Endogenous TFP, Business Cycle Persistence and the Productivity Slowdown

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Motivation

- Severity and persistence of the Great Recession and simultaneously observed productivity slowdown

- Exogeneity of TFP in standard macroeconomic frameworks

- Growing evidence on the procyclicality of TFP and its role in business cycle amplification for the US (e.g. Bianchi et al. (2017); Anzoategui, Gertler, Comin and Martinez (2017))

- Discussion on the degree of the procyclicality of TFP and its relevancy in assessing the current business cycle position and the future path of productivity
What this paper does

Analyses euro area **business cycle persistence** and **productivity slowdown** by means of a **New Keynesian DSGE model** with endogenous TFP mechanism

**Research questions:**
1. What is the role of the endogeneity of TFP in business cycle amplification and persistence in the euro area?
2. To what extent can EA TFP be considered endogenous?
3. How did endogenous TFP evolve over time?
4. What are the key drivers of the EA productivity slowdown from the model’s perspective?
Overview of main model features

New Keynesian DSGE model with endogenous TFP mechanism (as in Anzoategui, Comin, Gertler and Martinez (2017))

Standard features

- Monopolistic competition in final and intermediate goods
- Nominal rigidities in prices and wages (Calvo rigidities)
- Taylor rule
- Flow adjustment costs in investment

Non-standard features

- Two types of labor: skilled and unskilled
- Endogenous evolution of TFP as a result of R&D and adoption activities
Endogenous TFP and production

- Final good composite:
  \[ Y_t = \left( \int_0^1 (Y_t^i)^{\mu_t} \, dj \right)^{\mu_t} \]  \hspace{1cm} (1)

- Final good production:
  \[ Y_t^i = X_t^i \]  \hspace{1cm} (2)

- Romer (1990)'s expanding variety approach of endogenous growth in intermediate goods composite:
  \[ X_t = \left( \int_0^{A_t} (X_t^j)^{\frac{1}{\vartheta}} \, dj \right)^{\vartheta} \]  \hspace{1cm} (3)

- Aggregate production:
  \[ Y_t = \left[ (A_t)^{\vartheta-1} \theta_t \right] (U_t K_t)^{\alpha} (L_t)^{1-\alpha} \]  \hspace{1cm} (4)
Technological progress: A two-stage process

- $A_t$: Endogenous component of TFP
- Two sources of endogenous growth: Creation of new technologies & adoption activity
Households

\[
\max_{C_t, B_{t+1}, L_{ut}^h, L_{st}^h, K_{t+1}} \sum_{\tau=0}^{\infty} \beta^\tau \left\{ \log (C_{t+\tau} - bC_{t+\tau-1}) + \varphi_t B_{t+1} \right. \\
- \frac{\nu_u (L_t^h)^{1+\varphi} + \nu_s (L_{st}^h)^{1+\varphi}}{1 + \varphi} \right\}
\]

s.t.

\[
C_t = w_{ut} L_{ut} + w_{st} L_{st} + \Pi_t + R_t^k Q_{t-1} K_t + R_t B_t - B_{t+1},
\]

\[
1 = E_t \{ \Lambda_{t,t+1} R_{k(t+1)} \}
\]

\[
1 = E_t \{ \Lambda_{t,t+1} R_{t+1} \} + \zeta_t
\]
Estimation

- Estimation of the model on euro area data (fixed composition, EA-12) from 1999:I to 2007:IV

- Series used in estimation:
  - GDP, consumption, investment, employment
  - Inflation, wages, nominal interest rates
  - Business R&D investment


- Shadow rate approach to account for the ZLB period (Kortela (2017); Wu and Xia (2017))
## Calibration

**Table: Calibrated Parameter values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\delta$</td>
<td>Capital depreciation</td>
<td>0.0200</td>
</tr>
<tr>
<td>$\frac{G}{Y}$</td>
<td>Steady state government consumption/output ratio</td>
<td>0.2000</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Steady state final goods mark up</td>
<td>1.1000</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>Steady state intermediate goods mark up</td>
<td>1.1800</td>
</tr>
<tr>
<td>$\vartheta$</td>
<td>Intermediate goods elasticity of substitution</td>
<td>1.3699</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Obsolescence rate</td>
<td>0.0200</td>
</tr>
<tr>
<td>$\bar{\lambda}$</td>
<td>Steady state adoption lag</td>
<td>0.0500</td>
</tr>
<tr>
<td>$\rho_\lambda$</td>
<td>Adoption elasticity</td>
<td>0.9500</td>
</tr>
</tbody>
</table>
Table: Prior and Posterior Distributions of Estimated Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Dist</th>
<th>Prior</th>
<th>Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>St.Dev.</td>
</tr>
<tr>
<td>$\rho^R$</td>
<td>Taylor rule smoothing</td>
<td>Beta</td>
<td>0.70</td>
<td>0.15</td>
</tr>
<tr>
<td>$\phi_\pi$</td>
<td>Taylor rule inflation</td>
<td>Gamma</td>
<td>1.50</td>
<td>0.25</td>
</tr>
<tr>
<td>$\phi_y$</td>
<td>Taylor rule labour</td>
<td>Gamma</td>
<td>0.30</td>
<td>0.10</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Inverse Frisch elast.</td>
<td>Gamma</td>
<td>2.00</td>
<td>0.75</td>
</tr>
<tr>
<td>$f''$</td>
<td>Investment adj. cost</td>
<td>Gamma</td>
<td>4.00</td>
<td>1.00</td>
</tr>
<tr>
<td>$\beta'(U)/\delta$</td>
<td>Capital util. elas.</td>
<td>Gamma</td>
<td>4.00</td>
<td>1.00</td>
</tr>
<tr>
<td>$\xi_p$</td>
<td>Calvo prices</td>
<td>Beta</td>
<td>0.50</td>
<td>0.10</td>
</tr>
<tr>
<td>$\xi_w$</td>
<td>Calvo wages</td>
<td>Beta</td>
<td>0.50</td>
<td>0.10</td>
</tr>
<tr>
<td>$\nu_p$</td>
<td>Price indexation</td>
<td>Beta</td>
<td>0.50</td>
<td>0.15</td>
</tr>
<tr>
<td>$\nu_w$</td>
<td>Wage indexation</td>
<td>Beta</td>
<td>0.50</td>
<td>0.15</td>
</tr>
<tr>
<td>$\mu_w$</td>
<td>SS Wage markup</td>
<td>Normal</td>
<td>0.15</td>
<td>0.05</td>
</tr>
<tr>
<td>$b$</td>
<td>Consumption habit</td>
<td>Beta</td>
<td>0.70</td>
<td>0.10</td>
</tr>
<tr>
<td>$\rho_z$</td>
<td>R&amp;D elasticity</td>
<td>Beta</td>
<td>0.60</td>
<td>0.15</td>
</tr>
<tr>
<td>$\beta^{est}$</td>
<td>$100 \times (\beta^{-1} - 1)$</td>
<td>Gamma</td>
<td>0.25</td>
<td>0.10</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Capital share</td>
<td>Normal</td>
<td>0.30</td>
<td>0.05</td>
</tr>
<tr>
<td>$100 \times \gamma_y$</td>
<td>SS output growth</td>
<td>Normal</td>
<td>0.10</td>
<td>0.20</td>
</tr>
</tbody>
</table>
What drives the euro area business cycle?

