Structural Change within the Service Sector and the Future of Baumol’s Cost Disease

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Ákos Valentinyi (University of Manchester, CEPR, and CERS–HAS)

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1 Motivation

The US productivity growth slowdown

Growth of real U.S. GDP per efficiency units of labour
average over previous 20 Years

Source: WORLD KLEMS, March 2017 release and own calculations.

Further evidence on the productivity growth slowdown

Duennecker, Herrendorf, Valentinyi
Lively debate about the growth slowdown

- **What are the reasons? What will future growth be?**
  - Gordon (Princeton University Press, 2016): major versus minor innovations
  - Fernald and Jones (AER, 2015):
    - time input into human capital accumulation and innovation
  - Nordhaus (BE Journal, 2008): Baumol’s cost disease

- **Baumol’s Cost Disease: structural change reduces productivity growth**
  - reallocation from goods to services;
  - average productivity growth lower in services.
The Future of Baumol’s Cost Disease

• What will happen once services have taken over?
  ○ Large productivity growth differences across services industries
    (for example, distribution versus hospitality/restaurants).
  ○ Which services industries will take over?
  ○ Will productivity growth in those industries be close to zero?

• Answering these questions requires two departures from the literature
  1. Dis-aggregate services sector and study structural change within services.
  2. Don’t impose aggregate balanced growth to solve model.
Our contributions

- We calculate the productivity effect of Baumol’s Cost Disease for the postwar U.S.
  - 1/3 of overall productivity growth slowdown.
- We build a new model with
  - two services subsectors: low and high productivity growth;
  - non-homothetic utility with persistent income effects.
- We use the model to predict the future of Baumol’s Cost Disease
  - Future productivity reduction will be considerably smaller than past one.
  - There is substitutability within the services sector.
  - Services with low productivity growth don’t take over.
2 Evidence on Baumol’s Cost Disease

Data

• Post World War II from WORLD KLEMS for U.S.
• Value added, prices, and efficiency units of labor (“quality–adjusted” hours).
• 65 industries.
How much productivity growth slowdown was due to structural change?

- Fix the sectoral shares at the average values during 1947–1967.
- Apply the actual annual growth rates of sectoral labor productivity.
- Measure sectoral labor in terms of efficiency units
  - otherwise sector productivity differences would include human capital differences;
  - reallocated workers would implicitly get average human capital of new sector.
## Sizeable Effect of Baumol’s Cost Disease in Postwar US

### Average annual growth of value added per efficiency unit

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Composition from 1947–67</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1947–1967</strong></td>
<td>2.31%</td>
<td>2.29%</td>
</tr>
<tr>
<td><strong>1996–2016</strong></td>
<td>1.06%</td>
<td>1.46%</td>
</tr>
<tr>
<td>Productivity Growth Slowdown</td>
<td>1.25</td>
<td>0.83</td>
</tr>
<tr>
<td>Baumol’s Cost Disease</td>
<td>0.42</td>
<td>(= 1.25 – 0.83)</td>
</tr>
<tr>
<td>Share of Slowdown</td>
<td>1/3</td>
<td>(= 0.42/1.25)</td>
</tr>
</tbody>
</table>
Taking stock

- Baumol’s Cost Disease accounts for considerable part of past growth slowdown.
- To gauge its future importance, we need a quantitative general equilibrium model.
  - Simulate model economy forward.
  - Assess different counterfactuals.
3 Model

Key features

• Goal
  ○ make it as simple and standard as possible.

• 3 sectors
  ○ goods;
  ○ services with high and low productivity growth
    (relevant margin for our purpose).

• Exogenous growth in efficiency units of labor and in sectoral productivity
  \[\Rightarrow\] income growth and changes in relative prices.

• Non–homothetic CES utility
  \[\Rightarrow\] reallocation of sectoral production.
Endowments and production

- $H_t$ efficiency units of labor that can be used in all sectors.
- Linear production function of value added per sector $i \in \{g, l, h\}$:

$$C_{it} = A_{it}H_{it}$$
Preferences

- No disutility from working (efficiency units inelastically supplied)
- Nested, non-homothetic CES over the sectoral value added.

