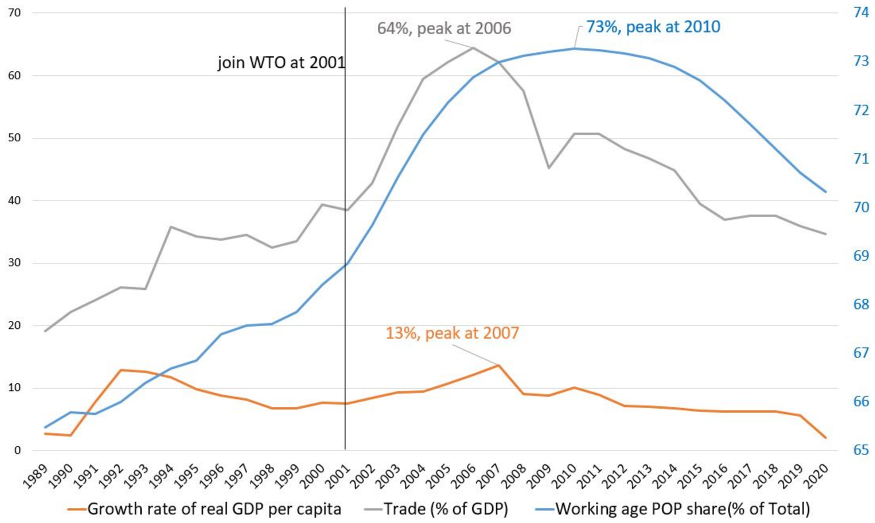


Back

Motivation

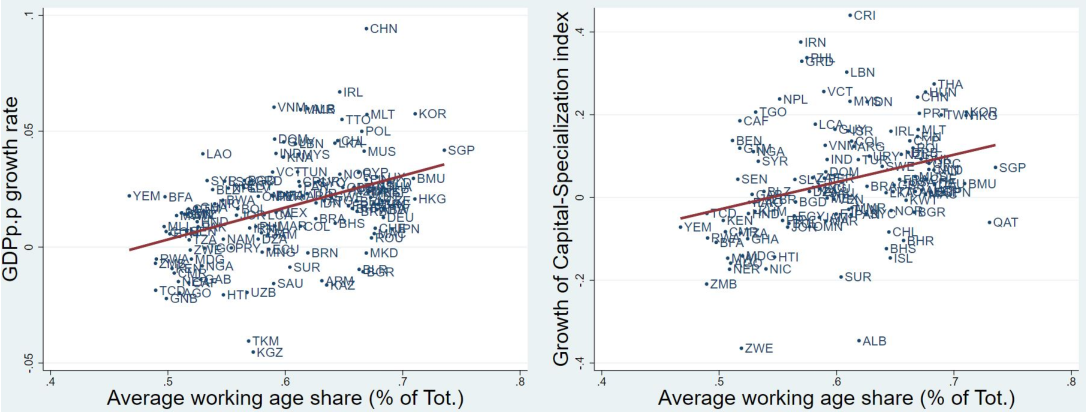
Back

Motivation



◂ Back

Motivation



Detail Back

Motivation

Capital-Specialization Index

$$Capital - Specialization\ Index_{n,t} = \sum_{j=1}^{J} \frac{Export_{n,t}^{j}}{\sum_{j=1}^{J} Export_{n,t}^{j}} \cdot CI^{j}$$

- CI^j: capital intensive index of sector j
  - $CI^j = 1$ means sector j is capital intensive sector
  - $CI^j = 0$ means sector j is not capital intensive sector

- A sector is capital intensive sector if
  - Capital valued added share > mean (across all sector) of capital valued added shares

- $Export_n^j$: Total exports of country n for sector j goods

Back

Facts of China

Growth slow down, and Old before rich :

- Real GDP per capita growth trended down since 2008
- Working-age share trended down since 2010
- At 2021
  - Median age CHN v.s. USA: 37.9 v.s 37.7
  - Real GDP per capita: CHN is 28% of USA

Past: Large and growing working-age share & openness to trade

- Low level of wages, specialize in labor-intensive goods
- Demographic-induced TFP growth
- Growing capital accumulation from working age people

Question: How do demographics affect trade and growth of China in the past and future? Back

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. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Back

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. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Back

