Unbalanced Growth Slowdown

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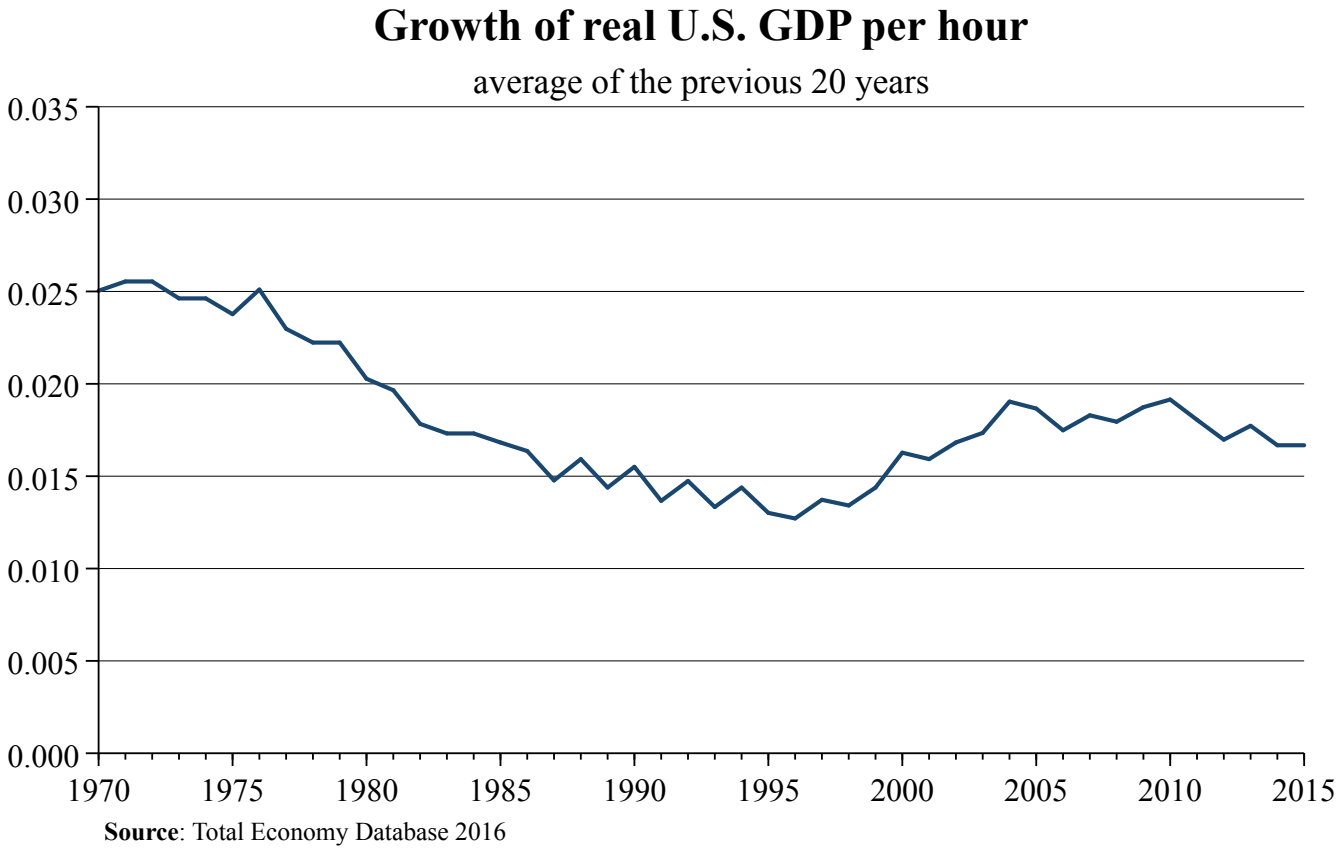
1. Motivation

Economic Scare of the Moment: Productivity Growth Slowdown



Robustness

Lively Debate about Growth Slowdown

- What are the reasons? Is it temporary or permanent?
- Prominent contributions to the debate
  - **Big innovations have been made (sanitation vs. iphone)**
    (Gordon, 2016)
  - **Finite time endowments limit innovation and human–capital accumulation**
    (Fernald and Jones, AER, 2015)
  - **Secular stagnation**
    (more on this in the next talk by Philippon and Jones)

Our Angle on the Debate: Unbalanced Growth Slowdown

- **Unbalanced growth (UBG)**
  - Sectoral productivity growth rates differ.
  - Baumol (AER, 1967): many service industries have low or zero productivity growth.

- **Structural transformation (ST)**
  - Sectoral composition changes when economy grows.
  - Ngai–Pissarides (AER, 2007)
    - reallocation to industries with slow productivity growth;
    - in the limit, the industry with the slowest productivity growth takes over the consumption sector in which ST happens.

- **Unbalanced growth slowdown (UBGS)**
  - ST implies reduction in productivity growth.
  - ST implies zero productivity growth in the consumption sector in the limit, if there is a service sector with zero productivity growth.

Our Contribution to the Debate

What we do

- We build a model of unbalanced growth slowdown.
- The novelty is that it disaggregate services.

What we find

- Effect of UBGS on productivity growth in the last 60 years: 1/4 of overall slowdown.
- Effect of UBGS on productivity growth in next 60 years: much smaller.
- The stagnating service industries won't take over the consumption sector.

2. Evidence on UBGS

Data from WORLD KLEMS

- **Real value added, raw hours, and efficiency hours by sector.**
- **Private US economy after WWII.**
  - Leave out government sector because value added is measured by inputs.
  - Government sector: Public Administration and Defense; Compulsory Social Security.

Quantifying UBGS

- How much more would productivity growth have been without ST?
- We answer this question by using the productivity accounting method of Nordhaus.
- We start with the 30 private industries of WORLD KLEMS.