Hanoch (Ectra, 1975); Sato (Ectra, 1975); Comin, Lashkari, Mestieri (2018):

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

\[ C_{st} = \left( \alpha_l C_t^{\varepsilon_l-1} C_{lt}^{\sigma_s-1} \right)^{\frac{1}{\sigma_s}} + \left( \alpha_h C_t^{\varepsilon_h-1} C_{ht}^{\sigma_s-1} \right)^{\frac{1}{\sigma_s}} \]

Evidence for non–homothetic CES
If $\varepsilon_i = 1$, nested HOMOTHETIC CES

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

\[
C_{st} = \left( \left( \alpha_l C_{lt}^{\sigma_s^{-1}} \right) \frac{1}{\sigma_s} + \left( \alpha_h C_{ht}^{\sigma_s^{-1}} \right) \frac{1}{\sigma_s} \right)^{\frac{\sigma_s}{\sigma_s - 1}}
\]
If $\varepsilon_i \neq 1$, nested NON-homothetic CES

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

$$C_{st} = \left( \alpha_l C_t^{\varepsilon_l - 1} C_{lt}^{\sigma_s - 1} \right)^{\frac{1}{\sigma_s}} + \left( \alpha_h C_t^{\varepsilon_h - 1} C_{ht}^{\sigma_s - 1} \right)^{\frac{1}{\sigma_s}}$$
4. Equilibrium

Firm problems

$$\max_{H_{it}} P_{it}A_{it}H_{it} - (1 + \tau_{it})W_{it}H_{it}, \quad i \in \{g, l, h\}$$

- Implied equilibrium relationships

$$\frac{P_{it}Y_{it}/H_{it}}{P_{gt}Y_{gt}/H_{gt}} = \frac{1 + \tau_{it}}{1 + \tau_{gt}}$$

- Labor distortions/wedges allow us to match relative nominal sectoral labor productivities.
Household problem

Outer layer

\[
\min_{C_{gt}, C_{st}} P_{gt}C_{gt} + P_{st}C_{st} \quad \text{s.t.} \quad \left( \left( \alpha_g C_t^{\varepsilon g - 1} C_{gt}^{\sigma_c - 1} \right)^\frac{1}{\sigma_c} + \left( \alpha_s C_t^{\varepsilon s - 1} C_{st}^{\sigma_c - 1} \right)^\frac{1}{\sigma_c} \right)^\frac{\sigma_c}{\sigma_c - 1} \geq C_t
\]

where \( P_{st} \) is the price index from the inner layer.

Inner layer

\[
\min_{C_{lt}, C_{ht}} P_{lt}C_{lt} + P_{ht}C_{ht} \quad \text{s.t.} \quad \left( \left( \alpha_l C_t^{\varepsilon l - 1} C_{lt}^{\sigma_s - 1} \right)^\frac{1}{\sigma_s} + \left( \alpha_h C_t^{\varepsilon h - 1} C_{ht}^{\sigma_s - 1} \right)^\frac{1}{\sigma_s} \right)^\frac{\sigma_s}{\sigma_s - 1} \geq C_{st}
\]
5. Analytical Results

Sectoral composition

- First-order conditions imply (as in Comin, Lashkari, Mestieri, 2018)

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

\[
\frac{P_{lt}C_{lt}}{P_{ht}C_{ht}} = \left(\frac{\alpha_l}{\alpha_h}\right)^{\frac{1}{\sigma_s}} C_t^{\varepsilon_l - \varepsilon_h} \left(\frac{P_{lt}}{P_{ht}}\right)^{1-\sigma_s}
\]

- Business as usual between goods and services
  - Goods necessities and services luxuries: \( \varepsilon_g < \varepsilon_s \).
  - Goods and services complements: \( 0 < \sigma_c < 1 \).
  - What about the two services subsectors? \( \varepsilon_l, \varepsilon_h \)? \( \sigma_s \).
The Future of Baumol’s Cost Disease

- Unclear which services subsector takes over in the limit

Relative Prices and Expenditures in Services

○ The two services are substitutes: $\sigma_s > 1$.
○ Service with low (high) productivity growth are luxuries (necessities): $\varepsilon_l > \varepsilon_h$. 

