The Aggregate Implications of Innovative Investment

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Discussion by erm, July 2017
Question

- If policy changed to induce more innovation,

- What happens to
  - Output
  - Productivity
  - Welfare?
Contribution of AB

- Develop model nesting many others

- Use discipline of national accounts
Why Important?

- Welfare gains are potentially huge
- But, results very sensitive to
  - Model choice
  - Parameter estimates
• AB’s main result doesn’t rely on cross-section data

• Aggregate implications of innovative investment:

  ○ Can estimate medium-run growth

  ○ Can’t yet estimate long-run growth or welfare
RBC-friendly Version

- Firm output:

\[ y_t = K_{lt}^p (k_{Tt}^{\alpha} k_{It}^\gamma l_{t}^{1-\alpha-\gamma}) \]

- Capital accumulation

\[ k_{Tt+1} = (1 - \delta_T) k_{Tt} + x_{Tt} \]
\[ k_{It+1} = (1 - \delta_I) k_{It} + A_{rt} K_{It}^{\phi-1} x_{It} \]

\[ y_{rt} \]
AB’s Impact Elasticity

• Given $\alpha, \gamma$, define:

\[ \log Z_t = \log Y_t - \alpha \log K_{Tt} - (1 - \alpha - \gamma) \log L_t \]

• Then growth rates are:

\[ g_{Zt} = (\rho + \gamma)g_{K_{It}} \]
\[ g_{K_{It}} = \log(1 - \delta_I + Y_{rt}/K_{It}) \]

• And AB’s elasticity is:

\[ \epsilon_{zr} = \frac{g_{Zt} - \bar{g}Z}{\log Y_{rt} - \log \bar{Y}_r} \approx (\rho + \gamma) \left( \frac{\exp \bar{g}K_I - 1 + \delta_I}{\exp \bar{g}K_I} \right) \]
\[ \epsilon_{zr} \approx (\rho + \gamma) \left( \frac{\exp \bar{g}_{K_I} - 1 + \delta_I}{\exp \bar{g}_{K_I}} \right) \]

\[ \rho + \gamma = \frac{1}{3} \text{ (based on variety models)} \]
\[ \bar{g}_Z = 0.0123 \text{ (based on BEA/BLS data)} \]
\[ \bar{g}_{K_I} = 0.0369 \text{ (from definition)} \]
\[ \delta_I? \]
\[ 0.0, \quad \epsilon_{zr} = 0.012 \]
\[ 0.15, \quad \epsilon_{zr} = 0.06 \]
\[ 1.0, \quad \epsilon_{zr} = \frac{1}{3} \]
AB’s Impact Elasticity

\[ \epsilon_{z\mathcal{r}} \approx (\rho + \gamma) \left( \frac{\exp \bar{g}_{K_I} - 1 + \delta_I}{\exp \bar{g}_{K_I}} \right) \]

\[ \rho + \gamma = 1/3 \text{ (based on variety models)} \]
\[ \bar{g}_Z = 0.0123 \text{ (based on BEA/BLS data)} \]
\[ \bar{g}_{K_I} = 0.0369 \text{ (from definition)} \]
\[ \delta_I? \text{ Not known} \]

\[ \Rightarrow \text{ use investment/value ratio } (X_I/V_I) \text{ instead} \]
AB’s Impact Elasticity

\[ \varepsilon_{zr} \approx (\rho + \gamma) \left( \frac{\exp \bar{g}_{K_I} - 1 + \delta_I}{\exp \bar{g}_{K_I}} \right) \]

\[ \rho + \gamma = 1/3 \text{ (based on variety models)} \]

\[ \bar{g}_Z = .0123 \text{ (based on BEA/BLS data)} \]

\[ \bar{g}_{K_I} = .0369 \text{ (from definition)} \]

\[ \delta_I? \text{ Not known} \]

\[ \Rightarrow \text{ use investment/value ratio } (X_I/V_I = .08) \]

\[ X_I: \text{ NIPA+imputation for entrants} \]

\[ V_I: \text{ dividends}/(\text{interest rate} - \text{growth rate}) \]
AB’s Impact Elasticity

$$\epsilon_{zr} \approx (\rho + \gamma) \left( \frac{\exp \bar{g}_{KI} - 1 + \delta_I}{\exp \bar{g}_{KI}} \right) \approx (\rho + \gamma) \frac{X_I}{V_I}$$

$$\rho + \gamma = 1/3 \text{ (based on variety models)}$$
$$\bar{g}_Z = .0123 \text{ (based on BEA/BLS data)}$$
$$\bar{g}_{KI} = .0369 \text{ (from definition)}$$
$$\delta_I? \text{ Not known}$$

$$\Rightarrow \text{ use investment/value ratio } (X_I/V_I = .08)$$
AB’s Impact Elasticity

\[ \epsilon_{zr} \approx (\rho + \gamma) \left( \frac{\exp \bar{g}_{KI} - 1 + \delta_I}{\exp \bar{g}_{KI}} \right) \approx (\rho + \gamma) \frac{X_I}{V_I} = .027 \]

\[ \rho + \gamma = \frac{1}{3} \text{ (based on variety models)} \]
\[ \bar{g}_Z = .0123 \text{ (based on BEA/BLS data)} \]
\[ \bar{g}_{KI} = .0369 \text{ (from definition)} \]
\[ \delta_I \text{? Not known} \]