First way of quantifying UBGS

period	labor productivity growth with	
	actual sector comp.	1947 sector comp.
1950–1970	2.77%	2.94%
1990–2010	1.77%	2.19%
Perc. pt. change	−1	−0.75

Second way of quantifying UBGS

sector composition	labor productivity growth
actual	2.07%
fixed at 1947	2.44% (+0.37 perc. pts)
fixed at 2010	1.72% (−0.35 perc. pts)

Towards a model of UBGS

- The usual three–sector split (agriculture, manufacturing, services) does not capture well what happened, because in developed countries services have a large share and are heterogeneous.
- We focus on the two broad sectors goods and services
  and disaggregate services into those with fast and with slow productivity growth.

Labor Productivity Growth in Private Service Industries 1947–2010

Services with fast productivity growth	Labor productivity per raw hour	Labor productivity per effic. hour
Post and Telecommunications	4.8%	4.5%
Wholesale and Commission Trade, except Motor Vehicles/Cycles	4.0%	3.6%
Sale, Maintenance and Repair of Motor Vehicles/Cycles; Retail Sale of Fuel	3.0%	2.8%
Retail Trade, except Motor Vehicles/Cycles; Repair of Household Goods	2.5%	2.2%
Financial Intermediation	2.3%	1.9%
Transport and Storage	2.0%	1.7%
Renting of Machinery & Equipment and Other Business Activities	1.8%	1.5%
Services with slow productivity growth		
Education	1.1%	0.5%
Real Estate Activities	1.0%	0.5%
Private Households With Employed Persons	0.3%	0.0%
Health and Social Work	-0.1%	-0.4%
Other Community, Social and Personal Services	-0.5%	-0.8%
Hotels and Restaurants	-0.8%	-1.0%

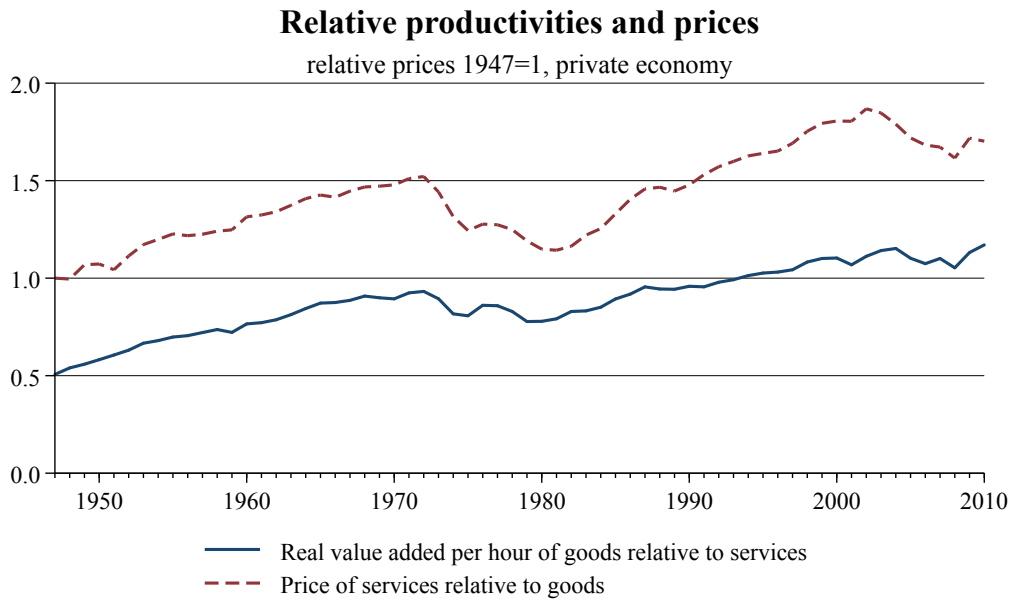
How much of UBGS do different splits of services capture?

	30 industries	13 serv. ind.	fast / slow grow.
1947 sector comp.	2.44%	2.29%	2.31%
2010 sector comp.	1.72%	1.72%	1.73%

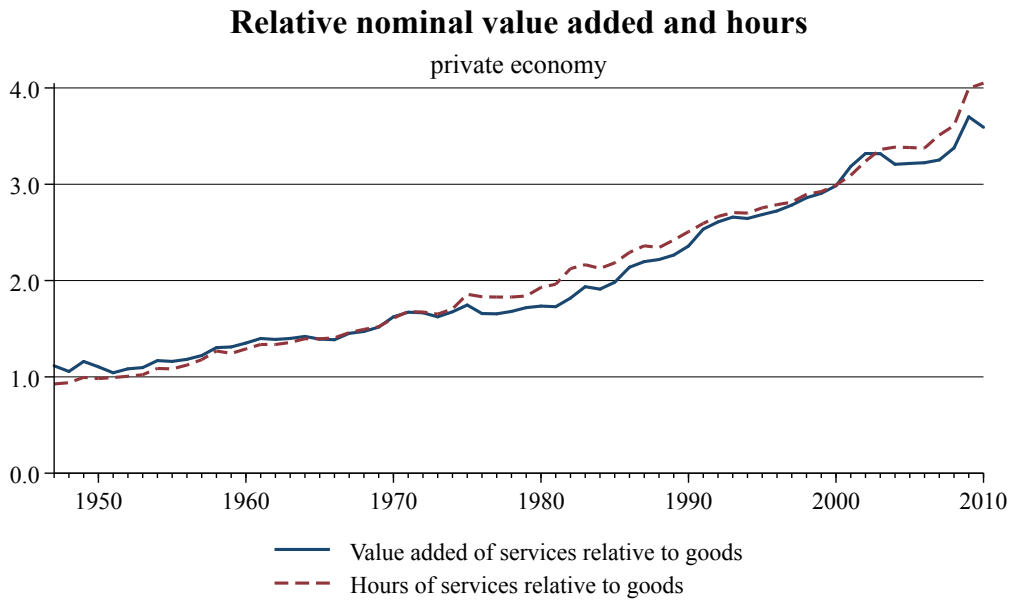
- The UBGS within services accounts for most of the 1947 counterfactual
- The UBGS within services accounts for all of the 2010 counterfactual
- Our two–sector split captures almost all of the UBGS within services