Demographics and TFP

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

	Average value (% GDP) in the future 7 years			
VARIABLES	Dom.Saving	Cap.Formation	Fix.Cap.Formation	Consumption
Dep.Ratio [0-14, 65+]/[15-64]	-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. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Back

Panel Regression Results

Under different cohort structure

	Average value in the future 4 years								
VARIABLES	TFP growth rate			Patent.Applications (per 1000 people)			Industrial.Design.Applications (per 1000 people)		
Different age intervals:	3 cohorts	4 cohorts	5 cohorts	3 cohorts	4 cohorts	5 cohorts	3 cohorts	4 cohorts	5 cohorts
3 cohorts:	21.48***	26.22***	25.36***	-1.60***	-1.56***	-1.11***	-0.89***	-0.55***	-0.53***
[0, 14], [15,64], [64,+)	(3.61)	(4.24)	(4.08)	(-4.60)	(-7.06)	(-4.09)	(-3.84)	(-3.87)	(-2.87)
	35.46***	34.48***	31.80***	0.58***	0.18	-1.72***	0.63***	0.71***	0.08
4 cohorts:	(5.19)	(4.28)	(4.35)	(2.73)	(0.46)	(-4.06)	(4.98)	(2.87)	(0.31)
[0,24], [25,49], [50,74],	38.25***	43.60***	34.74***	2.29**	4.90***	3.59***	-0.42	1.08***	1.75***
[75, +)	(3.42)	(4.41)	(3.46)	(2.50)	(7.40)	(6.47)	(-0.98)	(2.93)	(5.20)
		13.47	55.17***		-2.59	4.23***		-1.85**	-0.31
5 cohorts:		(0.90)	(5.35)		(-1.59)	(3.99)		(-1.99)	(-0.46)
[0, 19], [20,39], [40,59],			-21.89			-7.67***			-1.09
[60,79], [80,+)			(-1.08)			(-2.62)			(-0.57)
Initial.Log	-3.46***	-3.51***	-3.51***						
.Dependent	(-4.77)	(-4.49)	(-4.55)						
PoP.Growth									
Observations	732	732	732	395	395	395	215	215	215
R-squared	0.266	0.263	0.272	0.859	0.880	0.886	0.935	0.939	0.942
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Panel Regression Results

Under different cohort structure

	Average value in the future 4 years								
VARIABLES	Cap.Formation(% GDP)			Gross.Consumption(% GDP)			K/L growth rate		
Different age intervals:	3 cohorts	4 cohorts	5 cohorts	3 cohorts	4 cohorts	5 cohorts	3 cohorts	4 cohorts	5 cohorts
3 cohorts:	9.34	16.69***	15.40**	98.55***	92.44***	92.98***	21.77***	24.08***	22.11***
[0, 14], [15,64], [64,+)	(0.98)	(2.64)	(2.32)	(9.21)	(14.84)	(12.62)	(3.69)	(4.50)	(4.02)
	34.10***	29.11***	26.71**	64.81***	60.55***	71.18***	32.98***	39.21***	36.72***
4 cohorts:	(6.74)	(4.14)	(2.52)	(9.15)	(5.58)	(5.39)	(5.32)	(5.36)	(5.30)
[0,24], [25,49], [50,74],	-31.87	37.83**	20.39	98.58***	59.95***	43.58*	8.34	19.18	27.00***
[75, +)	(-1.30)	(2.05)	(1.13)	(2.95)	(3.23)	(1.85)	(0.61)	(1.66)	(2.98)
		-124.60***	53.93**		150.74***	100.97**		4.22	21.25
5 cohorts:		(-2.77)	(2.37)		(3.21)	(2.47)		(0.24)	(1.41)
[0, 19], [20,39], [40,59],			-224.74***			126.47*			-9.87
[60,79], [80,+)			(-3.07)			(1.75)			(-0.33)
Trade Cost							-0.83**	-0.83**	-0.79**
							(-2.13)	(-2.11)	(-2.00)
Initial.Log							-1.99***	-1.98***	-1.93***
.Dependent							(-3.45)	(-3.21)	(-3.14)
PoP.Growth							-33.14*	-35.31**	-30.58
							(-1.84)	(-2.08)	(-1.64)
Observations	724	724	724	725	725	725	758	758	758
R-squared	0.971	0.972	0.972	0.996	0.996	0.996	0.785	0.787	0.787
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Panel Regression Results

