U.S. Agricultural Productivity and Returns to Research

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Food & Fuel: The Implications for Agricultural Research Policy
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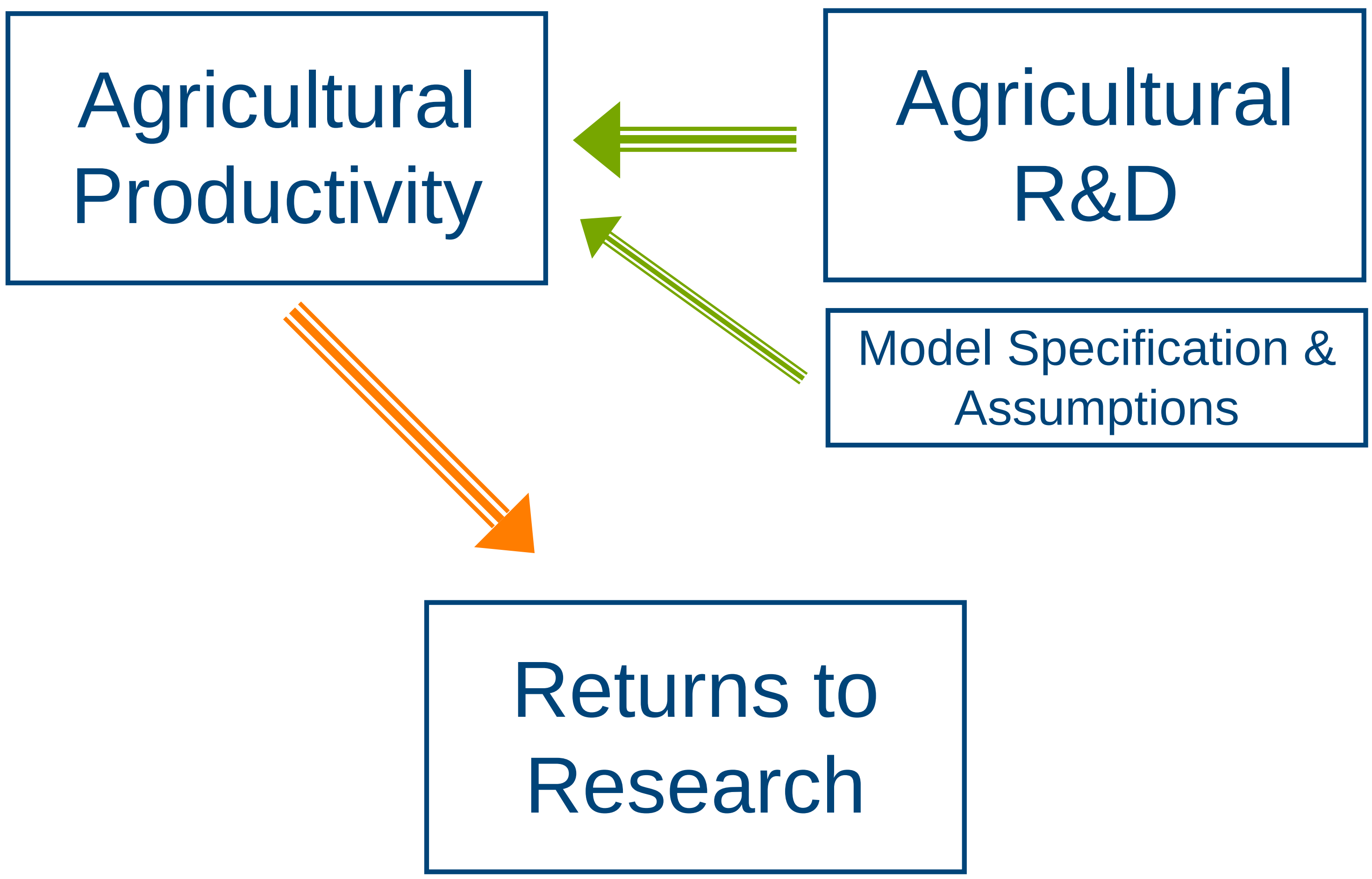
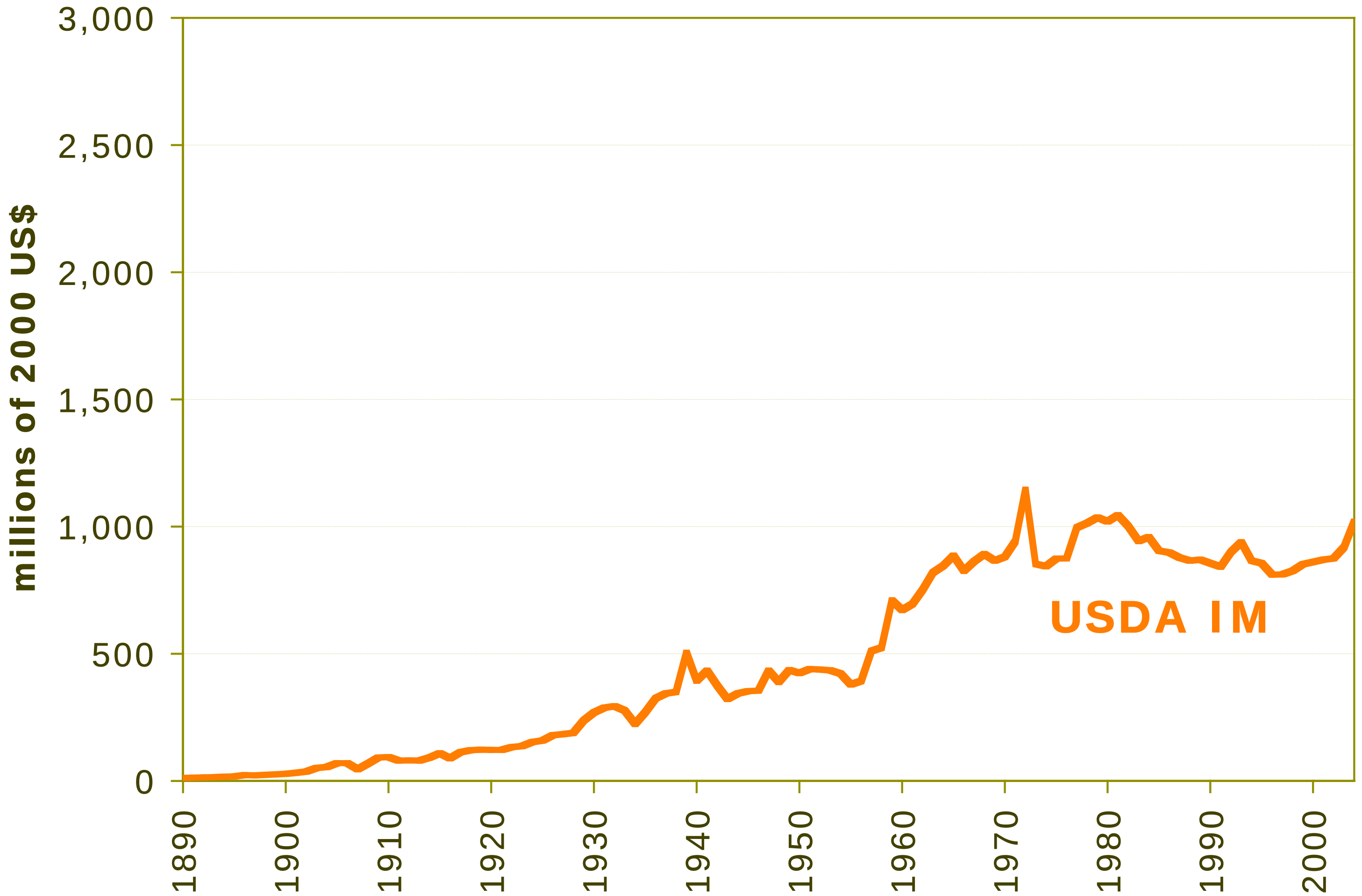
Overview

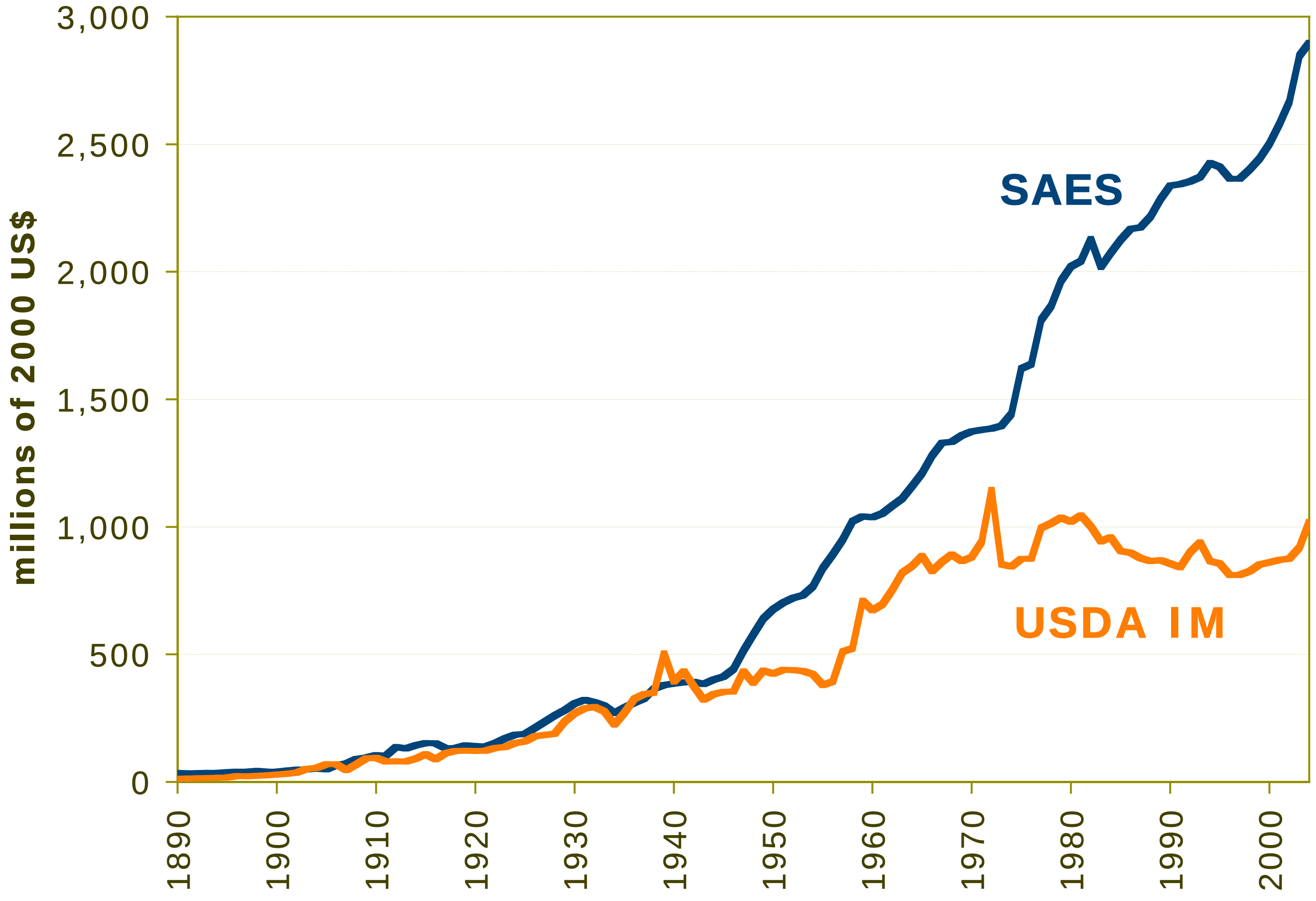


Agricultural Productivity
Agricultural R&D
Model Specification & Assumptions
Returns to Research