Stylized facts of UBG and ST

Goods vs Services



Source: WORLD KLEMS

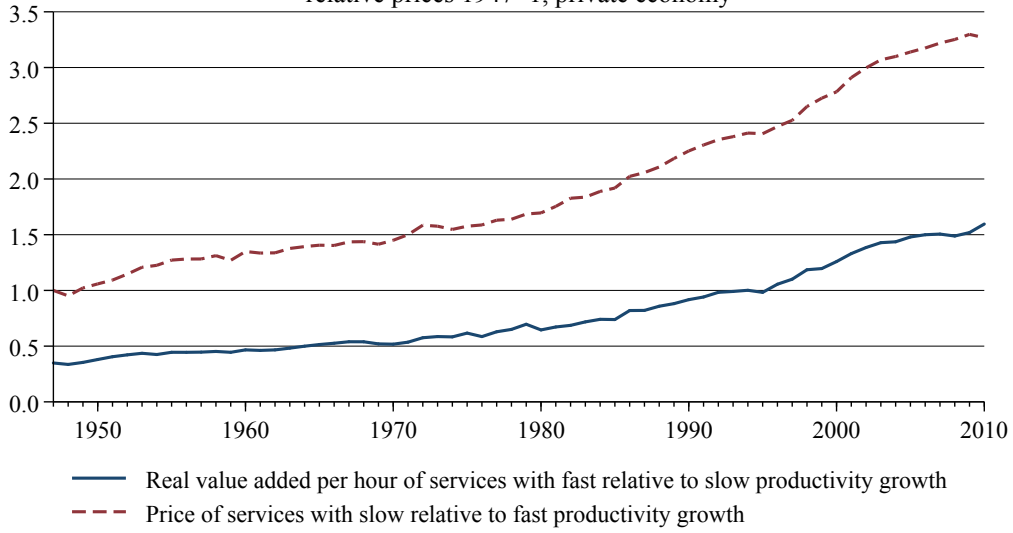


Source: WORLD KLEMS

Services with fast vs slow productivity growth

Relative productivities and prices within services

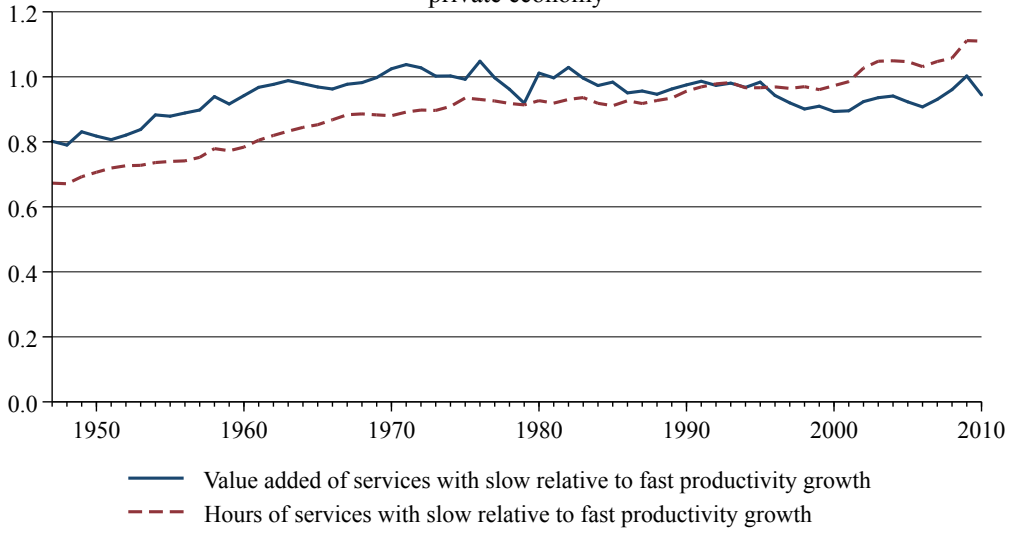
relative prices 1947=1, private economy



Source: WORLD KLEMS

Relative nominal value added and hours within services

private economy



Source: WORLD KLEMS

Discussion

The literature pays little attention to UBGS

- Looks for a GBGP to characterize the equilibrium path
  (Growth measured in units of current numeraire is constant and UBGS is not an issue).
- Focuses on ST and cross–country differences in levels or growth rates of productivity
  (e.g. Duarte and Restuccia 2015, Moro 2015)

We will show for a canonical model of ST

- Growth of welfare and productivity measured in chained prices is slowing.
- Growth of productivity measured in current–period numeraire is constant.

3. Model

Goal: make it as standard as possible

- Sequence of static economies (no capital for now).
- 3 sectors produce goods and services with fast and slow productivity growth.
- Uneven technological progress at the sector level.
- Non–homothetic CES utility with long–run income effects.

Production functions

$$Y_{it} = A_{it} L_{it}, \quad i \in \{g, 1, 2\}$$

- Growth factors

$$\widehat{A}_{it} \equiv \frac{A_{it}}{A_{it-1}}$$

- **Assumption:** Uneven technological progress

$$1 < \widehat{A}_2 < \widehat{A}_1 < \widehat{A}_g$$

Endowments

- One unit of labor that is inelastically supplied.
- Labor can be used in all sectors.

Resource constraints

$$Y_{it} \geq C_{it}, \quad i \in \{g, 1, 2\}$$

$$1 \geq \sum_{i \in \{g,1,2\}} L_{it}$$

Nested non–homothetic CES utility

$$C_t = \left(\alpha_g C_t^{\frac{\varepsilon_g - 1}{\sigma_c}} C_{gt}^{\frac{\sigma_c - 1}{\sigma_c}} + \alpha_s C_t^{\frac{\varepsilon_s - 1}{\sigma_c}} C_{st}^{\frac{\sigma_c - 1}{\sigma_c}} \right)^{\frac{\sigma_c}{\sigma_c - 1}}$$

$$C_{st} = \left(\alpha_1 C_t^{\frac{\varepsilon_1 - 1}{\sigma_s}} C_{1t}^{\frac{\sigma_s - 1}{\sigma_s}} + \alpha_2 C_t^{\frac{\varepsilon_2 - 1}{\sigma_s}} C_{2t}^{\frac{\sigma_s - 1}{\sigma_s}} \right)^{\frac{\sigma_s}{\sigma_s - 1}}$$