Regression Coefficients follows hump shape

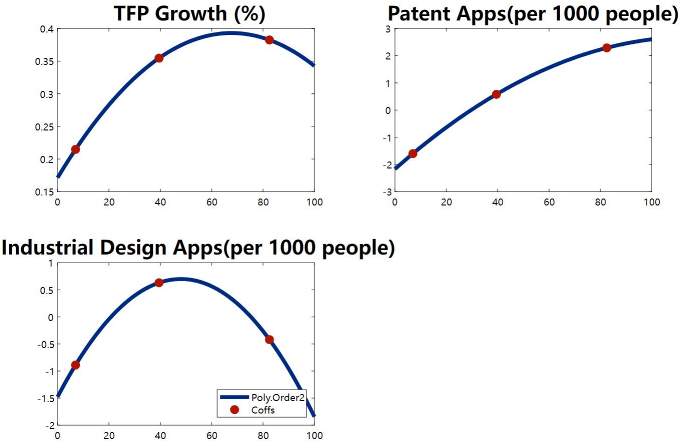


Figure: 3 cohorts: [0, 14], [15,64], [64,+)

Similar hump shape for 4 cohorts and 5 cohorts:

4 cohorts: [0,24], [25,49], [50,74], [75, +) ▸ 4 cohorts

5 cohorts: [0, 19], [20,39], [40,59], [60,79], [80,+) ▸ 5 cohorts

Panel Regression Results

Regression Coefficients follows hump shape

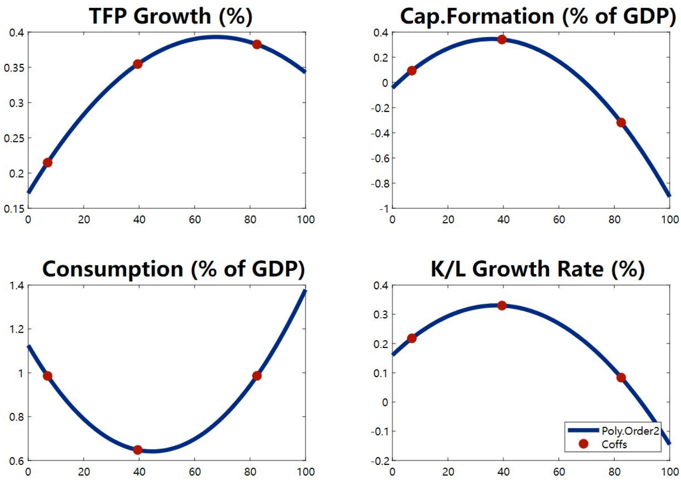


Figure: 3 cohorts: [0, 14], [15,64], [64,+)

Similar hump shape for 4 cohorts and 5 cohorts:

4 cohorts: [0,24], [25,49], [50,74], [75, +) ▸ 4 cohorts

5 cohorts: [0, 19], [20,39], [40,59], [60,79], [80,+) ▸ 5 cohorts

Panel Regression Results

Under different cohort structure

	Average value in the future 4 years											
VARIABLES	TFP growth rate			Cap.Formation(% GDP)			Gross.Consumption(% GDP)			K/L growth rate		
Different age intervals:	3 cohorts	4 cohorts	5 cohorts	3 cohorts	4 cohorts	5 cohorts	3 cohorts	4 cohorts	5 cohorts	3 cohorts	4 cohorts	5 cohorts
3 cohorts:	21.48***	26.22***	25.36***	9.34	16.69***	15.40**	98.55***	92.44***	92.98***	21.77***	24.08***	22.11***
[0, 14], [15,64], [64,+)	(3.61)	(4.24)	(4.08)	(0.98)	(2.64)	(2.32)	(9.21)	(14.84)	(12.62)	(3.69)	(4.50)	(4.02)
	35.46***	34.48***	31.80***	34.10***	29.11***	26.71**	64.81***	60.55***	71.18***	32.98***	39.21***	36.72***
4 cohorts:	(5.19)	(4.28)	(4.35)	(6.74)	(4.14)	(2.52)	(9.15)	(5.58)	(5.39)	(5.32)	(5.36)	(5.30)
[0,24], [25,49], [50,74],	38.25***	43.60***	34.74***	-31.87	37.83**	20.39	98.58***	59.95***	43.58*	8.34	19.18	27.00***
[75, +)	(3.42)	(4.41)	(3.46)	(-1.30)	(2.05)	(1.13)	(2.95)	(3.23)	(1.85)	(0.61)	(1.66)	(2.98)
		13.47	55.17***		-124.60***	53.93**		150.74***	100.97**		4.22	21.25
5 cohorts:		(0.90)	(5.35)		(-2.77)	(2.37)		(3.21)	(2.47)		(0.24)	(1.41)
[0, 19], [20,39], [40,59],			-21.89			-224.74***			126.47*			-9.87
[60,79], [80,+)			(-1.08)			(-3.07)			(1.75)			(-0.33)
Trade Cost										-0.83**	-0.83**	-0.79**
										(-2.13)	(-2.11)	(-2.00)
Initial.Log	-3.46***	-3.51***	-3.51***							-1.99***	-1.98***	-1.93***
.Dependent	(-4.77)	(-4.49)	(-4.55)							(-3.45)	(-3.21)	(-3.14)
PoP.Growth										-33.14*	-35.31**	-30.58
										(-1.84)	(-2.08)	(-1.64)
Observations	732	732	732	724	724	724	725	725	725	758	758	758
R-squared	0.266	0.263	0.272	0.971	0.972	0.972	0.996	0.996	0.996	0.785	0.787	0.787
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Back