U.S. Public R&D Funding, 1890-2004



U.S. Public R&D Funding, 1890-2004



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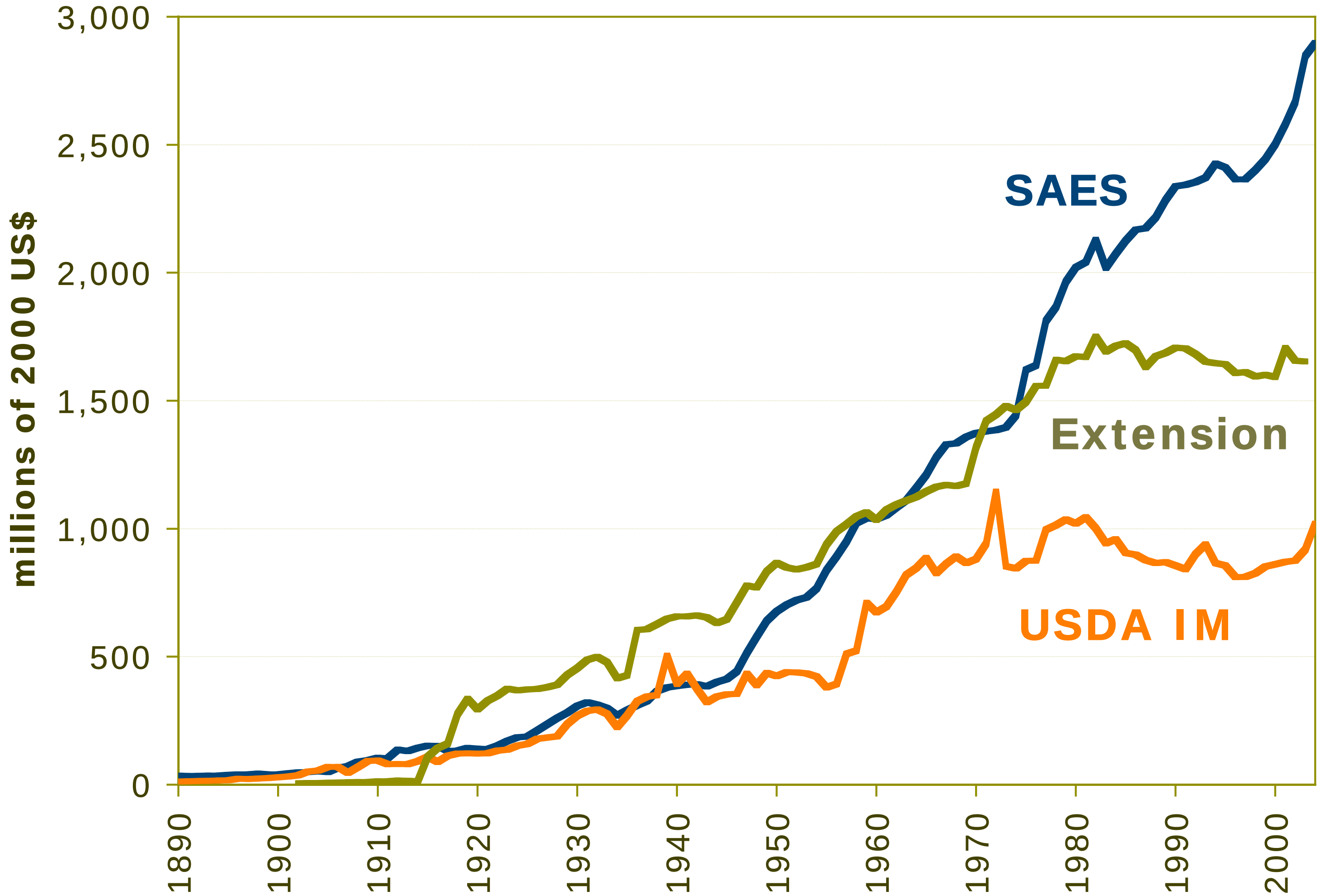
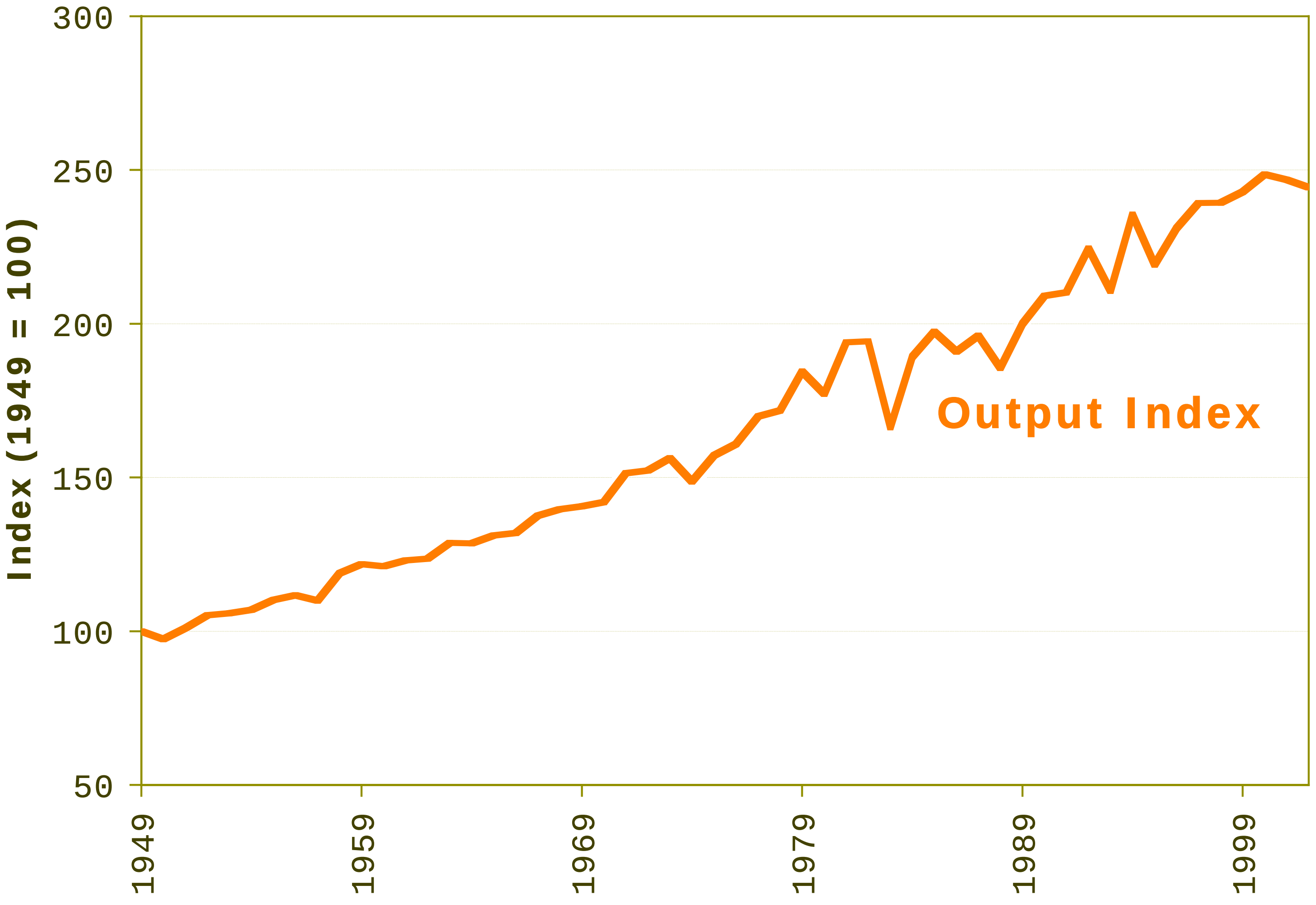


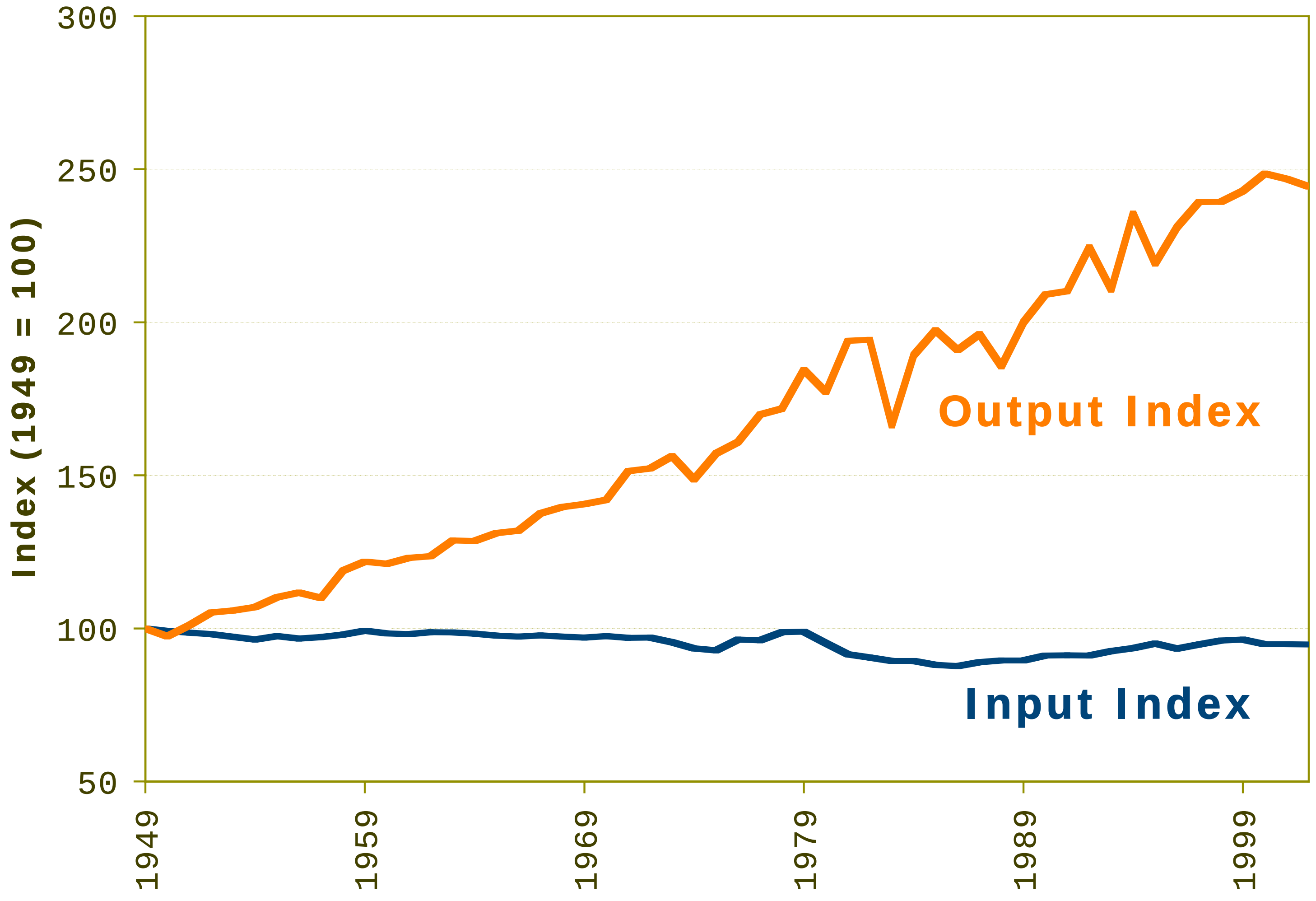
U.S. Agricultural Productivity

- Productivity Data
  - Based on input and output quantities
  - Started with data from Aquaye, Alston, and Pardey, 2002
    - Quantities adjusted for quality
    - State-specific prices used in index construction
  - Revised by Alston, Andersen, and Pardey
    - Added more outputs and inputs
    - Improved accounting of capital components
- Multi-Factor Productivity (MFP)
  - Output per quantity of Input