- $\varepsilon_g, \varepsilon_s, \varepsilon_1, \varepsilon_2$ determine the size and the sign of the income effect
- if $\varepsilon_g = \varepsilon_s = \varepsilon_1 = \varepsilon_2 = 1$, preferences are homothetic

4. Equilibrium

Result 1: Structural transformation between goods and services

$$\frac{P_{st}C_{st}}{P_{gt}C_{gt}} = \frac{\alpha_s}{\alpha_g}\left(\frac{P_{st}}{P_{gt}}\right)^{1-\sigma_c} C_t^{\varepsilon_s-\varepsilon_g}$$

Assumptions

- Goods and services complements: $0 < \sigma_c < 1$.
- Goods necessities and services luxuries: $\varepsilon_g < 1 < \varepsilon_s$.

Bottom line

- "Business as usual between goods and services"

Result 2: Structural transformation within services

$$\frac{P_{2t}C_{2t}}{P_{1t}C_{1t}} = \frac{\alpha_2}{\alpha_1}\left(\frac{P_{2t}}{P_{1t}}\right)^{1-\sigma_s} C_t^{\varepsilon_2-\varepsilon_1}$$

Assumptions

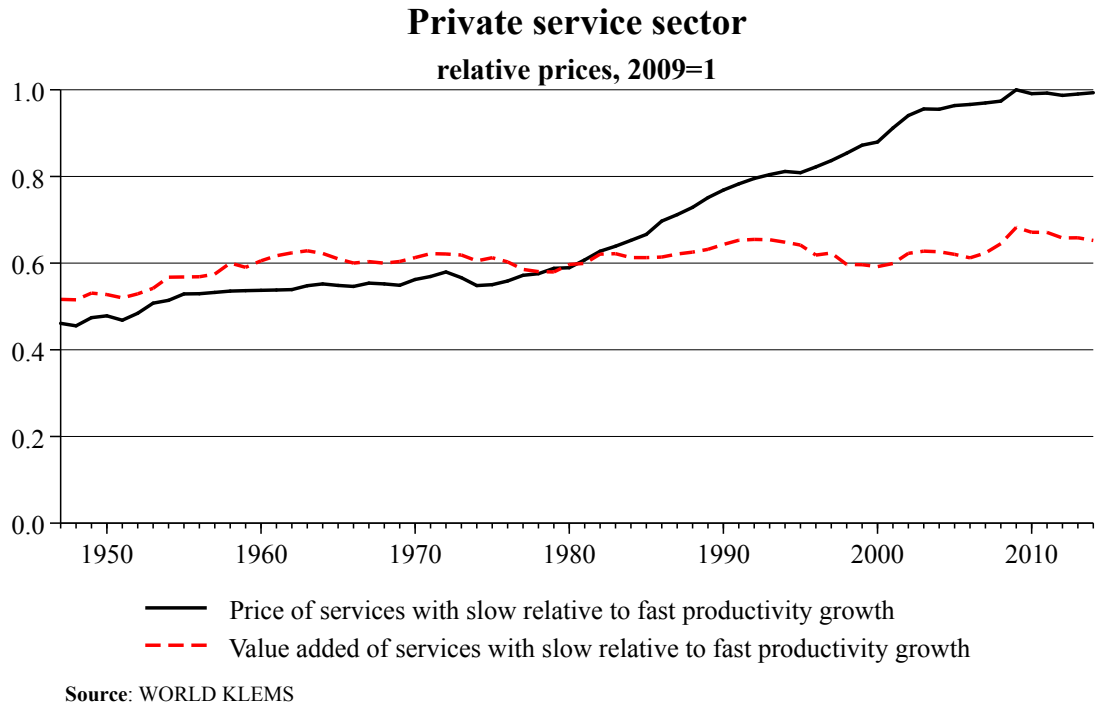
- The two services are substitutes: $\sigma_s > 1$
- Service with fast productivity growth are necessities: $\varepsilon_1 < 1$
- Service with slow productivity growth are luxuries: $\varepsilon_2 > 1$

Bottom line

- It's not clear analytically which service sector takes over in the limit.

Justification of parameter restrictions for the two service sectors

- The two services are substitutes.
- Services with fast productivity growth are necessities.
- Services with slow productivity growth are luxuries.



Source: WORLD KLEMS

Result 3: Unbalanced Growth Slowdown

Proposition

- The equilibrium path has the following properties:
  - Welfare growth declines over time.
  - In units of numeraire current goods, GDP growth is constant (crucial for calculating the equilibrium path).
  - In units of chained prices, GDP growth declines over time.

Bottom line

- Model generates growth slowdown in welfare and GDP if GDP is measured in units of chained prices as in NIPA.

5. Quantitative Analysis

Basic way of proceeding

- Calibrate model to match key features of ST in U.S. postwar economy (1947–2010)
- Simulate model to assess how much growth will slow down in the next decades

Challenge in our context

- The demand system pins down only 2 of the 4 ε_i's (only $\varepsilon_g - \varepsilon_s$ and $\varepsilon_1 - \varepsilon_2$ show up), but simulating the model requires values for all four ε_i's
- Use indirect inference to pin down the other two ε_i's
  (target P_{st}, C_{st}, P_t, C_t while calculating them in the same way in the model and data)

Findings about future growth slowdown

calibration period	predicted aggregate productivity growth (in %)			
	2010–30	2030–50	2050–70	2010–70
1990–2010	1.23	1.20	1.19	1.20

Why was past growth slowdown relatively large?

- Income and substitution effects: strong reallocation from goods to services
- Goods fast productivity growth and services slow productivity growth

Why is future growth slowdown relatively small?