Panel Regression Results

Coefficients of different cohort

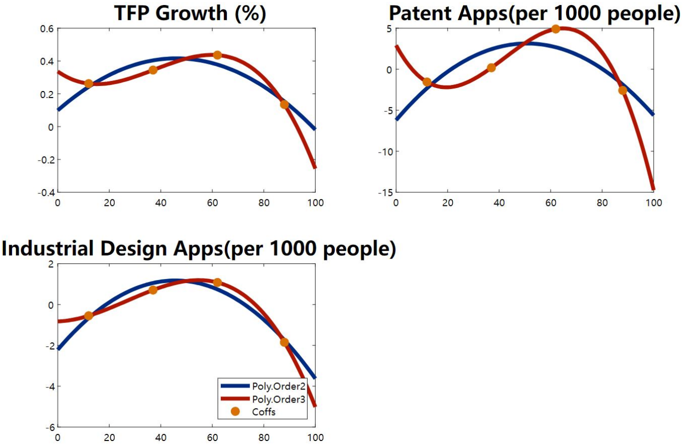


Figure: 4 cohorts

Back

BACK

Panel Regression Results

Coefficients of different cohort

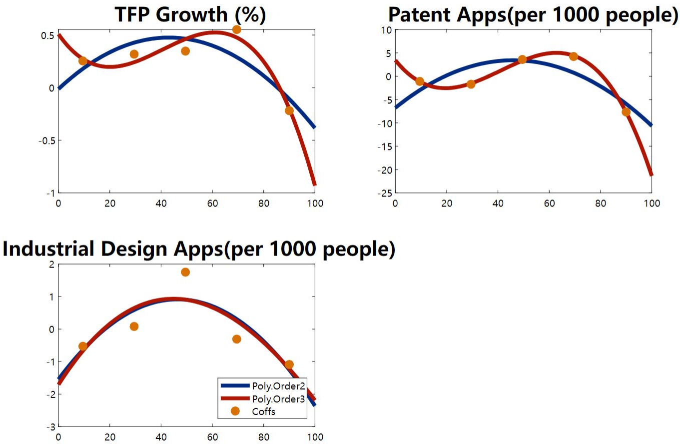


Figure: 5 cohorts

Back

BACK

Panel Regression Results

Coefficients of different cohort

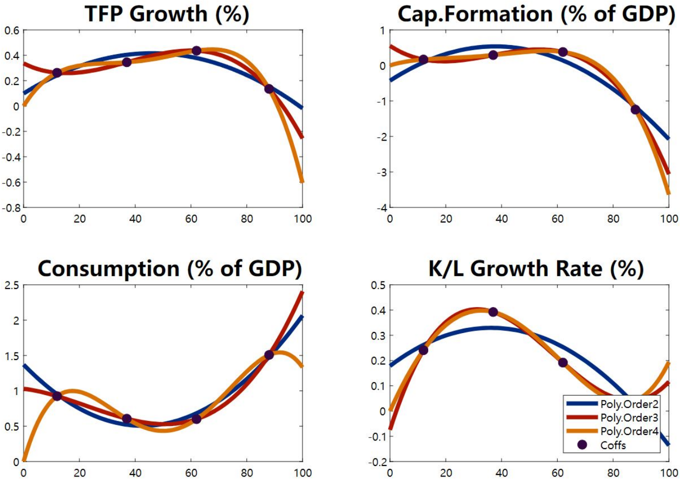


Figure: 4 cohorts

◂ Back

◂ BACK

Panel Regression Results

Coefficients of different cohort

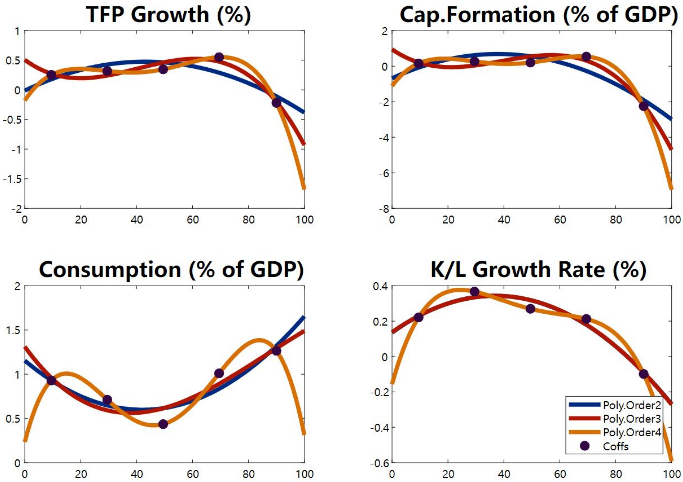


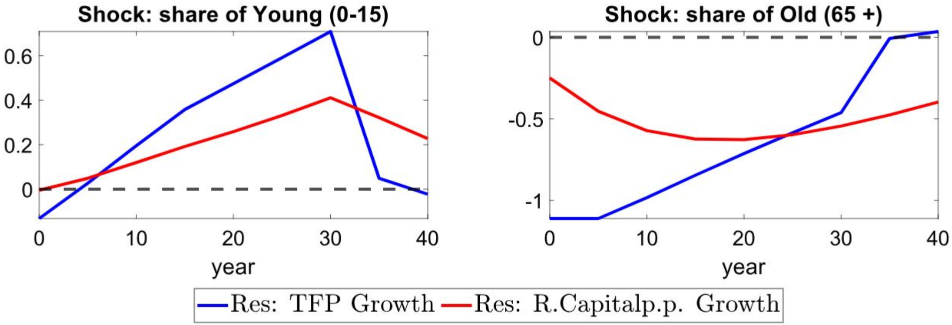
Figure: 5 cohorts

Back

BACK

Panel VARX model

IRF of exogenous shock on
I.TFP growth; **II**. Growth rate of real capital stock per person

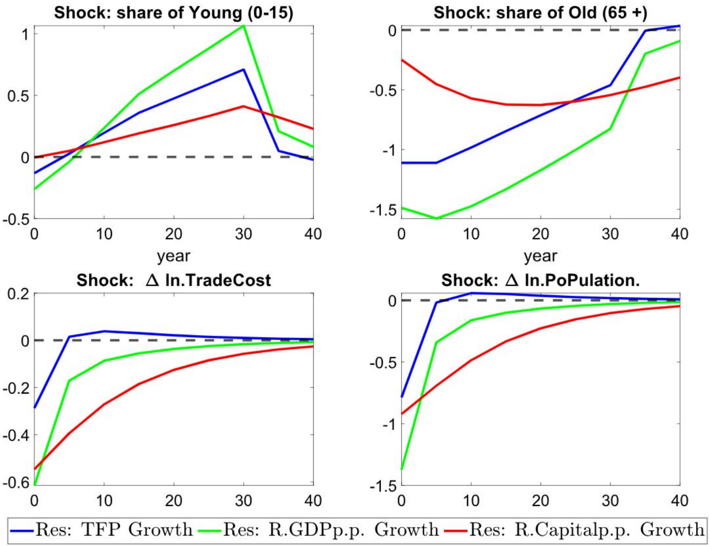


Back

Panel VARX model

IRF of exogenous shock on

I.TFP growth, **II**. Growth rate of Real GDP per person, **III**. Growth rate of real capital stock per person