U.S. Agricultural Productivity, 1949-2002



U.S. Agricultural Productivity, 1949-2002



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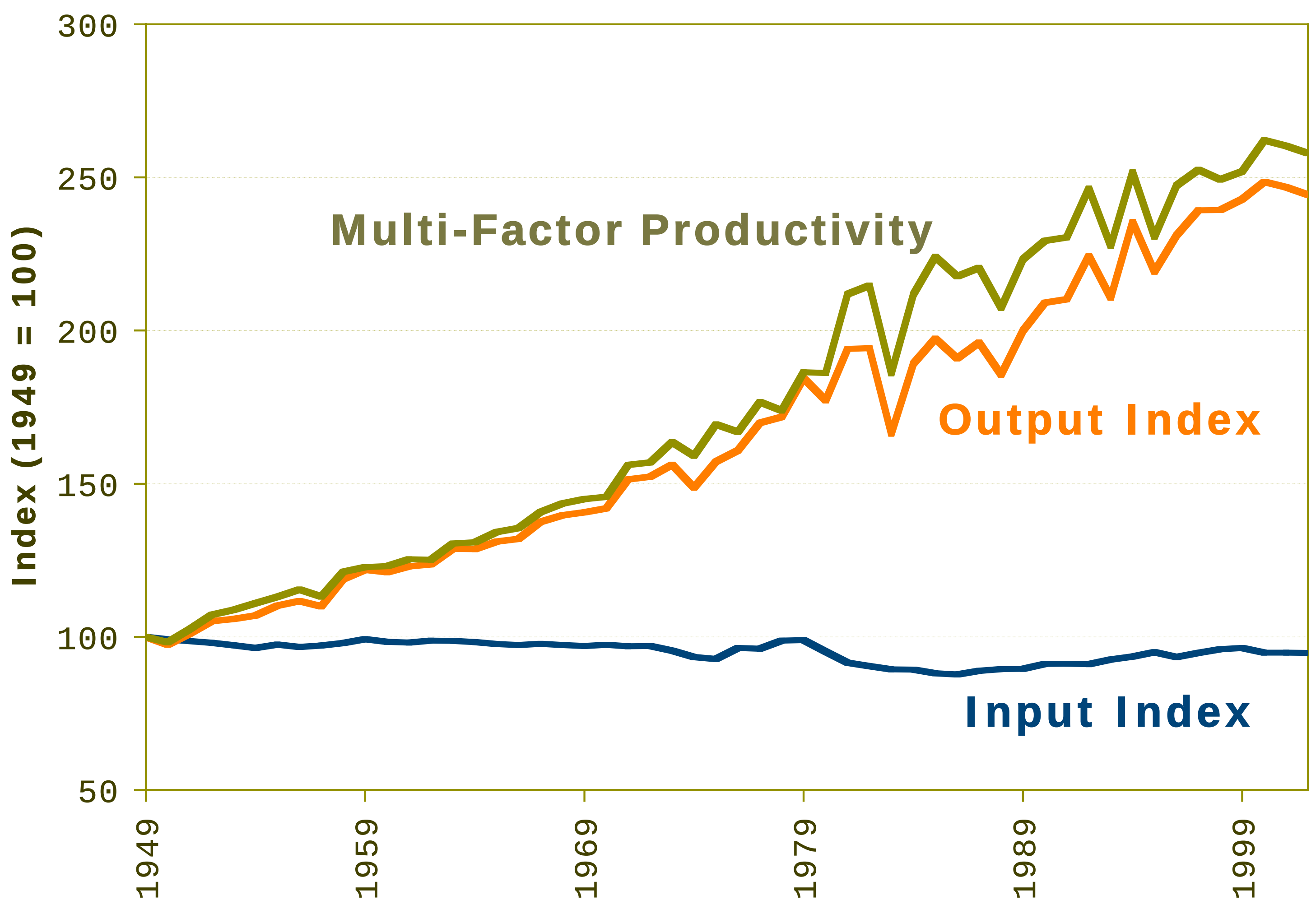
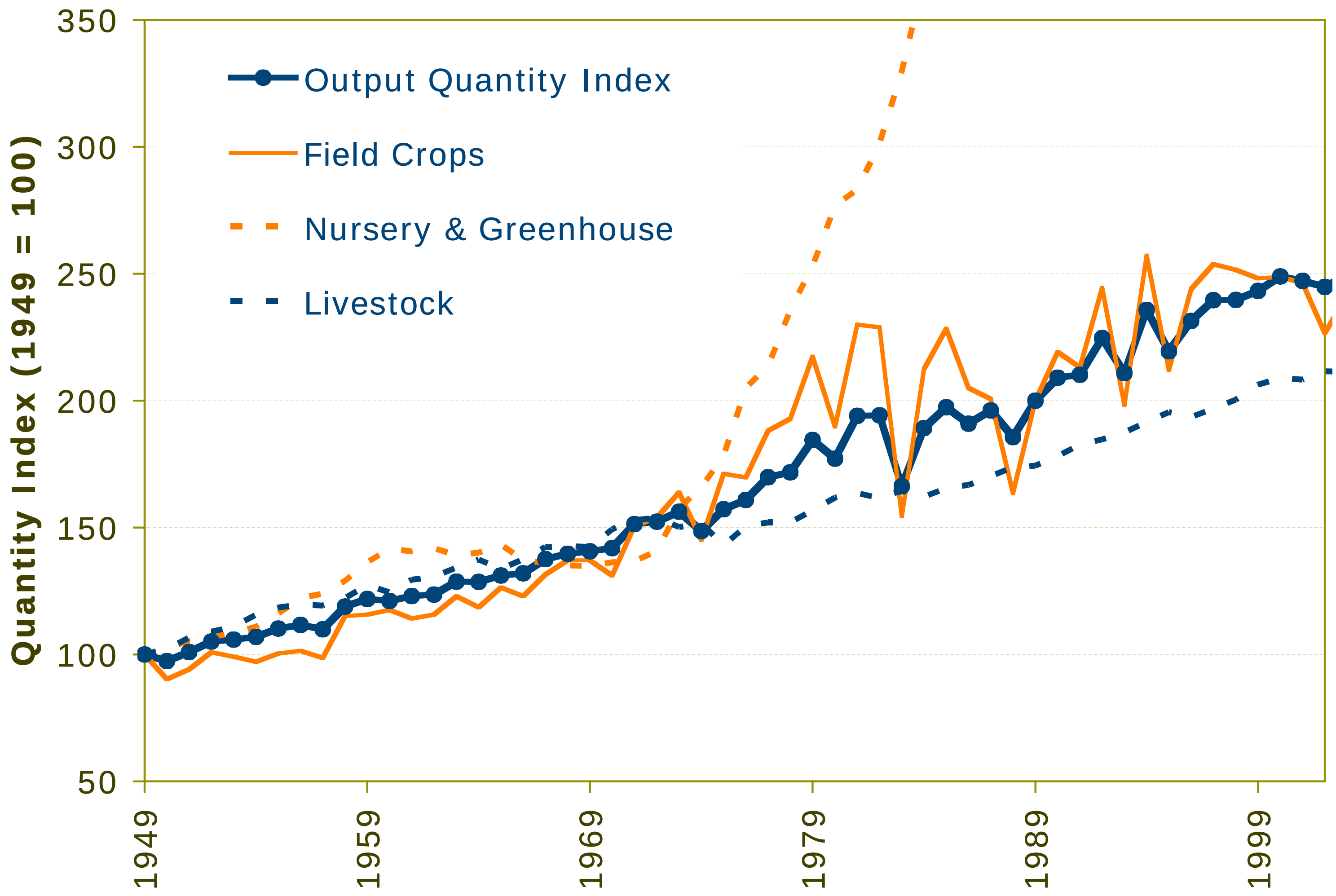
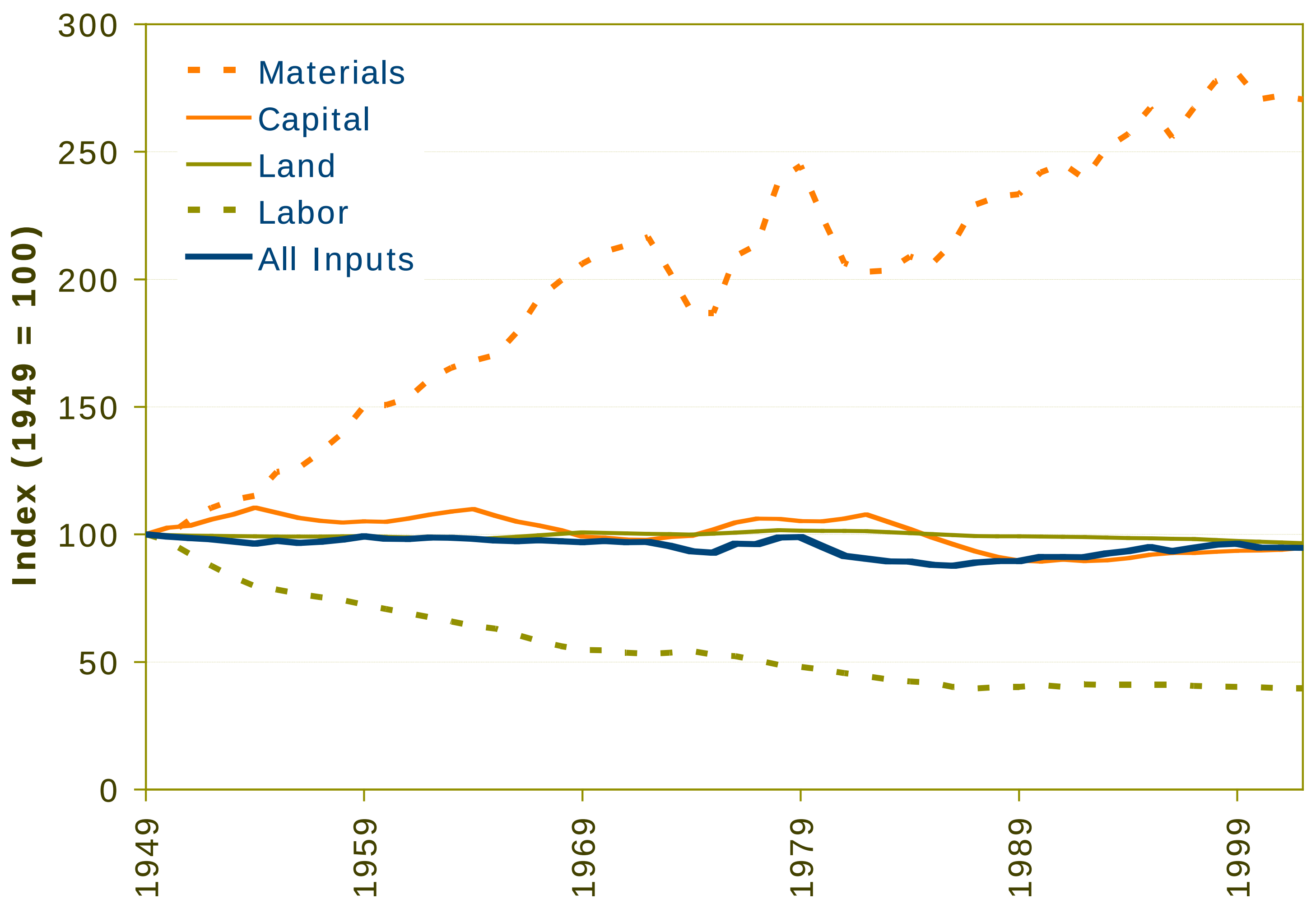


