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# **Non-Neutral Marginal Research Costs and Induced Innovation**

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# 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.

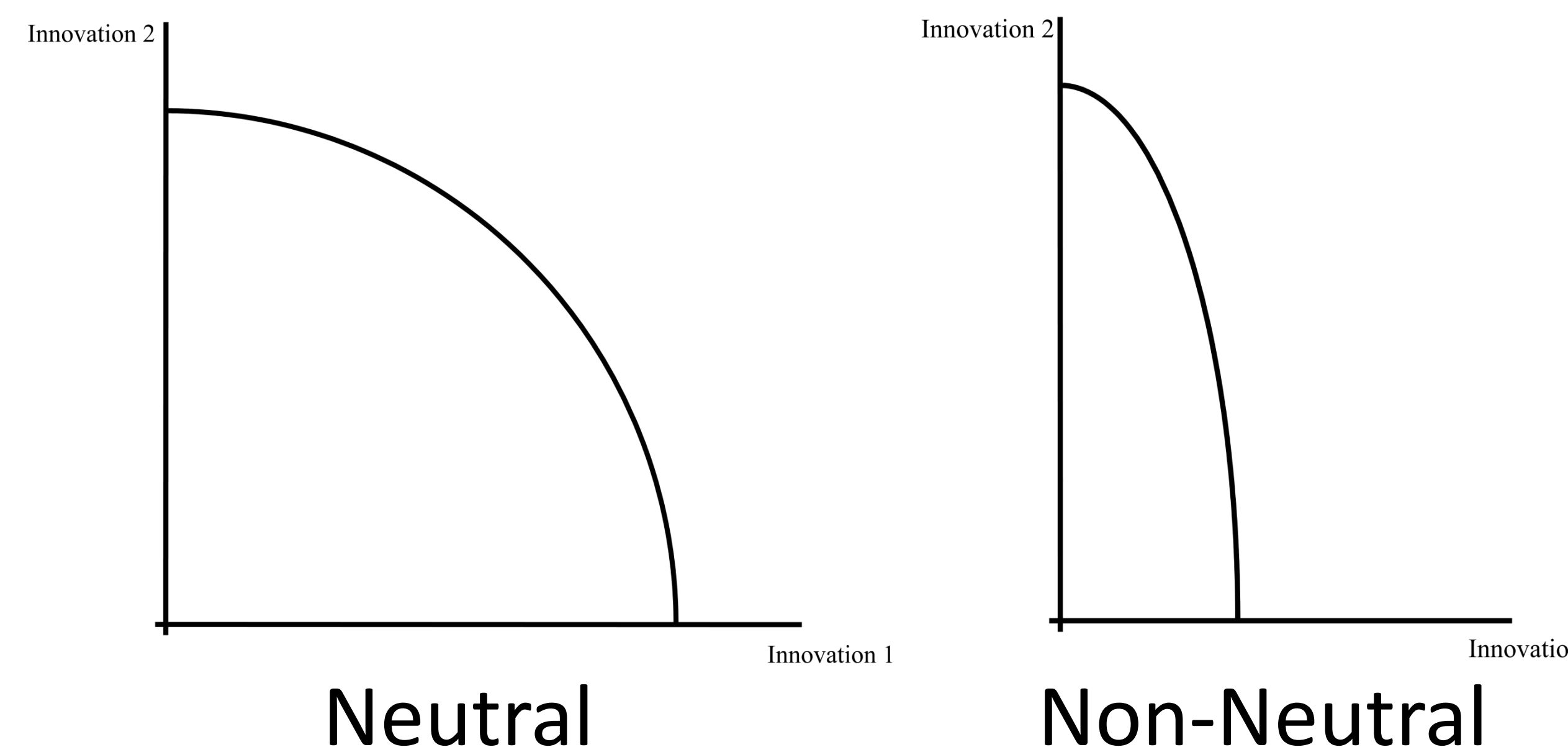
## Why NNMRC matters?

- 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.

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



- 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

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

## 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).