- Income effect: shares of services and slow–growth services increase
- Substitution effect: share of slow–growth services decreases
- Net effect: share of slow–growth services remains roughly constant

Conclusions

- **Our results**
  - ST has reduced the growth of labor productivity in the postwar US.
  - But our canonical model of ST nonetheless predicts limited future growth slowdown services with slow productivity growth do not take over consumption in the limit).
- **Our next steps**
  - Take into account input–output relationships
    (many fast growing services are intermediate inputs, e.g., business services)
  - Use more recent KLEMS data

Appendix

Robustness

Slowdown of GDP per capita

Source: Total Economy Database 2016

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Structural breaks

- Serious econometric tests confirm there was structural break in productivity series
- For example Antolin–Diaz etal (REStat, 2016)

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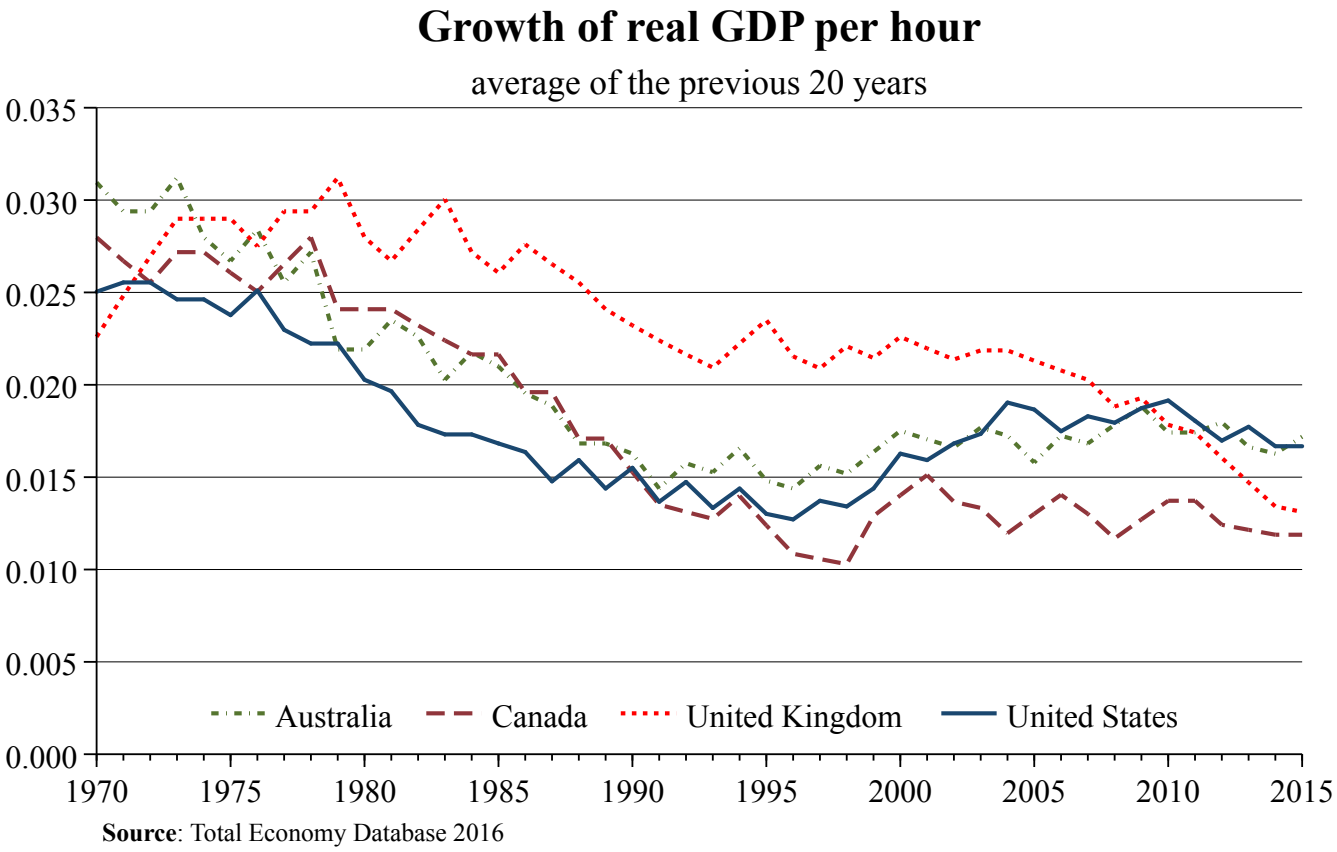
Growth slowdown in other countries

- **Focus on UBGS, avoid growth slowdown resulting from conditional convergence**
  - If initial values of capital are below BGP, transition to BGP leads to growth slowdown
  - France, Germany, Japan (reconstruction booms, growth miracles after WWII)
- **This leaves the English speaking countries for comparison**

Growth slowdown in major English speaking countries



Source: Total Economy Database 2016

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Different ways of splitting services

Note: first column ranks service industries from fastest to slowest productivity growth.

1 = 2 =	Fast Growth Slow Growth	Modern Traditional	Market Non–Market	Low Skill High Skill
Post and Telecom.	1	1	1	1
Wholesale ...	1	1	1	1
Sale ... of Motor Vehicles ...	1	1	1	1
Retail ...	1	1	1	1
Financial ...	1	1	1	2
Transport ...	1	1	1	1
... Business Services	1	1	1	2
Education	2	2	2	2
Real Estate ...	2	2	2	2
Health ...	2	2	2	2
Private Households ...	2	2	1	1
... Personal Services	2	2	1	1
Hotels ...	2	1	1	1

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Key feature 1: Reduces to nested homothetic CES for $\varepsilon_i = 1$

$$C_t = \left(\alpha_g C_{gt}^{\frac{\sigma_c - 1}{\sigma_c}} + \alpha_s C_{st}^{\frac{\sigma_c - 1}{\sigma_c}} \right)^{\frac{\sigma_c}{\sigma_c - 1}}$$

$$C_{st} = \left(\alpha_1 C_{1t}^{\frac{\sigma_s - 1}{\sigma_s}} + \alpha_2 C_{2t}^{\frac{\sigma_s - 1}{\sigma_s}} \right)^{\frac{\sigma_s}{\sigma_s - 1}}$$

