Structural Transformation and Aggregate Productivity in China

Junmin Liao
Ande Shen

Wuhan University

Nov 9, 2017

Background

- Unprecedented growth during the past thirty decades
- This impressive growth performance accompanied important structural transformations:

$$\frac{Y}{L} = \sum_{i} \frac{L_i}{L} \frac{Y_i}{L_i},\ i \in \{a, m, s\}$$

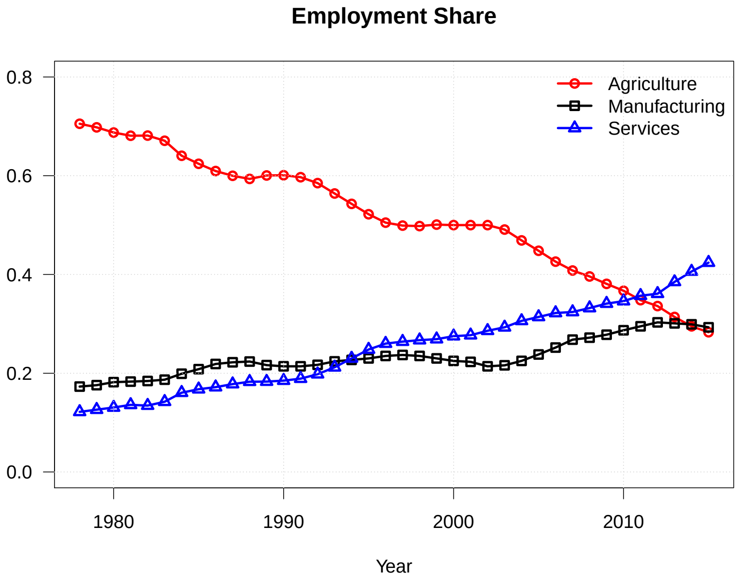
Motivation

- What theories can account for the facts of structural transformation in China?
- Help understanding the role of structural transformation in China's productivity growth.
- Help understanding China's growth miracle in the past and growth potential in the future.

Introduction

- Test major structural change models with data:
  - Generalized Stone-Geary preference
  - Non-homothetic CES preference
  - Price independent generalized linearity preference
- Measure sectoral labor productivity using the Non-homothetic CES preference

Facts of Structural Transformation in China



Traditional Structural Change Theory

- Generalized Stone-Geary utility function:

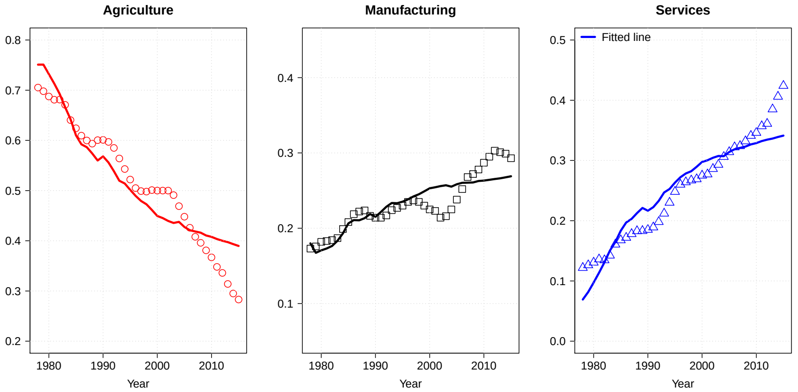
$$u(c) = \left[\phi_a (c_a + \bar{c}_a)^{\frac{\epsilon-1}{\epsilon}} + \phi_m (c_m + \bar{c}_m)^{\frac{\epsilon-1}{\epsilon}} + \phi_s (c_s + \bar{c}_s)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}},$$

where $\phi_i \in (0,1)$ and $\sum_i \phi_i = 1$.