6. Quantitative Analysis

Services with high and low productivity growth in the data

<table>
<thead>
<tr>
<th>Service Industries with Above Average Productivity Growth</th>
<th>Annual Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline Transportation</td>
<td>5.6%</td>
</tr>
<tr>
<td>... Broadcasting and Telecommunications</td>
<td>4.4%</td>
</tr>
<tr>
<td>... Wholesale Trade</td>
<td>3.1%</td>
</tr>
<tr>
<td>... Securities, Commodity Contracts, and Investments</td>
<td>2.8%</td>
</tr>
<tr>
<td>... Insurance Carriers and Related Activities</td>
<td>1.6%</td>
</tr>
<tr>
<td>Warehousing and Storage</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service Industries with Below Average Productivity Growth</th>
<th>Annual Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of Companies and Enterprises</td>
<td>1.3%</td>
</tr>
<tr>
<td>... Educational Services</td>
<td>0.8%</td>
</tr>
<tr>
<td>... Ambulatory Health Care Services</td>
<td>0.6%</td>
</tr>
<tr>
<td>... State and Local General Government</td>
<td>−0.4%</td>
</tr>
<tr>
<td>... Food Services and Drinking Places</td>
<td>−0.5%</td>
</tr>
<tr>
<td>Transit and Ground Passenger Transportation</td>
<td>−0.7%</td>
</tr>
</tbody>
</table>
Basic approach to quantitative analysis

  - Match behavior of real and nominal labor productivities and of sectoral composition.
  - Distinguish carefully between $C_t$ (model utility) and $E_t$ (data expenditures).
- Assume past growth rates of TFP, taxes, and efficiency units continue into future.
- Simulate model to predict by how much productivity growth will slow down in the future.
Calibrated Parameters

- **Calibration confirms qualitative features from above**
  - Complementarity between goods and services: $\sigma_c < 1$
  - Substitutability between services: $\sigma_s > 1$
  - Services luxuries and goods necessities: $\varepsilon_s - \varepsilon_g > 0$
  - Services with low (high) productivity growth luxuries (necessities): $\varepsilon_l - \varepsilon_h > 0$

- **Calibration is robust**
  - Same qualitative features also hold in CEX micro data.

Details
Model fit

**Relative value added**

- **VA**/VA
- **VA**/VA

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<tr>
<td>Model</td>
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**Employment shares**

- **H**
- **H**
- **H**

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**Aggregate labor productivity**

- **Data**
- **Model**

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<td>Model</td>
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# The Future of Baumol’s Cost Disease

(Average Annual Growth Rate of Labor Productivity in %)

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</thead>
<tbody>
<tr>
<td>2.31</td>
<td>1.06</td>
<td>0.85</td>
<td></td>
<td>1996–2016</td>
</tr>
<tr>
<td>0.88</td>
<td>0.85</td>
<td></td>
<td></td>
<td>1986–2016</td>
</tr>
<tr>
<td>0.91</td>
<td></td>
<td></td>
<td></td>
<td>1976–2016</td>
</tr>
<tr>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td>1996–2016, %\Delta A_l = 0</td>
</tr>
</tbody>
</table>

- Future effect of Baumol’s Cost Disease is at most $3/4$ of its past effect.
- $3/4 \approx (1.06 – 0.75)/(0.41)$.
Why was the past growth slowdown large?

- Income and substitution effects: strong reallocation from $C_{gt}$ to $C_{st}$
- $C_{gt}$ have high and $C_{st}$ low productivity growth

Why is the future growth slowdown smaller?