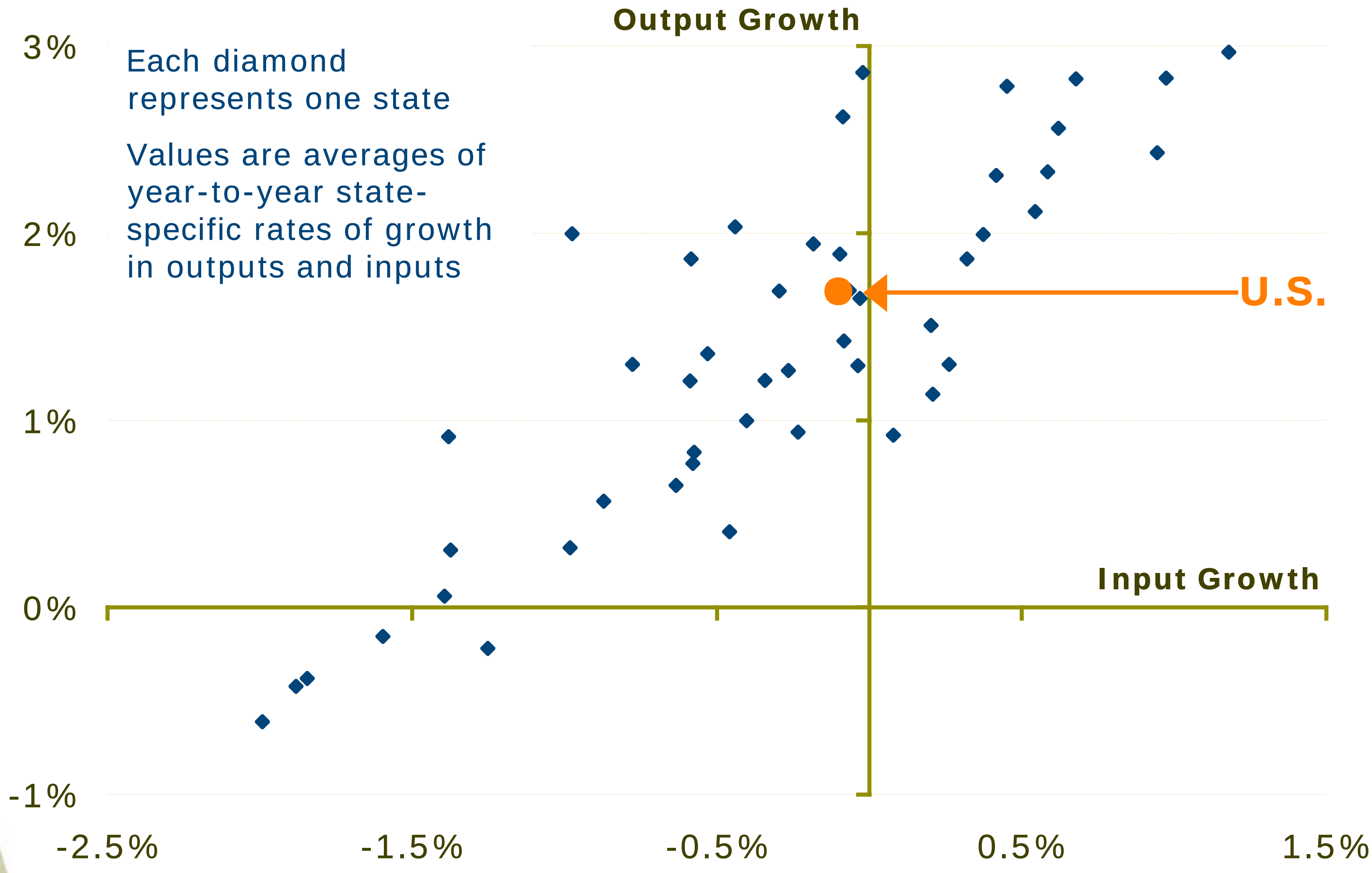
Output Indexes in U.S. Agriculture



Input Indexes in U.S. Agriculture



State-Specific Growth in Inputs and Outputs, 1950-2002



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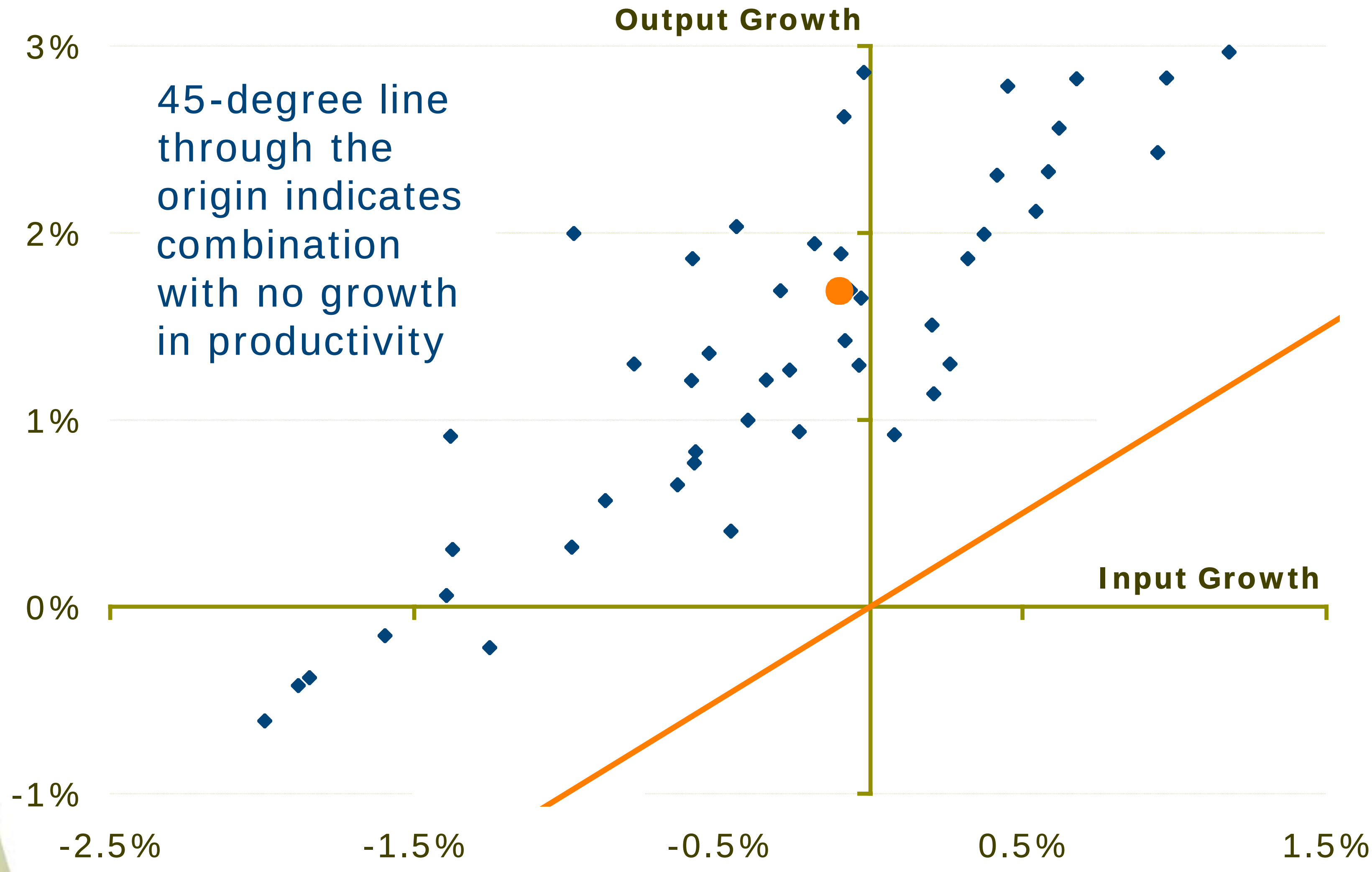

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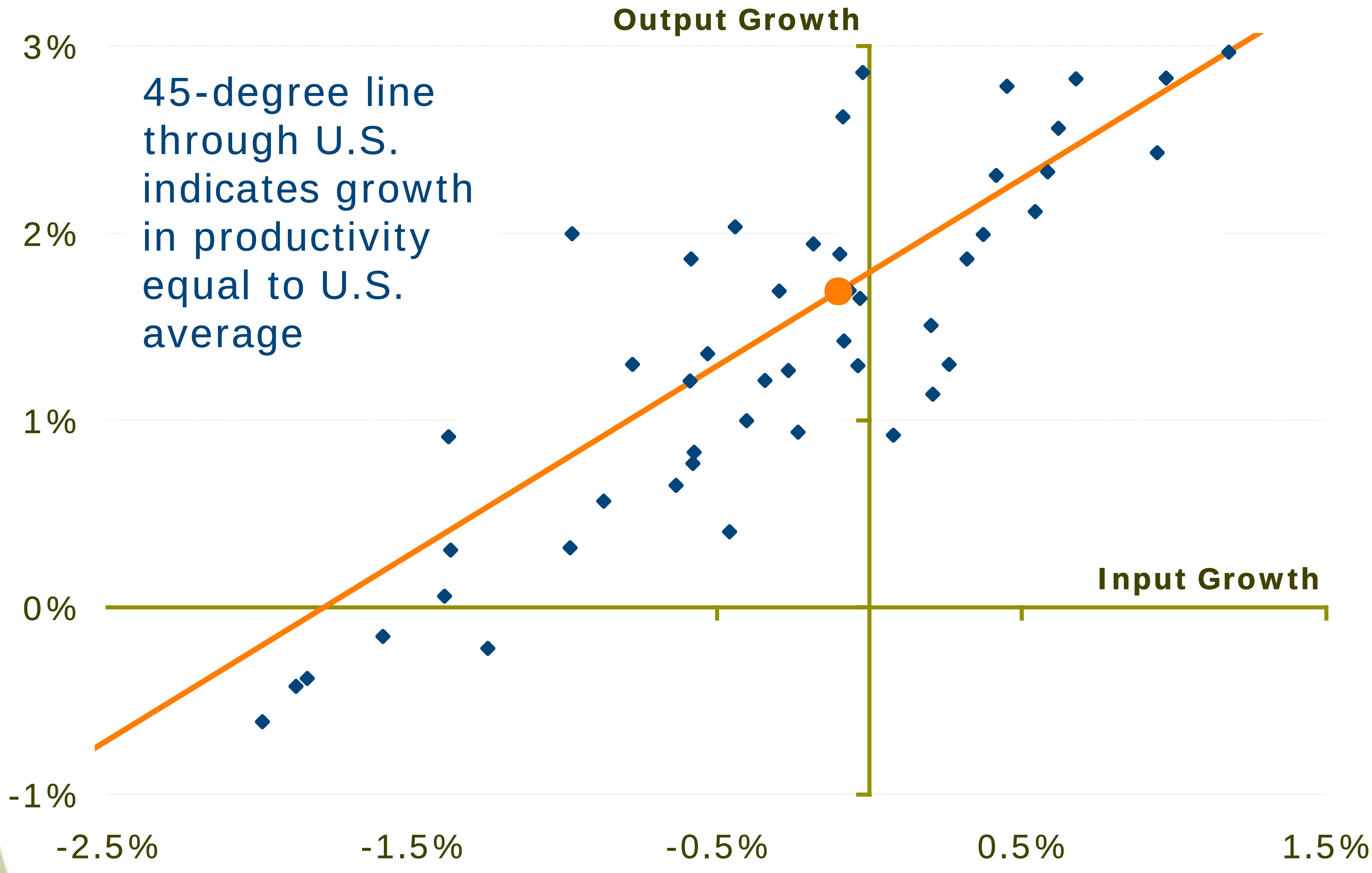
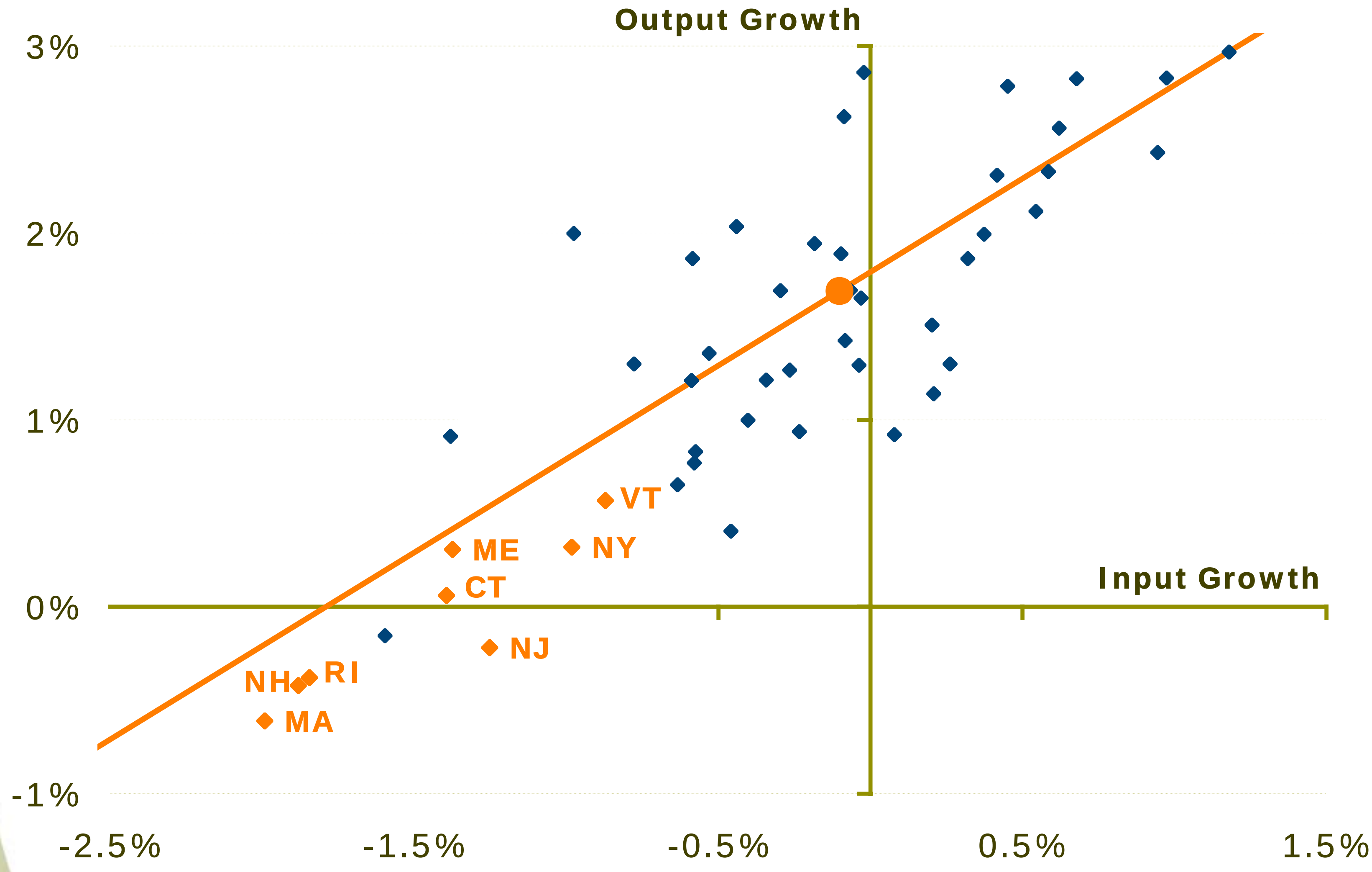