  - Stone-Geary parameter: $\bar{c}_a < 0$, $\bar{c}_m = 0$, $\bar{c}_s > 0$
  - Elasticity of substitution: $0 < \epsilon < 1$
  - Equilibrium

$$\frac{L_i}{L} = \frac{\phi_i p_i^{1-\epsilon}}{\sum_i \phi_i p_i^{1-\epsilon}} \left(1 + \frac{\sum_i p_i \bar{c}_i}{\sum p_i c_i}\right) - \frac{p_i \bar{c}_i}{\sum_i p_i c_i}$$

Disadvantages of Generalized Stone-Geary Utility



Alternative Theories

- Boppart (2014), Alder et al (2017): Price independent generalized linearity preference (PIGL)
- $$v\left(e,p\right)=\frac{1}{\epsilon}\left[\frac{e-f_1\left(p\right)}{f_2\left(p\right)}\right]^{\epsilon}-\frac{1}{\epsilon}+f_3\left(p\right),$$

  where

  $$\begin{aligned} f_1\left(p\right)&=\tau p_a^{1-\rho}p_s^{\rho} \\ f_2\left(p\right)&=p_m^{1-\theta}p_s^{\theta} \\ f_3\left(p\right)&=-\left(\frac{\gamma_1}{\psi_1}\left[\frac{p_a}{p_s}\right]^{\psi_1}+\frac{\gamma_2}{\psi_2}\left[\frac{p_m}{p_s}\right]^{\psi_2}\right) \end{aligned}$$

Alternative Theories

- Comin et al (2015): Non-homothetic CES preference

$$\phi_a^{\frac{1}{\epsilon}} c^{\frac{\mu_a - \epsilon}{\epsilon}} c_a^{\frac{\epsilon-1}{\epsilon}} + \phi_m^{\frac{1}{\epsilon}} c^{\frac{\mu_m - \epsilon}{\epsilon}} c_m^{\frac{\epsilon-1}{\epsilon}} + \phi_s^{\frac{1}{\epsilon}} c^{\frac{\mu_s - \epsilon}{\epsilon}} c_s^{\frac{\epsilon-1}{\epsilon}} = 1$$

  - μ_i: income elasticity parameter for good i (CES if $\mu_i = 1$)
  - Constant elasticity of the relative demand for two different goods with respect to aggregate consumption:

$$\frac{\partial \ln (c_i/c_j)}{\partial \ln c} = \mu_i - \mu_j$$

  - Constant elasticity of substitution:

$$\frac{\partial \ln (c_i/c_j)}{\partial \ln (p_j/p_i)} = \epsilon$$

Model Assessment

- Non-homothetic CES

$$\frac{L_i}{L_j} = \frac{\phi_i}{\phi_j}\left(\frac{p_i}{p_j}\right)^{1-\epsilon} c^{\mu_i-\mu_j}$$

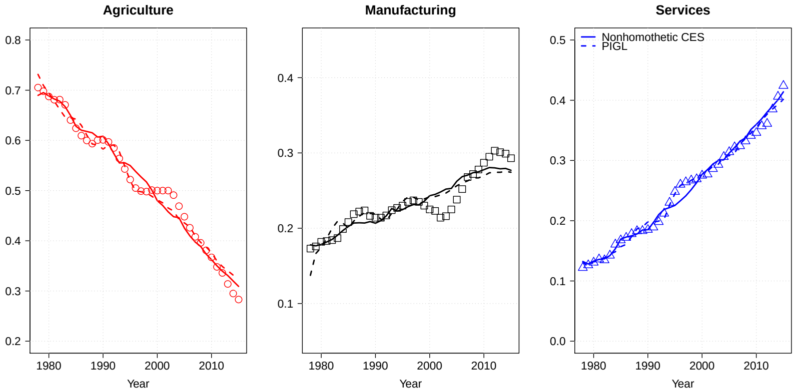
- PIGL

$$\frac{L_a}{L} = (1-\rho)\frac{f_1(p)}{e} + \gamma_1\left(\frac{p_a}{p_s}\right)^{\psi_1}\left[\frac{e-f_1(p)}{f_2(p)}\right]^{1-\epsilon}\frac{f_2\,(p)}{e}$$

$$\frac{L_m}{L} = -(1-\theta)\frac{f_1(p)}{e} + (1-\theta) + \gamma_2\left[\frac{p_m}{p_s}\right]^{\psi_2}\left[\frac{e-f_1(p)}{f_2(p)}\right]^{1-\epsilon}\frac{f_2\,(p)}{e}$$

$$\frac{L_s}{L} = -(\rho-\theta)\frac{f_1(p)}{e} + \theta - \left(\gamma_1\left[\frac{p_a}{p_s}\right]^{\psi_1} + \gamma_2\left[\frac{p_m}{p_s}\right]^{\psi_2}\right)\left[\frac{e-f_1(p)}{f_2(p)}\right]^{1-\epsilon}\frac{f_2\,(p)}{e}$$