### Table: Variance Decomposition

<table>
<thead>
<tr>
<th>Variables</th>
<th>Liquidity Demand</th>
<th>Money Demand</th>
<th>Govt Exp</th>
<th>Price of Capital</th>
<th>TFP</th>
<th>R&amp;D</th>
<th>Mark up</th>
<th>Wage mark up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Growth</td>
<td>64.46</td>
<td>12.69</td>
<td>16.04</td>
<td>3.08</td>
<td>1.49</td>
<td>0.01</td>
<td>1.85</td>
<td>0.39</td>
</tr>
<tr>
<td>Consumption Growth</td>
<td>77.57</td>
<td>13.89</td>
<td>4.89</td>
<td>0.11</td>
<td>1.51</td>
<td>0.00</td>
<td>1.62</td>
<td>0.40</td>
</tr>
<tr>
<td>Investment Growth</td>
<td>39.84</td>
<td>11.29</td>
<td>3.22</td>
<td>40.44</td>
<td>1.57</td>
<td>0.03</td>
<td>2.90</td>
<td>0.72</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.84</td>
<td>0.91</td>
<td>0.22</td>
<td>0.06</td>
<td>7.99</td>
<td>0.06</td>
<td>61.14</td>
<td>28.78</td>
</tr>
<tr>
<td>Nominal R</td>
<td>33.44</td>
<td>39.90</td>
<td>1.60</td>
<td>0.84</td>
<td>3.34</td>
<td>0.04</td>
<td>12.77</td>
<td>8.08</td>
</tr>
<tr>
<td>Hours</td>
<td>63.88</td>
<td>16.02</td>
<td>7.61</td>
<td>2.48</td>
<td>6.91</td>
<td>0.03</td>
<td>1.61</td>
<td>1.45</td>
</tr>
<tr>
<td>Endogenous TFP</td>
<td>71.62</td>
<td>15.84</td>
<td>0.70</td>
<td>0.46</td>
<td>0.79</td>
<td>0.73</td>
<td>9.72</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Endogenous TFP and business cycle persistence

Figure: Impulse response to 1 std. dev. liquidity demand shock

Output
Consumption
Investment

Inflation
Nominal R
Spread $R^k - R$

Endogenous TFP
R & D
Adoption Rate

% Dev. from S.S.
% Dev. from S.S.
% Dev. from S.S.
%
%
% Quarterly

Baseline Model
Exogenous TFP
TFP, endogenous TFP and labor productivity

![Graph showing TFP, Endogenous TFP and Labour Productivity over time from 1998Q4 to 2018Q4. The graph includes lines for TFP, Endogenous component of TFP, and Labour Productivity.]
Evolution and key drivers of endogenous TFP
Stagnant R&D vs. slowing technology diffusion?

Sources of Endogenous Technology

Adopted Tech. (A), Technology (Z)

Adoption Rate (\(\lambda\)), %

% deviation from trend
Main takeaways

1. **Why has the euro area recovery been so slow?**
   - Hysteresis: Long-lasting effect of the EA crises on R&D and technology diffusion
   - Feedback mechanism between overall economic conditions and depressed productivity

2. **What can we learn about the nature of the productivity slowdown?**
   - Slowdown observable as of early 2000s, drastic acceleration in crises
   - Decline in R&D efficiency (pre-crisis) & liquidity demand shock (crisis years & onward)
   - Pre-crisis: Drop in innovation output; subsequent periods: technological diffusion
Main takeaways

3 Endogeneity of TFP alters the Phillips curve
   ▶ Traditional relationship between economic slack and marginal costs featured in the model
   ▶ Procyclical productivity movements weaken the Phillips curve relationship

4 Demand-side matters greatly for the supply-side
   ▶ Demand shocks key in explaining fluctuations in euro area economy
   ▶ Substantial component of productivity evolves endogenously

5 What to expect in the future?
   ▶ Recovery in TFP discernible from 2015 onward, in line with overall improving economic conditions
   ▶ Positive feedback mechanism to be expected in an upswing (c.p.)
   ▶ Structural factors remain a drag to productivity