Key feature 2: Long–run income effects for $\varepsilon_i \neq 1$

$$C_t = \left(\alpha_g C_t^{\frac{\varepsilon_g - 1}{\sigma_c}} C_{gt}^{\frac{\sigma_c - 1}{\sigma_c}} + \alpha_s C_t^{\frac{\varepsilon_s - 1}{\sigma_c}} C_{st}^{\frac{\sigma_c - 1}{\sigma_c}} \right)^{\frac{\sigma_c}{\sigma_c - 1}}$$

$$C_{st} = \left(\alpha_1 C_t^{\frac{\varepsilon_1 - 1}{\sigma_s}} C_{1t}^{\frac{\sigma_s - 1}{\sigma_s}} + \alpha_2 C_t^{\frac{\varepsilon_2 - 1}{\sigma_s}} C_{2t}^{\frac{\sigma_s - 1}{\sigma_s}} \right)^{\frac{\sigma_s}{\sigma_s - 1}}$$

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Step 1: Calibrate $\left\{\tau_{gt}, \tau_{1t}, \tau_{2t}\right\}_{t=1947}^{2010}$ and $\left\{A_{gt}, A_{1t}, A_{2t}\right\}_{t=1947}^{2010}$

- Set $\tau_{gt} = 0$ and compute $\{\tau_{1t}, \tau_{2t}\}$ by using

$$1 + \tau_{jt} = \frac{\widetilde{VA}_{jt}/\widetilde{L}_{jt}}{\widetilde{VA}_{gt}/\widetilde{L}_{gt}}$$

- Normalize $A_{g1947} = 1$ and obtain $\{A_{gt}\}_{t=1948}^{2010}$ by using:

$$A_{gt} = A_{gt-1}\frac{\widetilde{VA}_{gt}/(\widetilde{P}_{gt}\widetilde{L}_{gt})}{\widetilde{VA}_{gt-1}/(\widetilde{P}_{gt-1}\widetilde{L}_{gt-1})}$$

- Obtain $\{A_{1t}, A_{2t}\}_{t=1947}^{2010}$ by using:

$$\frac{\widetilde{P}_{jt}A_{jt}}{\widetilde{P}_{gt}A_{gt}} = 1 + \tau_{jt}$$

Step 2: Calibrate $\left(\alpha_g, \alpha_s, \alpha_1, \alpha_2 \quad \sigma_c, \sigma_s \quad \epsilon_g, \epsilon_s, \epsilon_1, \epsilon_2\right)$ to match

- Nominal value added shares

$$\left\{ \frac{\widetilde{P}_{2t}\widetilde{C}_{2t}}{\widetilde{P}_{gt}\widetilde{C}_{gt}}, \quad \frac{\widetilde{P}_{2t}\widetilde{C}_{2t}}{\widetilde{P}_{1t}\widetilde{C}_{1t}} \right\}_{t=1947,...,2010}$$

- Slope coefficient of linear regression of $\widetilde{P}_t$ on $\widetilde{C}_t$

- Service share and relative price of services

$$\left\{ \frac{\widetilde{C}_{st}}{\widetilde{C}_t}, \quad \frac{\widetilde{P}_{st}}{\widetilde{P}_t} \right\}_{t=1947,...,2010}$$

Recall functional forms

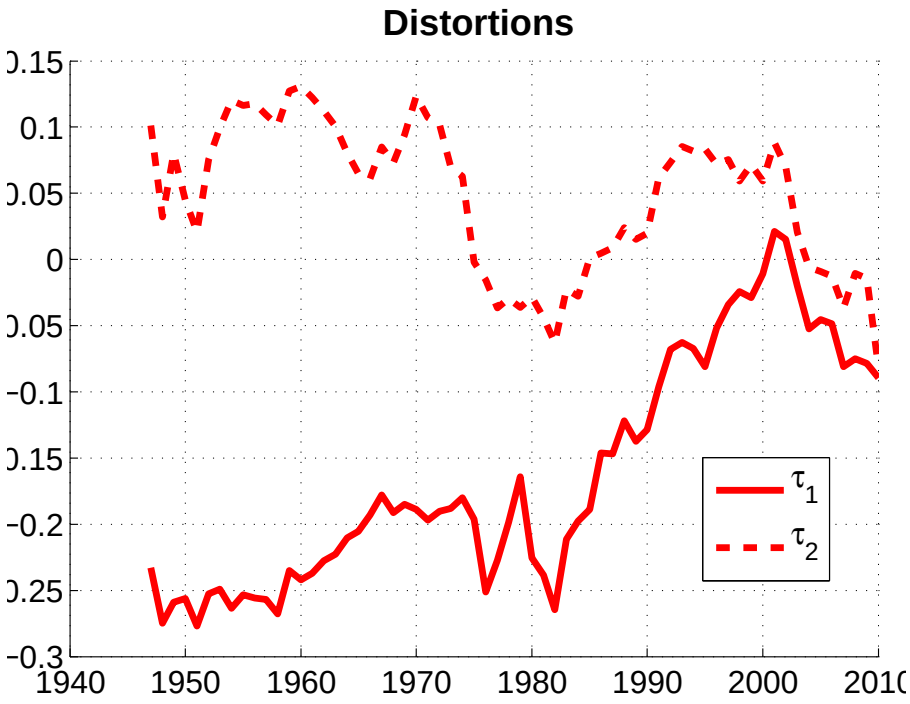
$$P_s = \left(\alpha_1 C^{\varepsilon_1 - 1} P_1^{1-\sigma_s} + \alpha_2 C^{\varepsilon_2 - 1} P_2^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}$$