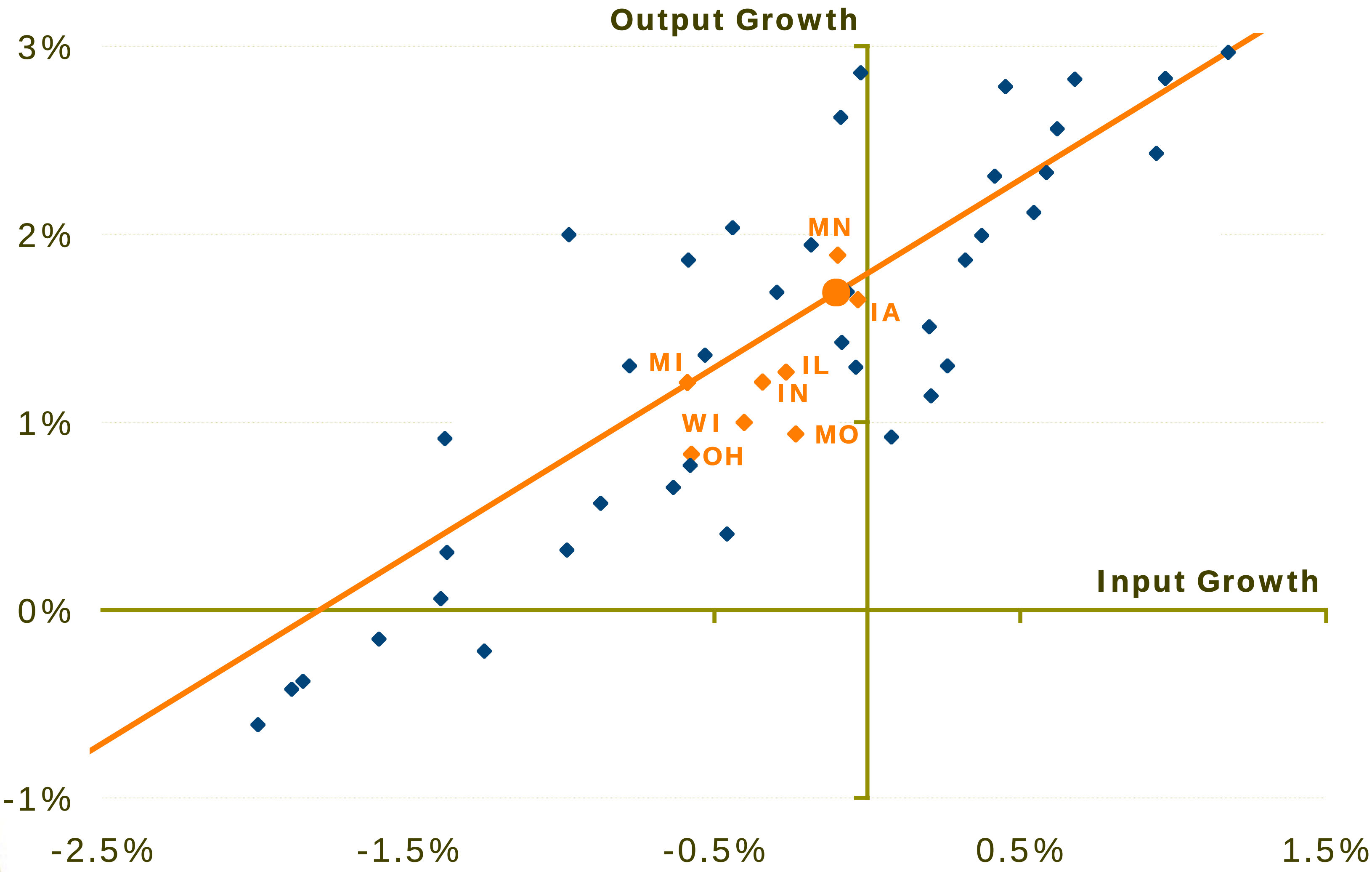
Spatial Patterns of Input and Output Growth

