Non-Neutral Marginal Research Costs and Induced Innovation

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Motivation

- Induced Innovation Hypothesis (IIH) states that technical change in production occurs in the way that producer can economize the use of expensive input (J.R. Hicks 1932).
- Implications on dynamic impacts of distortionary tax or subsidy.
- Necessary conditions for testing the IIH have not been discussed enough.

Issues of prior empirical tests

- A typical prior test for the IIH was to see if there holds a negative relationship between lagged input price ratio and input quantity ratio,
  i.e., $\frac{P_1}{P_2}\uparrow \Rightarrow \frac{X_1}{X_2}\downarrow$
- Little consideration on innovation supply side.
- Most prior tests assume neutral and time invariant marginal research costs.

Research Objectives

- Develop a IIH test procedure robust to non-neutral and time varying marginal research costs.
- Test whether technical change in U.S. agriculture has been consistent with the IIH.

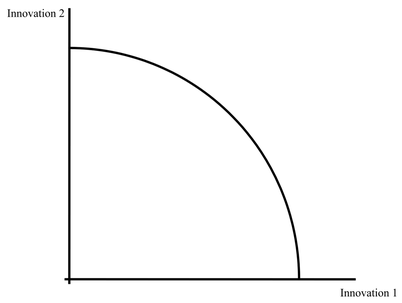
Why NNMRC matters?

- Non-Neutral Marginal Research Costs (NNMRC) imply different research costs on different research projects.
- Even if price of an input, say labor, is great, if cost of innovation in production to save labor use is even greater, the negative relationship may not hold.

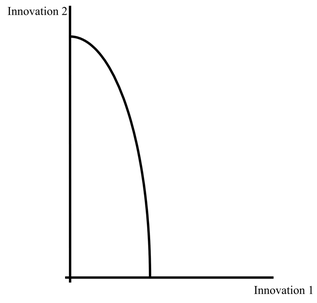
Theoretical Model

- A two-stage cost minimizing model under two-level CES production function.
- Innovation function reflecting non-neutral marginal costs of research.

$$R_i = \left(c_{i1}\hat{a}_{i1}\right)^{\theta_i} + \left(c_{i2}\hat{a}_{i2}\right)^{\theta_i} \quad \text{for } \theta_i > 1$$



Neutral



Non-Neutral

- Our model shows that input quantity ratio depends on ratio of marginal research costs as well as price ratio.
- However, information on research costs is usually unavailable.

Identification Strategy

- Assumption: unobserved trends in relative marginal costs of research are equal among state.
- Difference-in-Differences (state and time difference)

Empirical Model

$$\Delta_{t,s}\ln\left(\frac{x_{i1st}}{x_{12st}}\right) = \beta_{i1}\Delta_{t,s}\ln\left(\frac{w_{i1st}}{w_{i2st}}\right) + \beta_{i2}\Delta_{t,s}\ln\left(\frac{E_{t-k}(w_{i1st})}{E_{t-k}(w_{i2st})}\right) + \beta_{i3}\Delta_{t,s}\ln\left(\frac{c_{i1st}}{c_{i2st}}\right) + \Gamma_i'\Delta_{t,s}Z_{ist} + \Delta_{t,s}\varepsilon_{ist}$$

Data

- Agricultural input prices and quantities of land labor, capital, and other intermediate input for 48 contiguous U.S. states during 1960-2004.

Empirical Results (6 models for each pair)

Input pair	Labor /Land	Capital /Land	Intermd /Land	Capital /Labor	Intermd /Labor	Intermed /Capital
Empirical Support	20%	50%	20%	60%	80%	90%

- Overall, 53% of the models were found to support the IIH – except land, percentage of empirical support is 76%.

Conclusions

- We develop a test procedure for the IIH that is robust to non-neutral and time varying marginal research costs and that can be readily applied in other sectors.
- Data of U.S. agriculture during 1960-2004 are generally consistent with the IIH for the three inputs, capital, labor, and other intermediate inputs while little support was found in land.
- The support level found is considerably greater than some recent works which did not consider non-neutral marginal research costs.
- Land may not be consistent with the IIH due to fixity of supply. (requires further investigation).