Fitting Results



Fitting Results

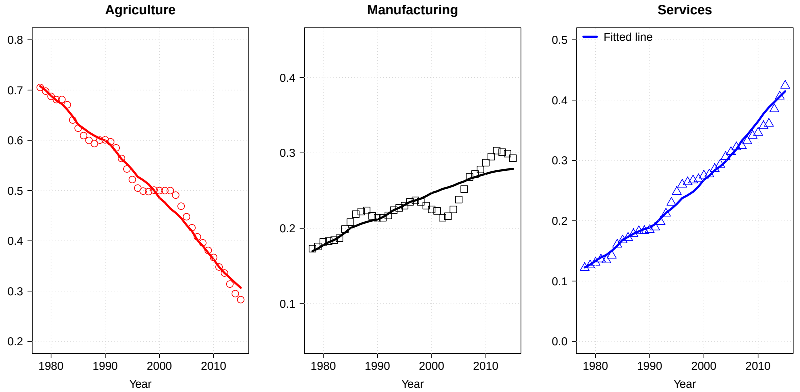
- Assessment

	(1)	(2)	(3)
SSR	0.04717	0.01282	0.01369
k	5	5	8
AICc	-5.04	-6.34	-5.94

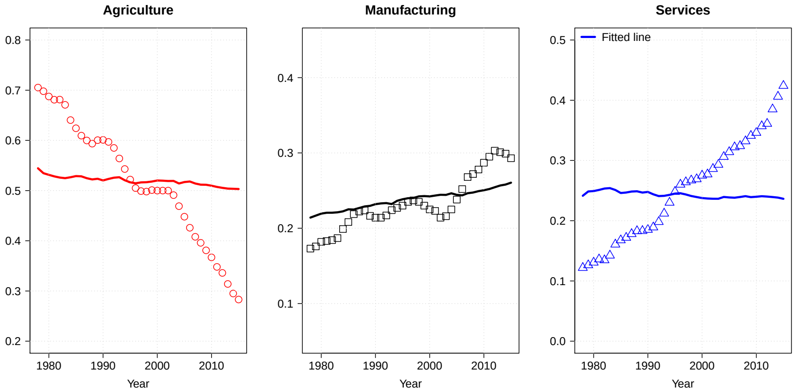
(1): Stone-Geary CES; (2): Non-homothetic CES; (3) PIGL

- Verdicts: Non-homothetic CES

Income Effect



Price Effect



The Quantitative Model

- Preferences

$$\max \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma},$$

s.t.

$$\sum_{i\in\{a,m,s\}} \phi_i^{\frac{1}{\epsilon}} c^{\frac{\mu_i-\epsilon}{\epsilon}} c_i^{\frac{\epsilon-1}{\epsilon}} = 1,$$

and

$$a_{t+1} + \sum_i p_{it} c_{it} = w_t + (1 + r_t)\, a_t$$

- Technologies:

$$Y_i = A_i L_i$$

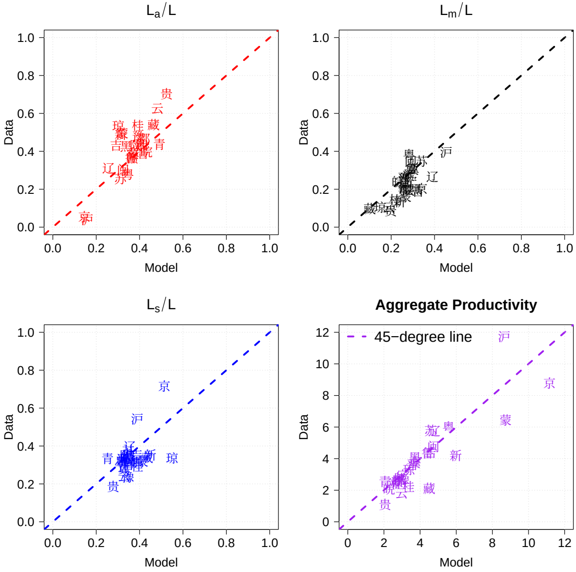
- Equilibrium:

$$\frac{L_i}{L} = \phi_i c^{\mu_i - \epsilon} A_i^{\epsilon-1}$$

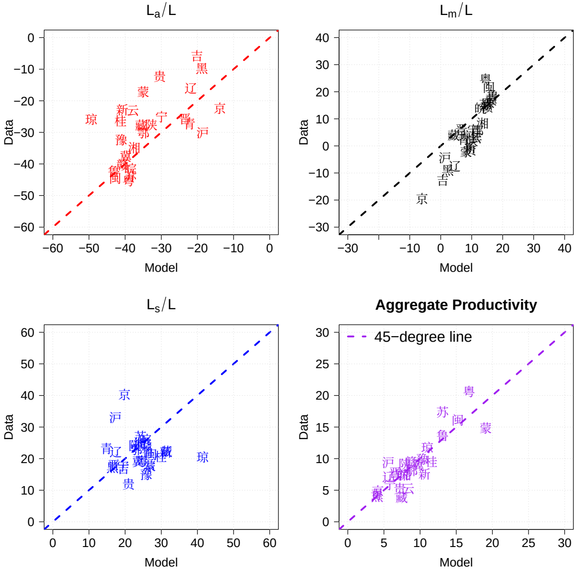
Calibration

Parameter	Value	Description
ϕ_a	0.41	weight of agricultural sector
ϕ_s	0.30	weight of service sector
ϵ	0.68	elasticity of substitution
μ_a	0.79	income elasticity parameter of agriculture
μ_m	2.40	income elasticity parameter of manufacturing
μ_s	2.82	income elasticity parameter of services