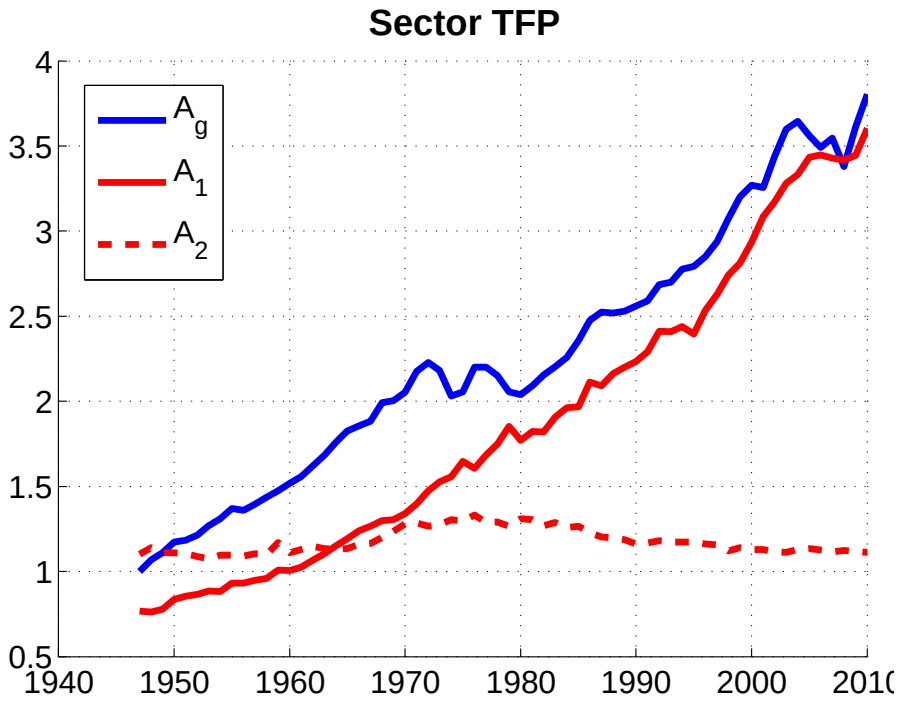
$$P = \left(\alpha_g C^{\varepsilon_g - 1} P_g^{1-\sigma_c} + \alpha_s C^{\varepsilon_s - 1} P_s^{1-\sigma_c} \right)^{\frac{1}{1-\sigma_c}}$$

$$C_s = \left(\alpha_1 C^{\frac{\varepsilon_1 - 1}{\sigma_s}} C_1^{\frac{\sigma_s - 1}{\sigma_s}} + \alpha_2 C^{\frac{\varepsilon_2 - 1}{\sigma_s}} C_2^{\frac{\sigma_s - 1}{\sigma_s}} \right)^{\frac{\sigma_s}{\sigma_s - 1}}$$

$$C = \left(\alpha_g C^{\frac{\varepsilon_g - 1}{\sigma_c}} C_g^{\frac{\sigma_c - 1}{\sigma_c}} + \alpha_s C^{\frac{\varepsilon_s - 1}{\sigma_c}} C_s^{\frac{\sigma_c - 1}{\sigma_c}} \right)^{\frac{\sigma_c}{\sigma_c - 1}}$$

Taxes and Sector TFPs





Calibrated Parameters

α_g	α_s	α_1	α_2	σ_s	σ_c	ε_g	ε_s	ε_1	ε_2
0.54	0.46	0.53	0.47	1.16	0.17	0.50	1.42	0.70	1.14

Key features

- Complementarity between goods and services: $1 > \sigma_c > 0$
- Substitutability between services: $\sigma_s > 1$
- Income effects of goods vs services: $\epsilon_s > 1 > \epsilon_g$
- Income effects within services: $\epsilon_2 > 1 > \epsilon_1$