▸ Back

Definition

A competitive equilibrium in the perfect foresight overlapping generations trade model with E+G-period lived agents and exogenous population dynamics, is defined as a series of capital distribution $\{b_{n,g+1,t+1}\}_{g=E+1,n}^{E+G-1}$ and rental rates $R_{t,n}$ and wage rates $W_{t,n}$ satisfies the following conditions:

- The households at different ages taking prices, transfer and deficit as given, optimize lifetime utility
- Firms taking prices as given, minimize production cost
- Each country purchases intermediate varieties from the least costly supplier/country subject to the trade cost
- All markets are clear.

Back
Equations

Model

Transitional Dynamics (1/2)

Table: Dynamic equilibrium conditions (1/2)

H1	$L_{n,t} \equiv \sum_{g=1}^{E+G} \eta_{n,g,t}$; $\bar{L}_{n,t} \equiv \sum_{g=E+1}^{E+G} \eta_{n,g,t}$; $N_{n,t} = \sum_{g=E+1}^{E+G} \eta_{n,g,t} l_g$	$\forall(n,t)$
H2	$P_{n,C,t} c_{n,g,t} + P_{n,I,t} i_{n,g,t} = R_{n,t} b_{n,g,t} + W_{n,t} l_g + \frac{TRS_{n,t}}{\bar{L}_{n,t}} + \frac{D_{n,t}}{\bar{L}_{n,t}}$ for $\forall g \geq E+1$	$\forall(n,t)$
H2'	$P_{n,C,t} c_{n,g,t} + P_{n,I,t} b_{n,g+1,t+1} = \left(1 + \frac{R_{n,t}}{P_{n,I,t}} - \delta\right) P_{n,I,t} b_{n,g,t} + W_{n,t} l_g + \frac{TRS_{n,t}}{\bar{L}_{n,t}} + \frac{D_{n,t}}{\bar{L}_{n,t}}$ for $\forall g \geq E+1$	$\forall(n,t)$
H3	$b_{g+1,t+1} = i_{g,t} + (1-\delta) b_{g,t}$, $b_{n,E+1,t} = b_{n,E+G+1,t} = 0$, $c_{n,E+g,t} > 0$, $\{c_{n,g,t+g-1}\}_{g=E+1}^{E+G}$, $\{b_{n,g+1,t+g}\}_{g=E+1}^{E+G-1}$	$\forall(n,t)$
H4	$TRS_{n,t} = P_{n,I,t} \left(1 + \frac{R_{n,t}}{P_{n,I,t}} - \delta\right) \sum_{g=E+2}^{E+S} (\eta_{n,g-1,t-1} - \eta_{n,g,t}) b_{n,g,t}$	$\forall(n,t)$
H5	$\left(\frac{c_{n,g+1,t+g}}{c_{n,g,t+g-1}}\right)^{1/\sigma} = \beta \left(1 + \frac{R_{n,t+g}}{P_{n,I,t+g}} - \delta\right) \frac{\frac{P_{n,I,t+g}}{P_{n,C,t+g}}}{\frac{P_{n,I,t+g-1}}{P_{n,C,t+g-1}}}$ for $\forall\ g \in [E+1, E+G-1]$	$\forall(n,t)$
H6	$C_{n,t} = \sum_{g=E+1}^{E+G} \eta_{n,g,t} c_{n,g,t}$; $I_{n,t} = \sum_{g=E+1}^{E+G} \eta_{n,g,t} i_{n,g,t}$; $K_{n,t} = \sum_{g=E+1}^{E+G} \eta_{n,g-1,t-1} b_{n,g,t}$	$\forall(n,t)$
F1	$W_{n,t} N_{n,t} = \sum_{j=1}^{J} \beta_n^j \gamma_n^j \sum_{i=1}^{N} \pi_{in,t}^j X_{i,t}^j$	$\forall(n,t)$
F2	$R_{n,t} K_{n,t} = \sum_{j=1}^{J} \left(1 - \beta_n^j\right) \gamma_n^j \sum_{i=1}^{N} \pi_{in,t}^j X_{i,t}^j$	$\forall(n,t)$

Model

Transitional Dynamics (2/2)

Table: Dynamic equilibrium conditions (2/2)