Northeastern States

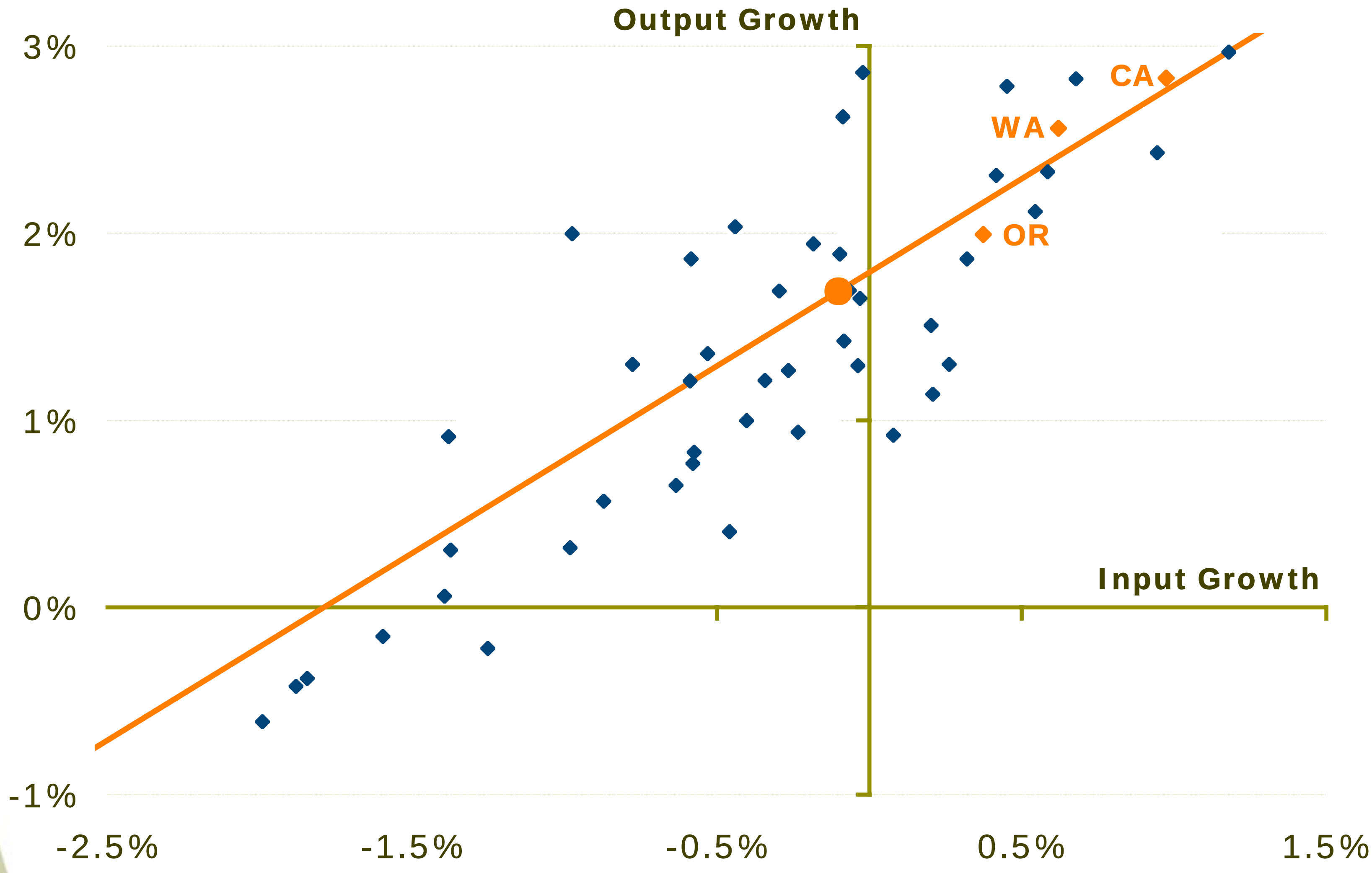


Spatial Patterns of Input and Output Growth

Corn Belt & Lake States

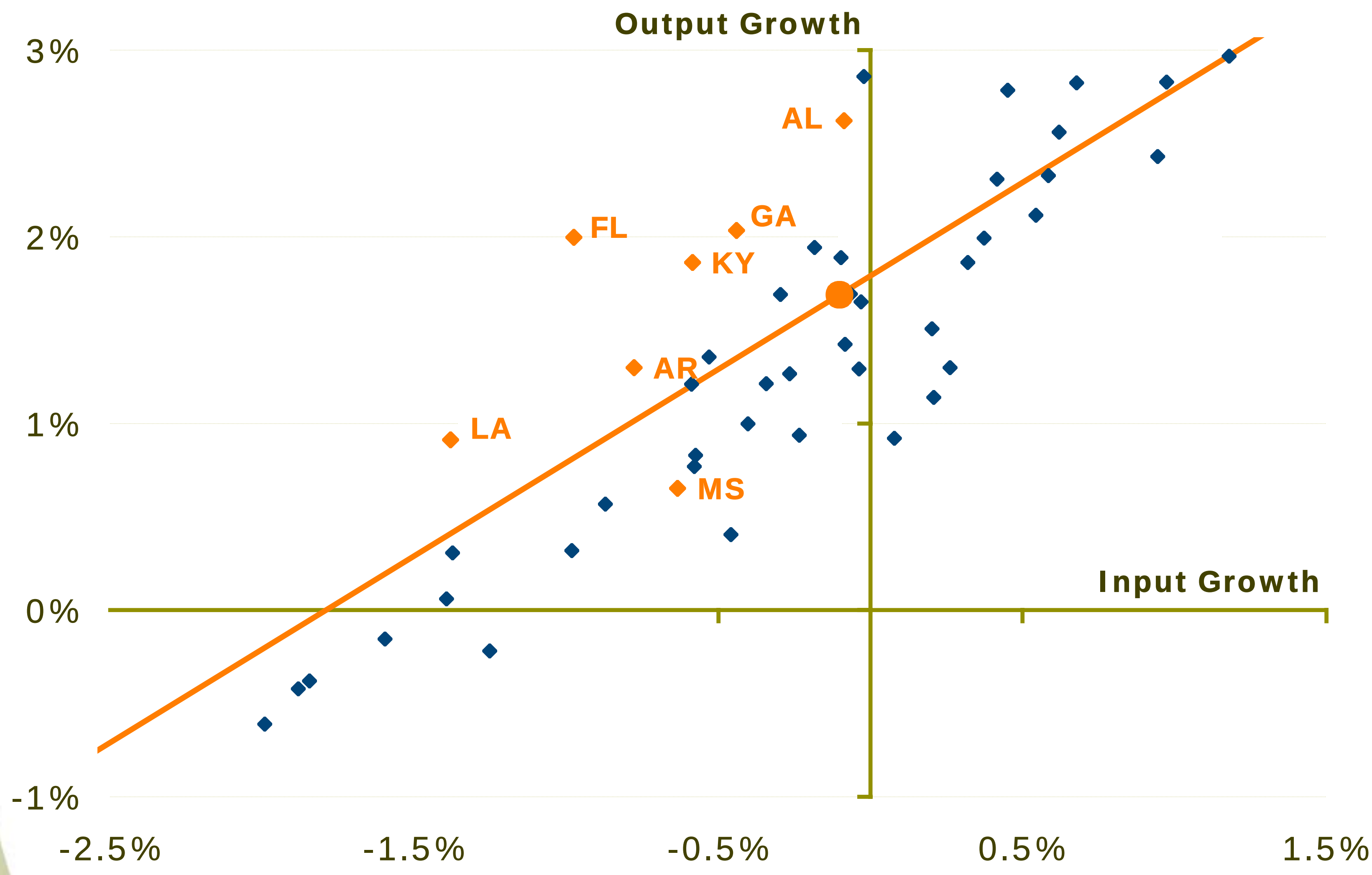


Spatial Patterns of Input and Output Growth
Pacific States



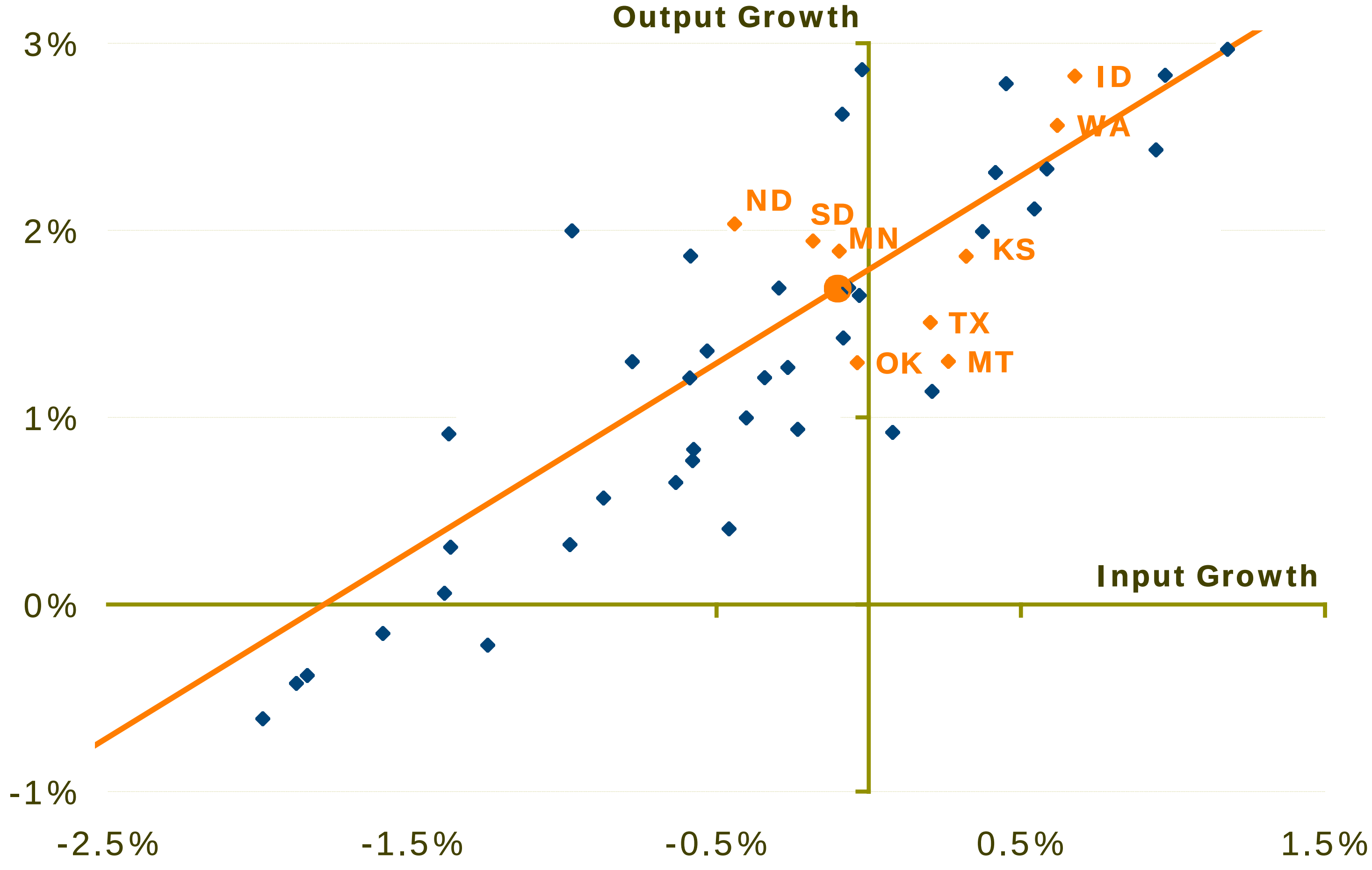
Spatial Patterns of Input and Output Growth

Southern States



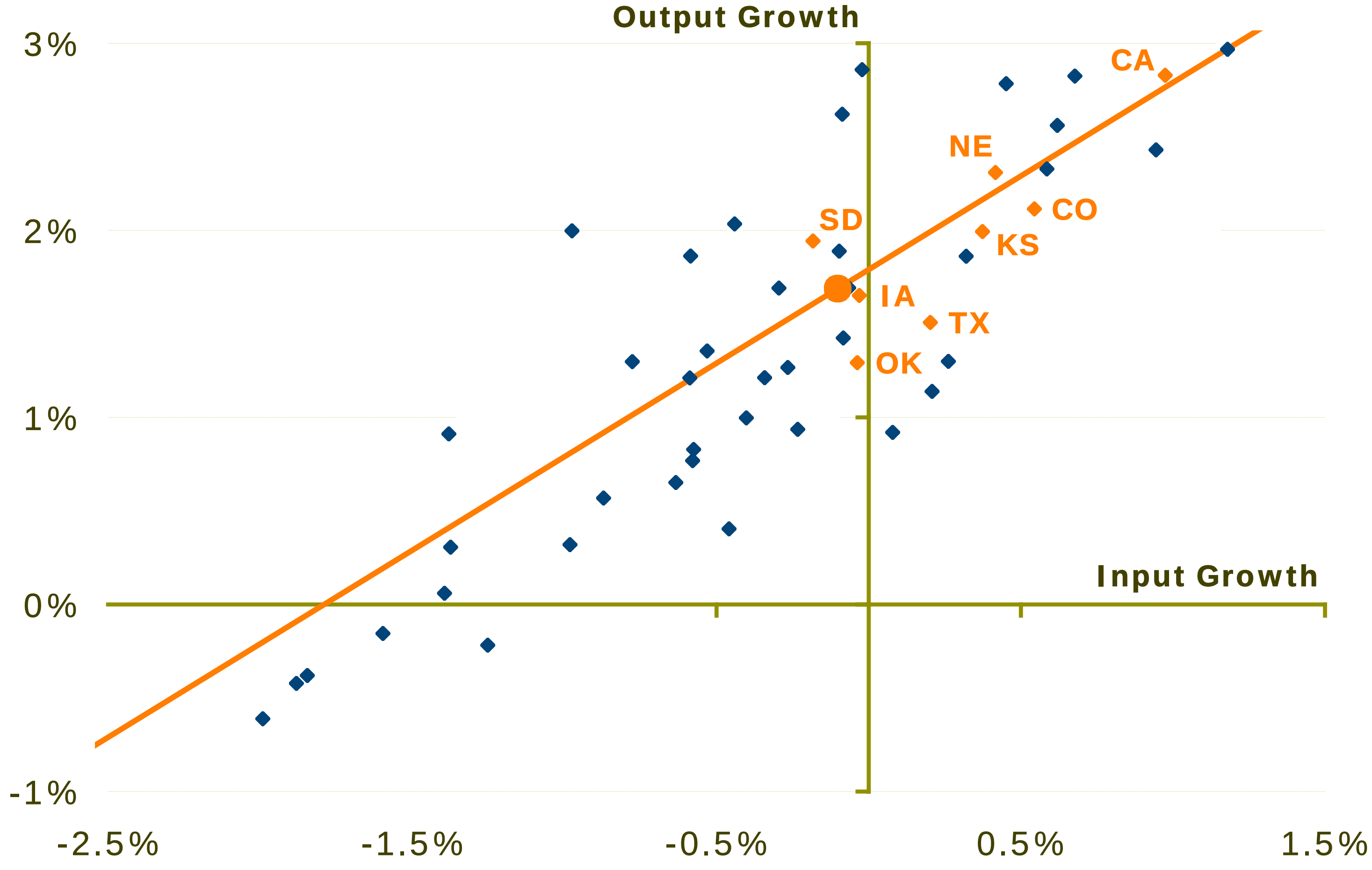
Spatial Patterns of Input and Output Growth