- Income effect: shares of $C_{st}$ in $C_t$ and of $C_{lt}$ in $C_{st}$ increase
- Substitution effect: share of $C_{lt}$ decreases
- Net effect: share of $C_{lt}$ remains roughly constant

Further findings
Robustness: Alternative preference specifications

- **Implicitly Additive Utility** (Hanoch or Sato, Ecta, 1975)

\[
1 = \sum_{i=1}^{I} \left( \alpha_i \frac{c_i^{\sigma_i-1}}{c_t^{\sigma_i-\varepsilon_i}} \right)^{\frac{1}{\sigma_i}}
\]

- **Implicitly Additive Utility with \( \sigma = \sigma_i \)** (Comin et al., 2019)

\[
C_t = \left( \sum_{i=1}^{I} \left( \alpha_i C_t^{\varepsilon_i-1} c_{it}^{\sigma_i-1} \right)^{\frac{1}{\sigma_i}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}
\]

- Robustness: \( \sigma_i \neq \sigma_j \) and/or \( i > 3 \).
The Future of Baumol’s Cost Disease with Alternative Preferences

Predicted Productivity Growth in % during 2046–2066
( estimation period for exogenous variables: 1996–2016 )

| $\sigma_c, \sigma_s$ | $i = g, l, h$ | 0.85 |
| $\sigma_i \neq \sigma_j$ | $i = g, l, h$ | 0.83 |
| $\sigma_i \neq \sigma_j$ | $i = g, 1, ..., 10$ | 0.76 |

- Again, future effect of Baumol’s Cost Disease at most $3/4 \approx (1.06 - 0.76)/(0.41)$ of past ones.
Conclusions

- **Our results**
  - Baumol’s Cost Disease considerably reduced postwar US labor productivity growth.
  - Nonetheless, its future effect will only be 1/4 of its past effect.
  - Key: services with low productivity growth do not take over economy.

- **Future work**
  - It is of interest to extend the previous analysis to other countries.
  - Our disaggregation into two services sectors may not apply outside the US.
  - But our disaggregation into 11 services industries will apply outside the US.
Appendix
The Future of Baumol’s Cost Disease

The US productivity growth slowdown

Growth of real U.S. GDP per hour
average of the previous 20 years

Source: Total Economy Database, May 2017
The slowdown in productivity growth in other countries

Growth of real GDP per hour

average of the previous 20 years

Source: Penn World Tables 9.1

Australia  
Canada  
United Kingdom  
United States
### Different ways of splitting services

<p>| 1 = | High Growth | Market Non–Market | Low skilled |</p>
<table>
<thead>
<tr>
<th>2 =</th>
<th>Low Growth</th>
<th></th>
<th>High skilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post and Telecom.</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Wholesale ...</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sale ... of Motor Vehicles ...</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Retail ...</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Financial ...</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Transport ...</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>... Business Services</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Education</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Real Estate ...</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Health ...</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Private Households ...</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>... Personal Services</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hotels ...</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Stylized facts of structural transformation

Goods vs Services

Services with high vs low productivity growth

Relative nominal value added and labor services
reference year=1947

- Value added of stagnant relative to progressive services
- Labor services of stagnant relative to progressive services

Relative productivities and prices
reference year=1947

- Price of stagnant relative to progressive services
- Real value added per labor services of progressive relative to stagnant services

Source: WORLD KLEMS, March 2017 release,
BEA/BLS Integrated Industry-level Production Account for the United States, own calculations.
Persistent income effects within services

Partial correlation between relative value added within services and aggregate value added per labor services

Residuals of log difference of nominal value added of different services

Residuals of log of aggregate real value added per labor services

-0.15 -0.10 -0.05 0.00 0.05 0.10 0.15
-0.15 -0.10 -0.05 0.00 0.05 0.10 0.15

Note: Residuals on the y-axis are from regressing the log difference of nominal value added of stagnant services and progressive services on the corresponding log difference of prices. Residuals on the x-axis are from regressing the log of aggregate real value added per labor services on the same log difference of prices.
Calibration