F3	$X_{n,t}^{j} = \alpha_{C,n}^{j} P_{C,n,t} C_{n,t} + \alpha_{I,n}^{j} P_{I,n,t} I_{n,t} + \sum_{k=1}^{J} \gamma_{n}^{j,k} \left(\sum_{i=1}^{N} X_{in,t}^{k} \right)$	$\forall(n,j,t)$
F4	$P_{n,t}^{j} I_{n}^{j} = \alpha_{I,n}^{j} P_{I,n,t} I_{n,t};\ P_{n,t}^{j} C_{n}^{j} = \alpha_{C,n}^{j} P_{C,n,t} C_{n,t}$	$\forall(n,j,t)$
F5	$IN_{n,t} \equiv R_{n,t} K_{n,t} + W_{n,t} N_{n,t} + D_{n,t} = P_{C,n,t} C_{n,t} + P_{I,n,t} I_{n,t}$	$\forall(n,t)$
T1	$c_{n,t}^{j} \equiv \Upsilon_{n}^{j} \left[\left(W_{n,t}^{j} \right)^{\beta_{n}^{j}} \left(R_{n,t}^{j} \right)^{1-\beta_{n}^{j}} \right]^{\gamma_{n}^{j}} \prod_{k=1}^{J} P_{n,t}^{k\ \gamma_{n}^{k,j}}$ where $\Upsilon_{n}^{j} \equiv \gamma_{n}^{j} \beta_{n}^{j\ -\gamma_{n}^{j} \beta_{n}^{j}} \gamma_{n}^{j} \left(1 - \beta_{n}^{j} \right)^{-\gamma_{n}^{j} \left(1-\beta_{n}^{j}\right)} \prod_{k=1}^{J} \gamma_{n}^{k,j\ -\gamma_{n}^{k,j}}$	$\forall(n,j,t)$
T2	$P_{n,t}^{j} = A \cdot \left[\sum_{i=1}^{N} \lambda_{i,t}^{j} \left(\kappa_{ni,t}^{j} c_{i,t}^{j} \right)^{-\theta} \right]^{-\frac{1}{\theta}}$ where $A \equiv \Gamma \left(\frac{1+\theta-\sigma}{\theta} \right)^{\frac{1}{(1-\sigma)}}$	$\forall(n,j,t)$
T3	$\pi_{ni,t}^{j} = \frac{\lambda_{i,t}^{j} \left(c_{i,t}^{j} \kappa_{ni,t}^{j} \right)^{-\theta}}{\sum_{m=1}^{N} \lambda_{m,t}^{j} \left(c_{m,t}^{j} \kappa_{nm,t}^{j} \right)^{-\theta}} = \lambda_{i,t}^{j} \left(\frac{A^{j} c_{i,t}^{j} \kappa_{ni,t}^{j}}{P_{n,t}^{j}} \right)^{-\theta}$	$\forall(n,i,j,t)$
T4	$P_{n,C,t} C_{n,t} + P_{n,I,t} I_{n,t} = R_{n,t} K_{n,t} + W_{n,t} N_{n,t} + D_{n,t}$	$\forall(n,t)$
T4'	$P_{n,C,t} C_{n,t} + P_{n,I,t} K_{n,t+1} = \left(1 + \frac{R_{n,t}}{P_{n,I,t}} - \delta \right) P_{n,I,t} K_{n,t} + W_{n,t} N_{n,t} + D_{n,t}$	$\forall(n,t)$
T5	$K_{n,t+1} = I_{n,t} + (1-\delta) K_{n,t}$	$\forall(n,t)$
T6	$\sum_{j=1}^{J} \sum_{i=1}^{N} X_{in,t}^{j} - \sum_{j=1}^{J} \sum_{i=1}^{N} X_{ni,t}^{j} = NX_{n,t} = -D_{n,t}$	$\forall(n,j,t)$
T7	$D_{n,t} = -\phi_{n,t} \left(R_{n,t} K_{n,t} + W_{n,t} N_{n,t} \right) + \bar{L}_{n,t} T_{t}^{P}$	$\forall(n,t)$
T8	$\sum_{n=1}^{N} \phi_{n,t} \left(R_{n,t} K_{n,t} + W_{n,t} N_{n,t} \right) = \sum_{n=1}^{N} \bar{L}_{n,t} T_{t}^{P}$	$\forall(n,t)$

◂ Equations