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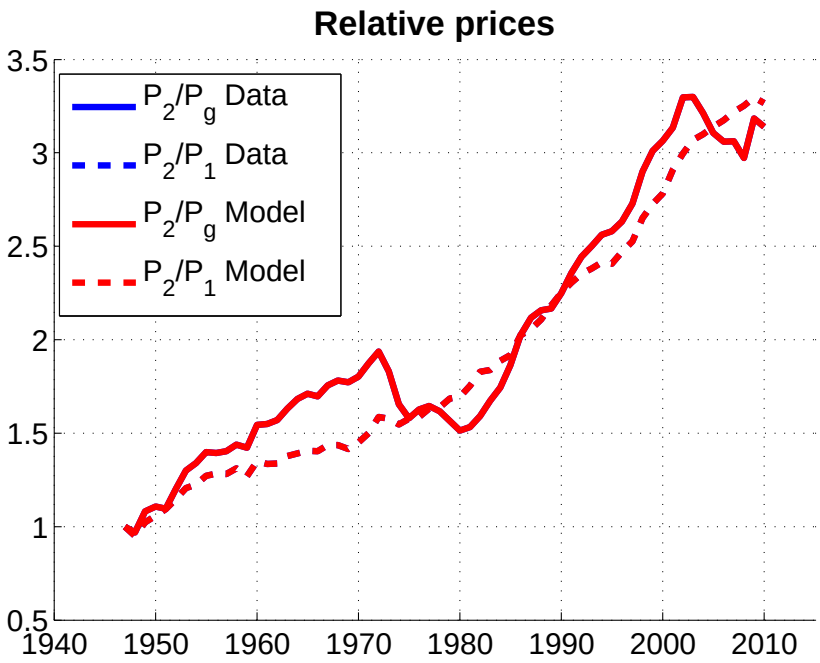
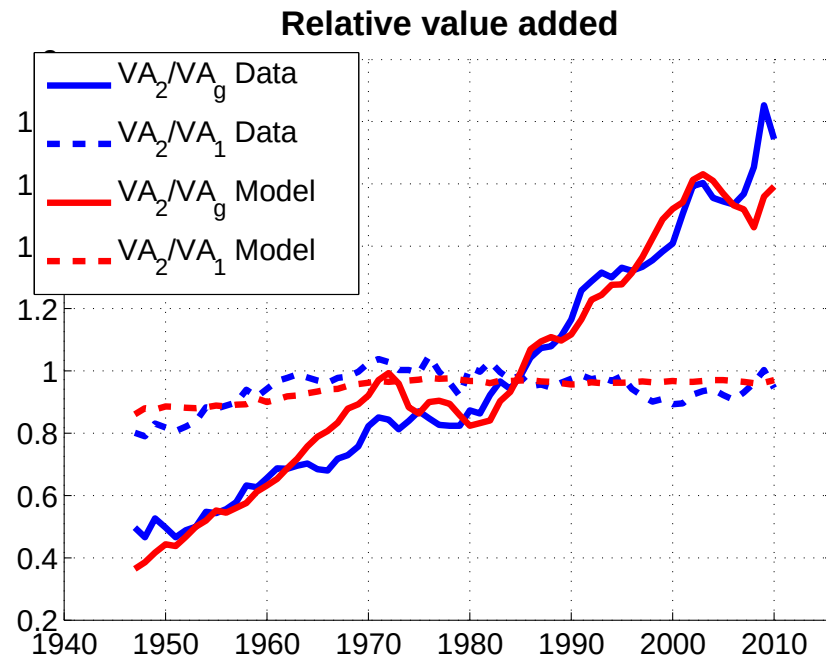
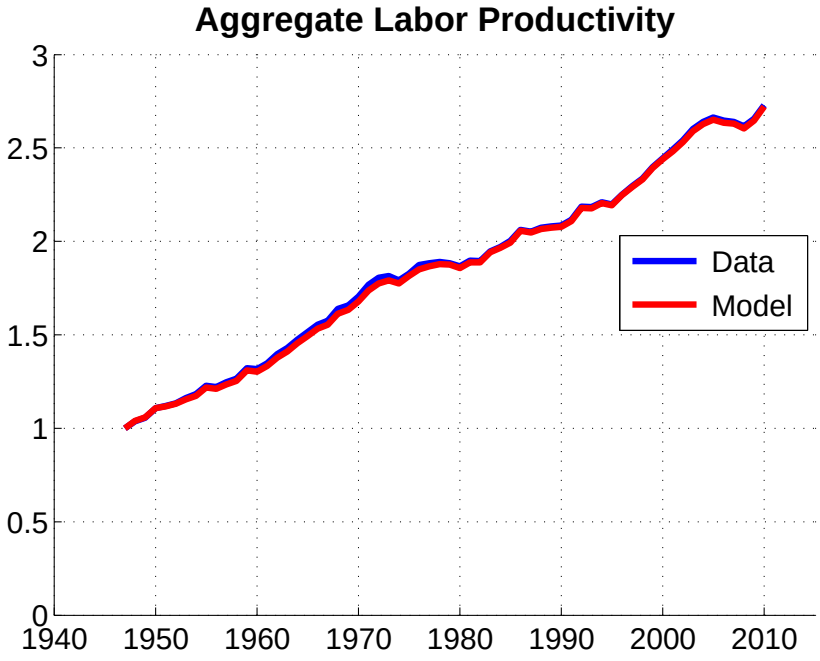
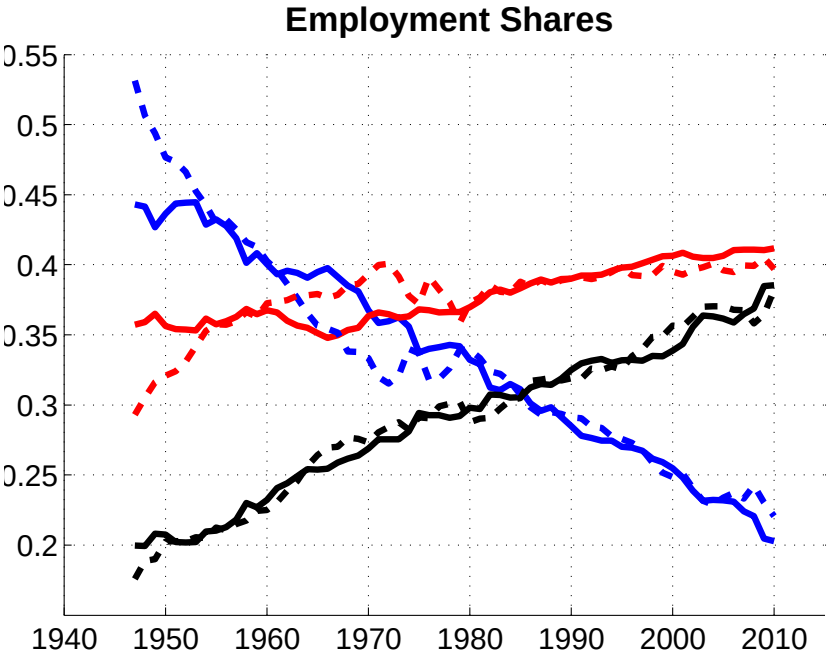

Relative prices
P2/Pg Data
P2/P1 Data
P2/Pg Model
P2/P1 Model
3.5
3
2.5
2
1.5
1
0.5
1940
1950
1960
1970
1980
1990
2000
2010


Relative value added
VA2/VAg Data
VA2/VA1 Data
VA2/VAg Model
VA2/VA1 Model
1.2
1
0.8
0.6
0.4
0.2
1940
1950
1960
1970
1980
1990
2000
2010


Aggregate Labor Productivity
Data
Model
3
2.5
2
1.5
1
0.5
0
1940
1950
1960
1970
1980
1990
2000
2010


Employment Shares
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
1940
1950
1960
1970
1980
1990
2000
2010

Data Averages over Calibration Period

calibration period	data averages over calibration period						
	ΔLP_t	$\Delta A_g/A_g$	$\Delta A_1/A_1$	$\Delta A_2/A_2$	$\Delta P_g/P_g$	τ_1	τ_2
1990–2010	1.29	1.94	2.35	-0.30	1.78	-0.05	0.04
1980–2010	1.20	1.98	2.15	-0.42	2.32	-0.10	0.02
1970–2010	1.25	1.56	2.48	-0.26	3.71	-0.12	0.02

Model Simulation

- We want to assess how much aggregate growth will slow down in the next decades
- We assume that $\left\{A_{gt}, A_{1t}, A_{2t}\right\}$ grow at same constant rates as during:
  - 1970–2010
  - 1980–2010
  - 1990–2010
- For $\left\{\tau_{1t}, \tau_{2t}\right\}$ we take the averages over the three periods