**Step 1:** Calibrate \( \left\{ \tau_{gt}, \tau_{ht}, \tau_{lt} \right\}_{t=1947}^{2016} \)

- Set \( \tau_{gt} = 0 \) and compute \( \left\{ \tau_{ht}, \tau_{lt} \right\} \) by using relative nominal productivities:

\[
1 + \tau_{jt} = \frac{\widetilde{VA}_{jt}/\widetilde{L}_{jt}}{\widetilde{VA}_{gt}/\widetilde{L}_{gt}}
\]
Step 2: Calibrate \( \{A_{gt}, A_{ht}, A_{lt}\}_{t=1947}^{2016} \)

- Normalize \( A_{g1947} = 1 \) and obtain \( \{A_{gt}\}_{t=1948}^{2016} \) by using real productivity growth:

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

- Obtain \( \{A_{ht}, A_{lt}\}_{t=1947}^{2016} \) by using relative real productivities:

\[
A_{jt} = (1 + \tau_{jt})A_{gt} \frac{\widetilde{P}_{gt}}{\widetilde{P}_{jt}}
\]
Step 3: Choose $\varepsilon_g = 0.91$ and $\varepsilon_h = 0.91$, $\alpha_s = 1 - \alpha_g$, and $\alpha_l = 1 - \alpha_h$.

Step 4: Calibrate $\{\alpha_g, \alpha_h, \sigma_s, \sigma_c, \varepsilon_s, \varepsilon_l\}$

- Match nominal value added shares

$$\left\{ \frac{\tilde{VA}_{lt}}{VA_{gt}}, \frac{\tilde{VA}_{lt}}{VA_{ht}} \right\}_{t=1947,\ldots,2016}$$
Calibrated parameters

<table>
<thead>
<tr>
<th>$\alpha_g$</th>
<th>$\alpha_h$</th>
<th>$\sigma_c$</th>
<th>$\sigma_s$</th>
<th>$\varepsilon_s - \varepsilon_g$</th>
<th>$\varepsilon_l - \varepsilon_h$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.47</td>
<td>0.43</td>
<td>0.28</td>
<td>1.03</td>
<td>1.99</td>
<td>0.23</td>
</tr>
</tbody>
</table>
Statistics Implied by the Calibration

- Distortions
- Sector TFPs
- Total consumption and relative price of services
Different Assumptions about Future Taxes
(estimation period for exogenous variables: 1996–2016)

<table>
<thead>
<tr>
<th>Assumption</th>
<th>2046–2066</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline: average $\tau_h$, $\tau_l$</td>
<td>0.85</td>
</tr>
<tr>
<td>$\tau_h = \max{\tau_h}$, $\tau_l = \max{\tau_l}$</td>
<td>0.86</td>
</tr>
<tr>
<td>$\tau_h = \max{\tau_h}$, $\tau_l = \min{\tau_l}$</td>
<td>0.85</td>
</tr>
<tr>
<td>$\tau_h = \min{\tau_h}$, $\tau_l = \max{\tau_l}$</td>
<td>0.87</td>
</tr>
<tr>
<td>$\tau_h = \min{\tau_h}$, $\tau_l = \min{\tau_l}$</td>
<td>0.85</td>
</tr>
</tbody>
</table>
\[ \Delta \tilde{P}_l = \omega \Delta P_l + (1 - \omega) \Delta P_h \]

**Quality Mismeasurement and Aggregate Productivity Growth in %**

(ESTIMATION PERIOD FOR EXOGENOUS VARIABLES: 1996–2016)

<table>
<thead>
<tr>
<th>( \omega )</th>
<th>1996–2016</th>
<th>2046–2066</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>1.04</td>
<td>0.85</td>
</tr>
<tr>
<td>0.75</td>
<td>1.15</td>
<td>0.98</td>
</tr>
<tr>
<td>0.50</td>
<td>1.26</td>
<td>1.11</td>
</tr>
<tr>
<td>0.25</td>
<td>1.37</td>
<td>1.24</td>
</tr>
</tbody>
</table>