⇒ use investment/value ratio \( (X_I/V_I = .08) \)
Main Result

- $\epsilon_{zr} = 2.7\%$

  - Used no information from LBD or GHK
  - Relied on only one dubious parameter ($\rho$)
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- $\epsilon_{zr} = 2.7\%$
  - Used no information from LBD or GHK
  - Relied on only one dubious parameter ($\rho$)

- What does this imply for future growth and welfare?
Future Growth

10% Increase in Innovation Investment

Spillovers relevant here

Impact elasticity relevant here

Log deviation of Y from BGP

0

0 20 40 60 80 100

10% Increase in Innovation Investment
100 Years Later

If $\phi = 0.99$, then $g_Y$ higher by 0.28% ($0.058/21$)

If $\phi = -1.6$, then $g_Y$ higher by 0.12% ($0.025/21$)

10% Increase in Innovation Investment
100 Years Later

If $\phi = 0.99$, then $g_Y$ higher by 0.35%.

If $\phi = -1.6$, then $g_Y$ higher by 0.04%.

10% Increase in Innovation Investment
But...

- To rationalize both
  - Observed growth in $Y$, $L$ and
  - Large negative spillovers
- Requires high growth in $A_r$
Mapping from Spillovers to $g_{Ar}$

- Recall

$$y_t = K_I^\rho (k_{It}^\alpha k_{It}^\gamma l_t^{1-\alpha-\gamma})$$
$$y_{rt} = A_{rt} K_{It}^{\phi-1} x_{It}$$

- Growth in output (with $\phi = 1$):

$$\bar{g}_Y = \underbrace{\frac{\rho + \gamma}{(1-\alpha)(2-\phi) - (\rho + \gamma)}}_{.762} g_{Ar} + \underbrace{\frac{(1-\phi)(1-\alpha-\gamma)}{(1-\alpha)(2-\phi) - (\rho + \gamma)}}_{0} g_{L}$$

$$\bar{g}_Y = \underbrace{\frac{\rho + \gamma}{(1-\alpha)(2-\phi) - (\rho + \gamma)}}_{.762} g_{Ar} + \underbrace{\frac{(1-\phi)(1-\alpha-\gamma)}{(1-\alpha)(2-\phi) - (\rho + \gamma)}}_{0} g_{L}$$
Mapping from Spillovers to $g_{Ar}$

- Recall

\[ y_t = K_{It}^\rho (k_{It}^\alpha k_{It}^\gamma l_t^{1-\alpha-\gamma}) \]
\[ y_{rt} = A_{rt} K_{It}^{\phi-1} x_{It} \]

- Growth in output (with $\phi = -1.6$):

\[
\tilde{g}_Y = \frac{\rho + \gamma}{(1-\alpha)(2-\phi)-(\rho+\gamma)} \begin{cases} g_{Ar} \\ .025 \end{cases} + \frac{(1-\phi)(1-\alpha-\gamma)}{(1-\alpha)(2-\phi)-(\rho+\gamma)} \begin{cases} g_L \\ .008 \end{cases}
\]

\[
\tilde{g}_Y = \frac{\rho + \gamma}{(1-\alpha)(2-\phi)-(\rho+\gamma)} .137 + \frac{(1-\phi)(1-\alpha-\gamma)}{(1-\alpha)(2-\phi)-(\rho+\gamma)} .672
\]
### Mapping from Spillovers to $g_{Ar}$

- Recall
  
  $$y_t = K^\rho_{It}(k^\alpha_{Tt}k^\gamma_{It}l^{1-\alpha-\gamma}_t)$$
  
  $$y_{rt} = A_{rt}K^{\phi-1}_{It}x_{It}$$

- Growth in output (with $\phi = -1.6$):

  $$\bar{g}_Y = \frac{\rho + \gamma}{(1 - \alpha)(2 - \phi) - (\rho + \gamma)} g_{Ar}$$

  $\bar{g}_Y = 0.025$ $g_{Ar} = 0.144$

  $$\bar{g}_L = \frac{(1 - \phi)(1 - \alpha - \gamma)}{(1 - \alpha)(2 - \phi) - (\rho + \gamma)} g_{L}$$

  $\bar{g}_L = 0.008$ $g_{L} = 0.008$

Choice of $\phi$ also matters for welfare...
Welfare estimates

• Depend importantly on
  ○ Spillovers
  ○ Appropriation

... which are both hard to estimate
Appropriation

- Proportion $\kappa$ stolen

\[ k_{I{t+1}} = (1 - \delta_I)k_{I{t}} + (1 + \kappa)q_{rt}x_{I{t}} - \kappa q_{rt}k_{I{t}} \frac{X_{I{t}}}{K_{I{t}}} \]

- New impact elasticity: $\epsilon^{*}_{zr} = \epsilon_{zr}/(1 + \kappa)$

- How to interpret $\kappa$?
  - Weak IP protection?
  - Quid pro quo policy?

- How to measure $\kappa$?
Implications for Welfare

- No appropriation:
  
  $1\% \text{ rise in } X_I/Y$

  $\Rightarrow$ 2.3 to 15% rise in welfare depending on $\phi$

- With appropriation:
  
  $1\% \text{ rise in } X_I/Y$

  $\Rightarrow$ possibly negative welfare!

- Optimal policy may involve barriers to new firms, products
Bottom Line

- Need estimates for some key parameters
- AB on right track
  - Match theory to NIPA
  - Should look at cross-country evidence
- Don’t see that they need LBD or GHK