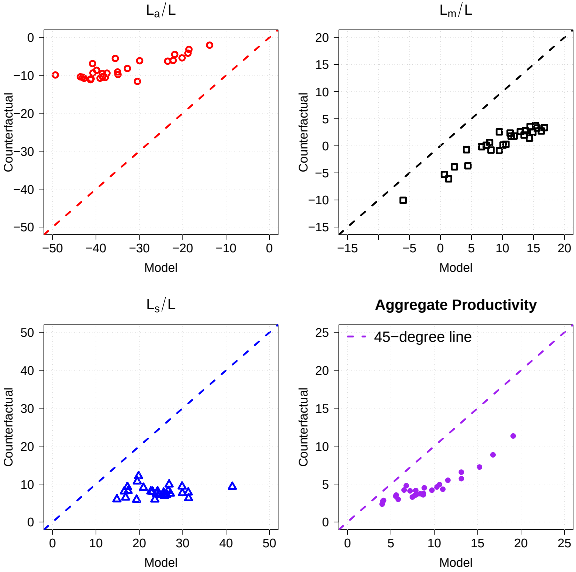
Calibration Assessment: Last Period



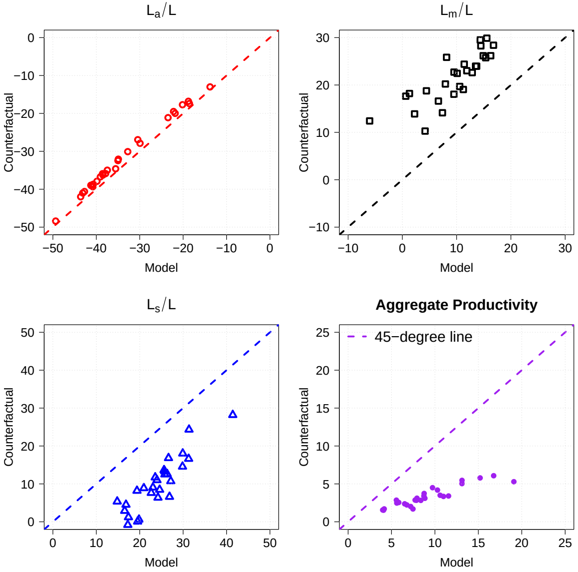
Calibration Assessment: Changes



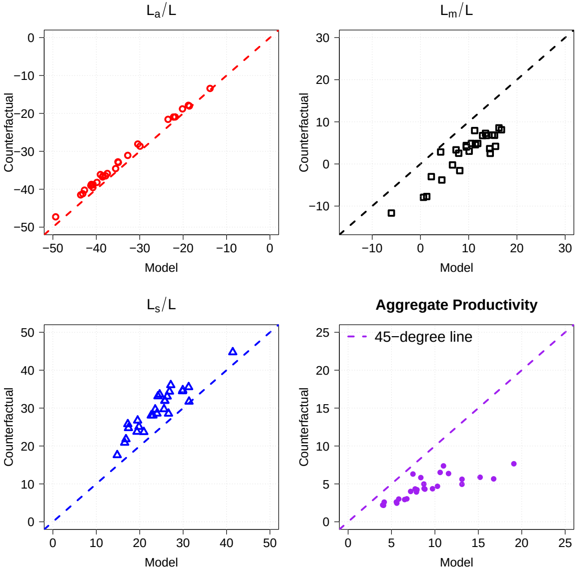
Counterfactual Analysis: $\gamma_a = 0$



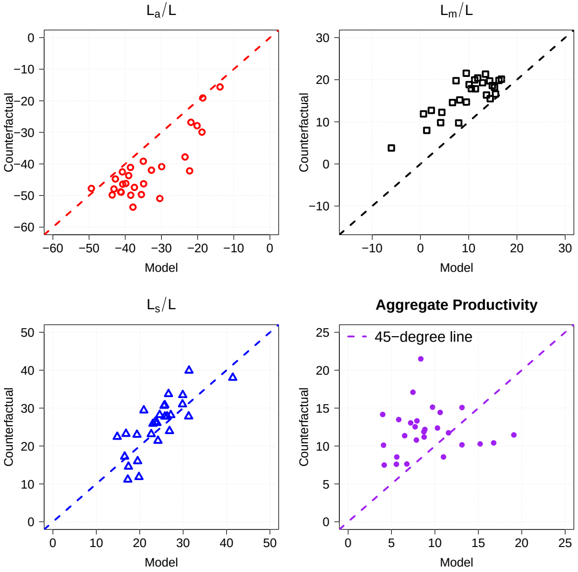
Counterfactual Analysis: $\gamma_m = 0$



Counterfactual Analysis: $\gamma_s = 0$



Counterfactual Analysis: $\gamma_i = \gamma^{national}$



Counterfactual Analysis

	Change in labor share			Change in aggregate productivity	
	Agriculture	Manufacturing	Services	Total	annualized rate (%)
Model	-33.75	9.59	24.17	9.11	7.79
Counterfactual:					
(1) $\gamma_a = 0$	-8.19	0.22	7.97	4.61	5.76
(2) $\gamma_m = 0$	-31.67	21.56	10.12	3.32	4.85
(3) $\gamma_s = 0$	-32.07	2.51	29.55	4.53	5.73
(4) $\gamma_i = \gamma^{national}$	-41.74	16.09	25.65	11.98	8.83

Counterfactual Analysis

	Change in labor share			Change in aggregate productivity	
	Agriculture	Manufacturing	Services	Total	Annualized rate (%)
Model	-33.75	9.59	24.17	9.11	7.79
Counterfactual:					
(1) $\gamma_a = \gamma_a^{national}$	-31.59	8.89	22.71	8.54	7.63
(2) $\gamma_m = \gamma_m^{national}$	-33.60	10.99	22.60	8.02	7.44
(3) $\gamma_s = \gamma_s^{national}$	-33.52	8.34	25.18	7.70	7.39
(4) $\gamma_i = \gamma_i^{national}$	-31.15	9.01	22.14	6.49	6.85

Counterfactual Analysis: by Groups

- By growth rate (GDP per capita from 1978 to 2008):
  - high (9.40% on average): Guangdong, Jiangsu, Fujian, Inner Mongolia, Shandong, Shanghai, Hebei, Hainan
  - median (7.63% on average): Xinjiang, Hubei, Hunan, Jiangxi, Shanxi, Shaanxi, Anhui, ...
  - low (5.95% on aerage): Ningxia, Heilongjiang, Qinghai, Guizhou

Counterfactual Analysis: High Growth Rate

	Change in labor share			Change in aggregate productivity	
	Agriculture	Manufacturing	Services	Total	annualized rate (%)
Model	-38.28	11.85	26.43	12.95	9.01
Counterfactual:					
(1) $\gamma_a = 0$	-9.04	1.01	8.04	6.46	6.74
(2) $\gamma_m = 0$	-36.30	25.81	10.48	4.80	5.97
(3) $\gamma_s = 0$	-36.33	2.53	33.80	5.52	6.34
(4) $\gamma_i = \gamma^{national}$	-41.21	15.59	25.62	11.08	8.59

Counterfactual Analysis: High Growth Rate

	Change in labor share			Change in aggregate productivity	
	Agriculture	Manufacturing	Services	Total	annualized rate (%)
Model	-38.28	11.85	26.43	12.95	9.01
Counterfactual:					
(1) $\gamma_a = \gamma_a^{national}$	-31.72	9.60	22.13	11.30	8.53
(2) $\gamma_m = \gamma_m^{national}$	-38.01	14.42	23.60	10.44	8.36
(3) $\gamma_s = \gamma_s^{national}$	-37.62	8.44	29.17	8.93	7.88
(4) $\gamma_i = \gamma_i^{national}$	-30.63	8.61	22.02	5.96	6.62

Counterfactual Analysis: Median Growth Rate

	Change in labor share			Change in aggregate productivity	
	Agriculture	Manufacturing	Services	Total	annualized rate (%)
Model	-33.58	8.95	24.63	8.08	7.55
Counterfactual:					
(1) $\gamma_a = 0$	-8.05	-0.08	8.13	4.04	5.51
(2) $\gamma_m = 0$	-31.58	20.65	10.93	2.90	4.58
(3) $\gamma_s = 0$	-31.98	2.54	29.44	4.46	5.72
(4) $\gamma_i = \gamma^{national}$	-42.24	15.86	26.38	12.27	8.89

Counterfactual Analysis: Median Growth Rate

	Change in labor share			Change in aggregate productivity	
	Agriculture	Manufacturing	Services	Total	annualized rate (%)
Model	-33.58	8.95	24.63	8.08	7.55
Counterfactual:					
(1) $\gamma_a = \gamma_a^{national}$	-31.85	8.37	23.48	7.74	7.42
(2) $\gamma_m = \gamma_m^{national}$	-33.45	10.15	23.31	7.49	7.29
(3) $\gamma_s = \gamma_s^{national}$	-33.49	8.31	25.17	7.56	7.35
(4) $\gamma_i = \gamma_i^{national}$	-31.60	8.90	22.70	6.77	6.94

Counterfactual Analysis: Low Growth Rate

	Change in labor share			Change in aggregate productivity	
	Agriculture	Manufacturing	Services	Total	annualized rate (%)
Model	-25.34	7.42	17.92	5.28	6.24
Counterfactual:					
(1) $\gamma_a = 0$	-7.00	-0.24	7.24	3.06	4.74
(2) $\gamma_m = 0$	-22.78	16.44	6.33	1.92	3.60
(3) $\gamma_s = 0$	-23.88	2.40	21.48	2.85	4.54
(4) $\gamma_i = \gamma^{national}$	-40.97	17.97	23.00	12.71	9.09

Counterfactual Analysis: Low Growth Rate

	Change in labor share			Change in aggregate productivity	
	Agriculture	Manufacturing	Services	Total	annualized rate (%)
Model	-25.34	7.42	17.92	5.28	6.24
Counterfactual:					
(1) $\gamma_a = \gamma_a^{national}$	-30.37	9.41	20.96	6.01	6.61
(2) $\gamma_m = \gamma_m^{national}$	-25.34	7.34	18.00	5.20	6.22
(3) $\gamma_s = \gamma_s^{national}$	-25.50	8.26	17.24	5.82	6.58
(4) $\gamma_i = \gamma_i^{national}$	-30.53	10.24	20.29	6.53	6.94