Big Wheat-Producing States

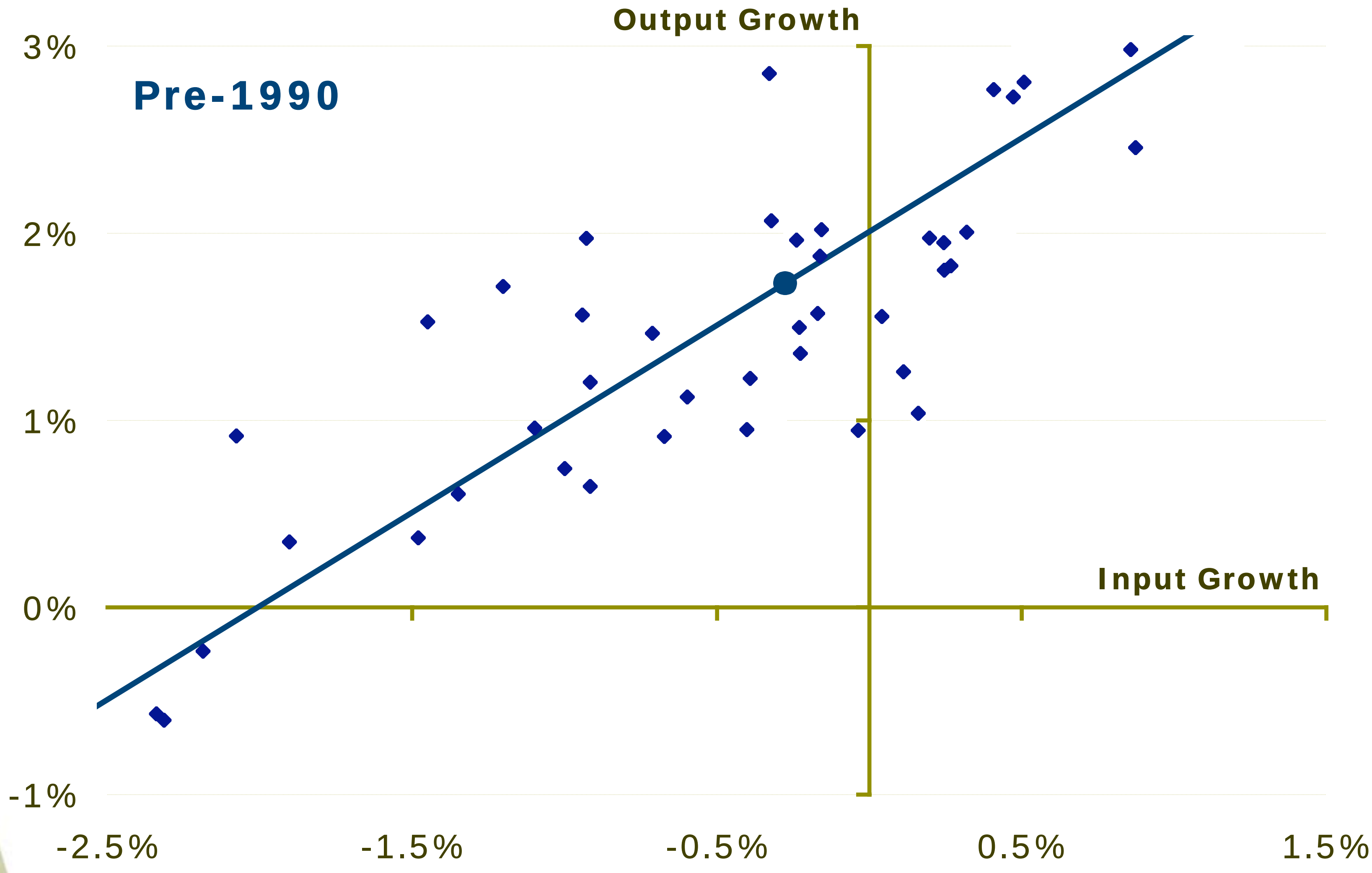


Spatial Patterns of Input and Output Growth

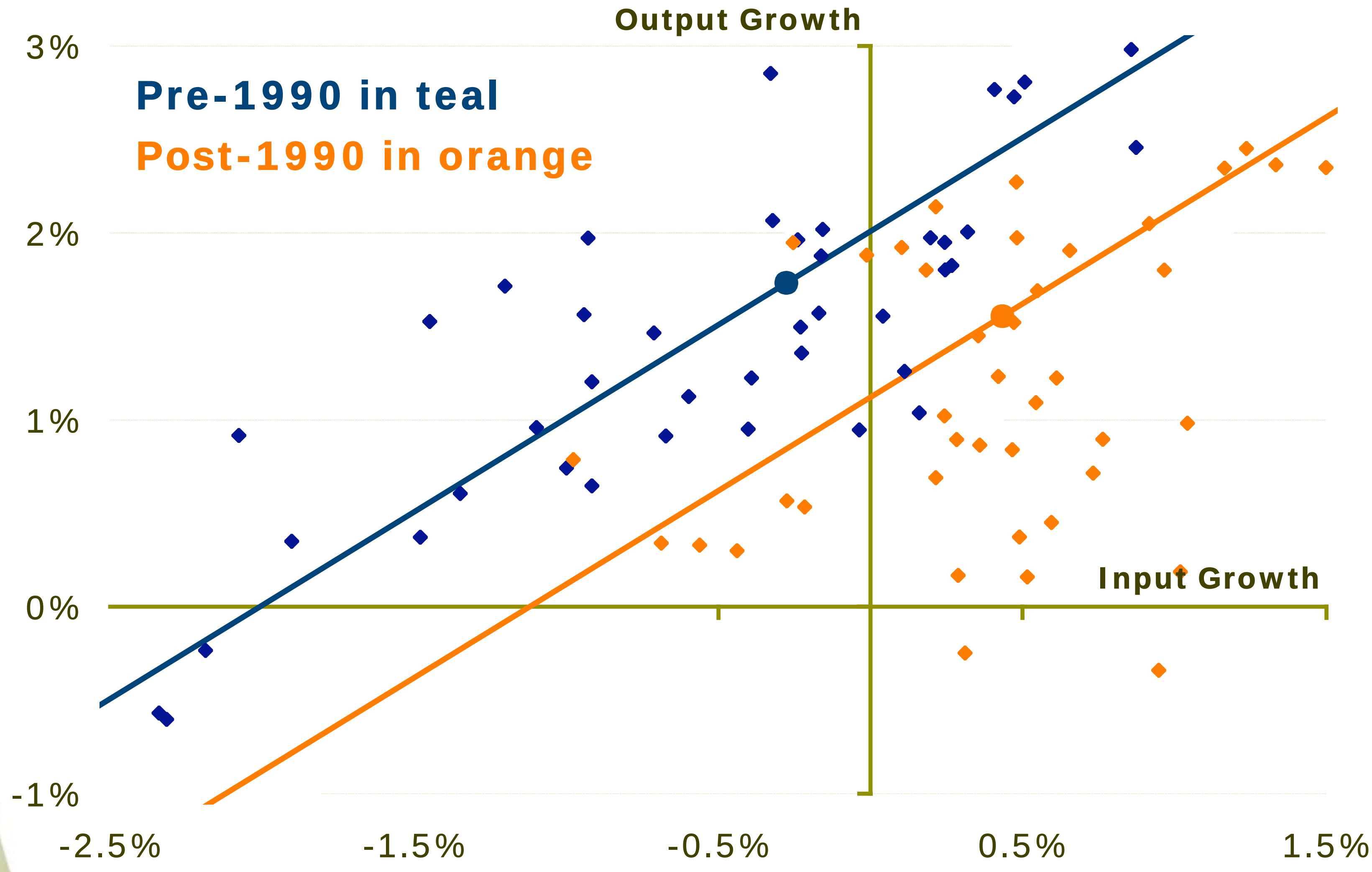
Big Beef-Producing States



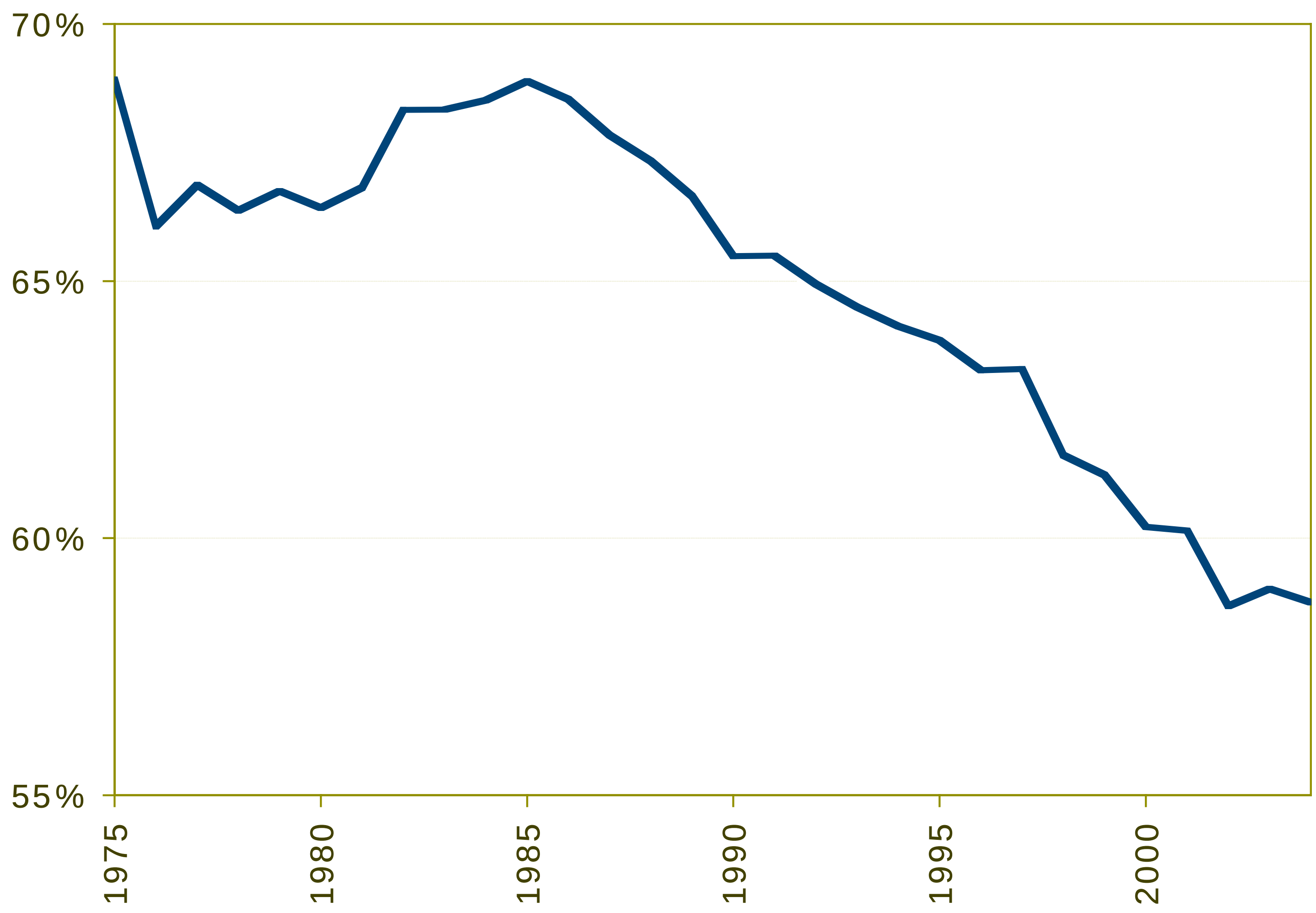
Temporal Patterns of Input and Output Growth, Pre- and Post-1990



Temporal Patterns of Input and Output Growth, Pre- and Post-1990



Share of Public R&D Directed to Enhancing Farm Productivity



Linking R&D Investments to Productivity

- Goals:
  - To obtain econometric estimates of the effect of R&D on productivity
  - To use those estimates to calculate the returns to research

MFP_{it} = f (R&D Spending, other factors)

R&D Spending	other factors
SAES Extension USDA-IM	Growing Condition Index

- Specification Issues:
  - Functional form
  - Imposing structure on spending data

Managing the Spending Data

- R&D spending by any particular state in any particular year will (most likely):
  - have little effect for several years
  - then have increasingly pronounced effects for some years
  - after which, effects taper off

  - Have similar effects in other states
    - Especially those that are agriculturally similar
- A complete econometric specification would include variables for
  - Each of two types of spending for 48 states
  - Federal IM spending
  - For last 50 years (give or take)

Managing the Spending Data (cont.)

- Problems with complete specification
  - Too many coefficients to estimate
  - Too much correlation among variables
- Solution – Create knowledge stocks
  - Weighted sum of spending data over previous __ years
  - Weights determined by gamma distribution
    - flexible
    - characterized by only two parameters
  - Alternative structure uses a trapezoid shape for weights
- Three knowledge stocks
  - Own-state research
  - Own-state extension
  - Spillins

Spillin Stocks and Spillover Coefficients

- Technological Spillovers
  - Technologies developed in one state may be adopted in other states
- Spillin Stocks
  - Weighted sum of research (and possibly extension) knowledge stocks in all other states
  - Weights are spillover coefficients
- Spillover Coefficients
  - Measure similarity of two states in their output mixes
  - Based on 74 outputs
  - Vary between zero (no similarity) and one (the same)

Estimation Strategy and Issues

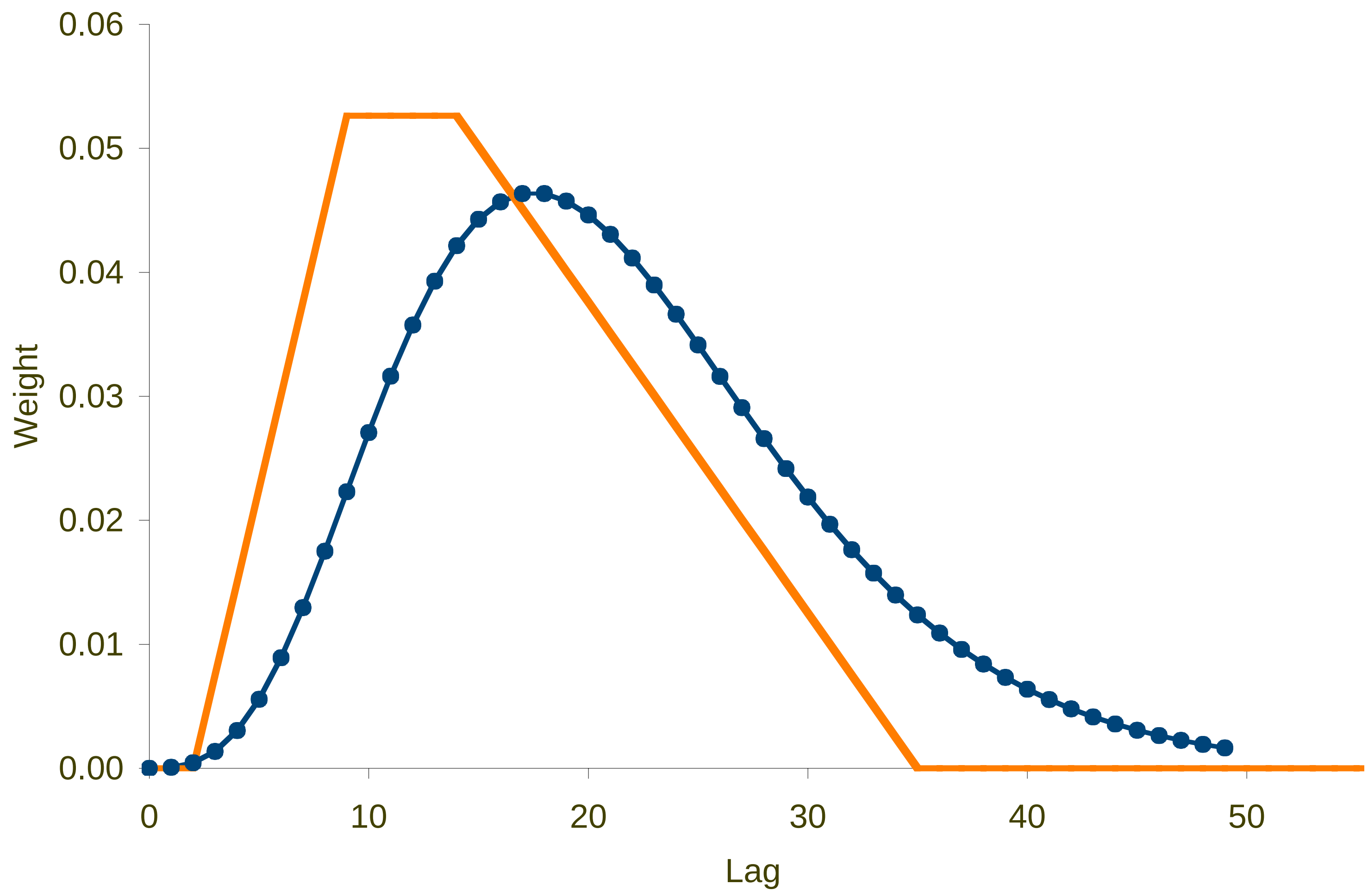
MFP_{it} = g (Knowledge Stocks, Other Factors)

Own-State
(inc. extension)
Spillins
(including USDA IM)

Growing
Condition
Index

- Estimate two parameters of gamma distribution
  - Abbreviated grid search

Lag Structure Used for Preliminary Results



Some **Preliminary** Results

- Elasticities implied:

	Log	Linear
wrt own-state stock	0.29	0.12
wrt spillin stock	0.32	0.49

- Double-log functional form

$$\ln MFP_{it} = a_i + 0.29*\ln(\text{Own-State Stock}) + 0.32*\ln(\text{Spillin Stock})$$

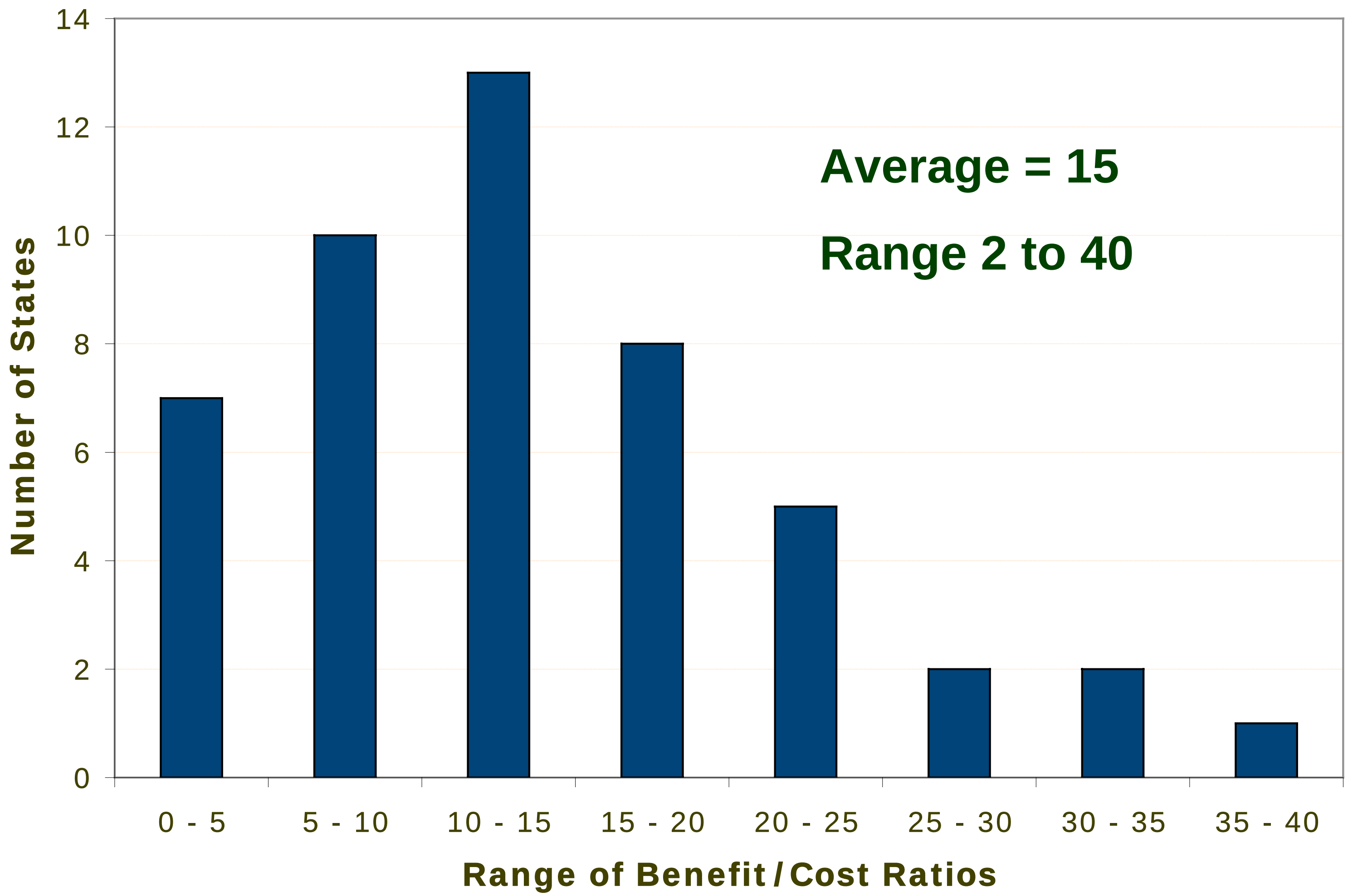
- Linear functional form

$$MFP_{it} = a_i + 0.00000057*\text{Own-State Stock} + 0.000000072*\text{Spillin Stock}$$

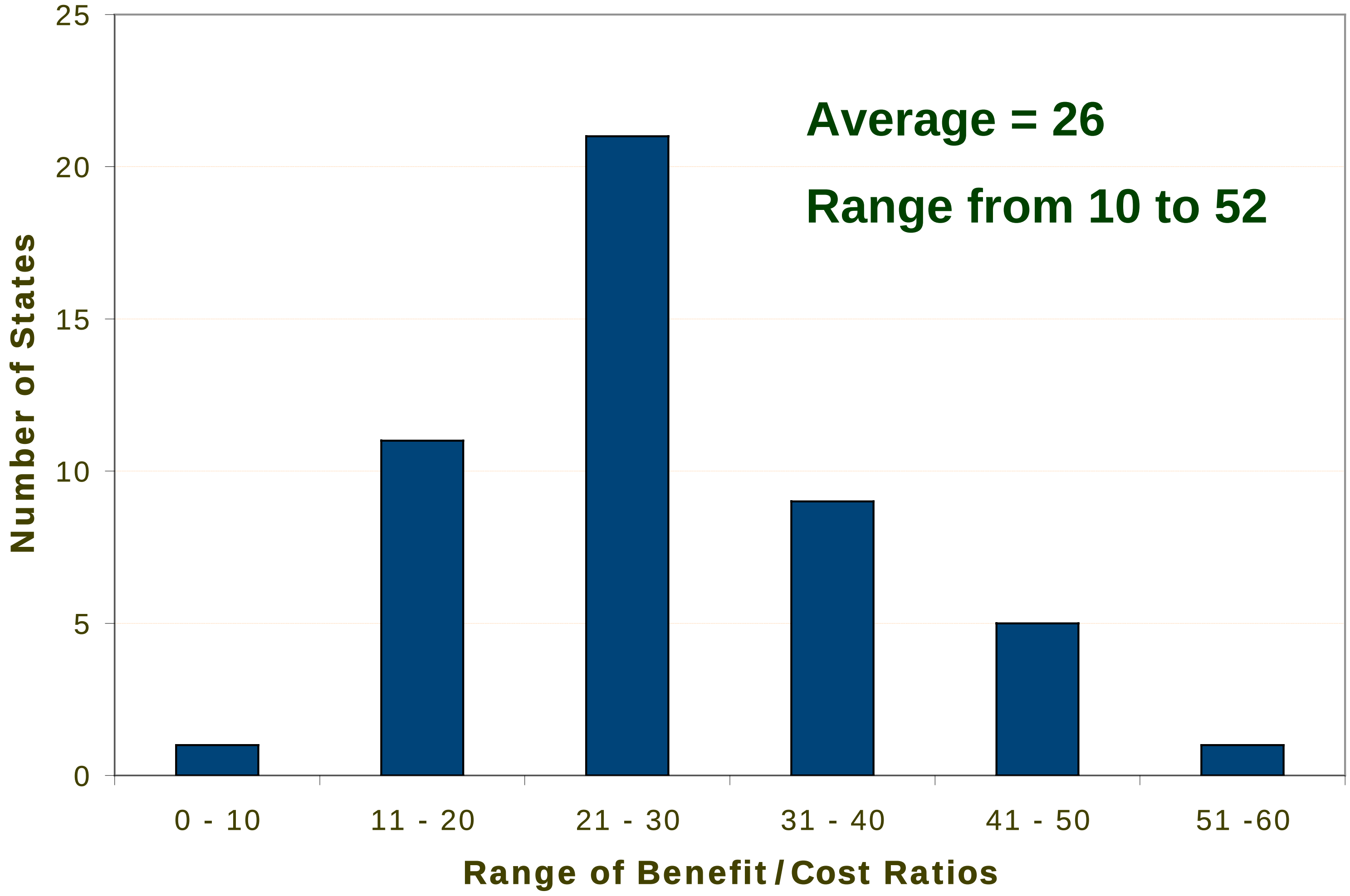
Calculating Returns to Research

- For a hypothetical increase in SAES spending in 1950 in one state
  - Calculate the % increase in productivity in all states in all years
  - Multiply by value of production for each state, year
  - Gives a stream of benefits
  - Discount or compound so valued at same time
  - Calculate the benefit/cost ratio
- Two Benefit/Cost Ratios for Each State
  - Private – only includes benefits accruing to state of hypothetical spending
  - Social – includes benefits accruing to all states (through spillovers)

Private Benefit/Cost Ratios
Double-Log Model

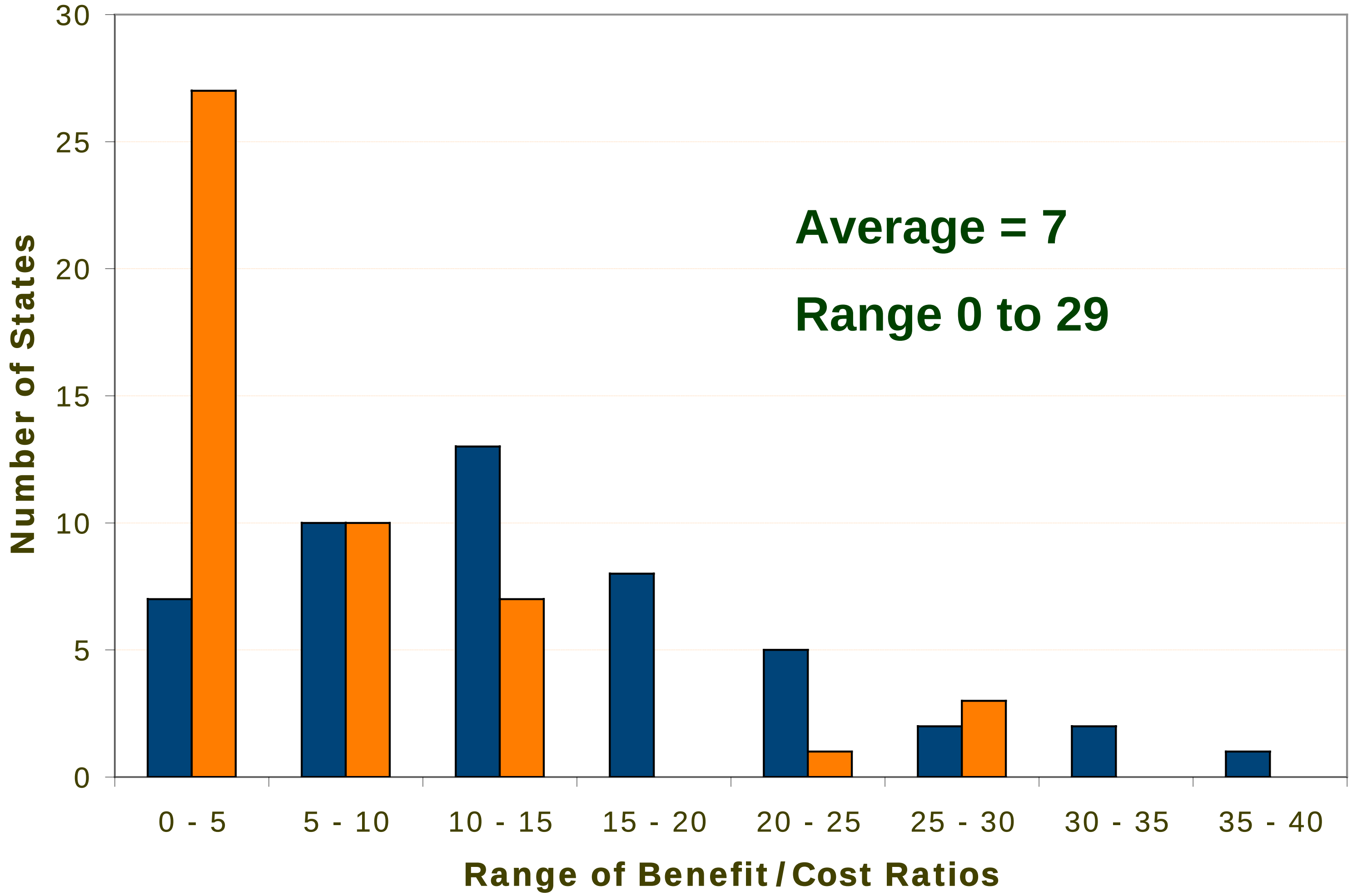


Social Benefit/Cost Ratios
Double-Log Model



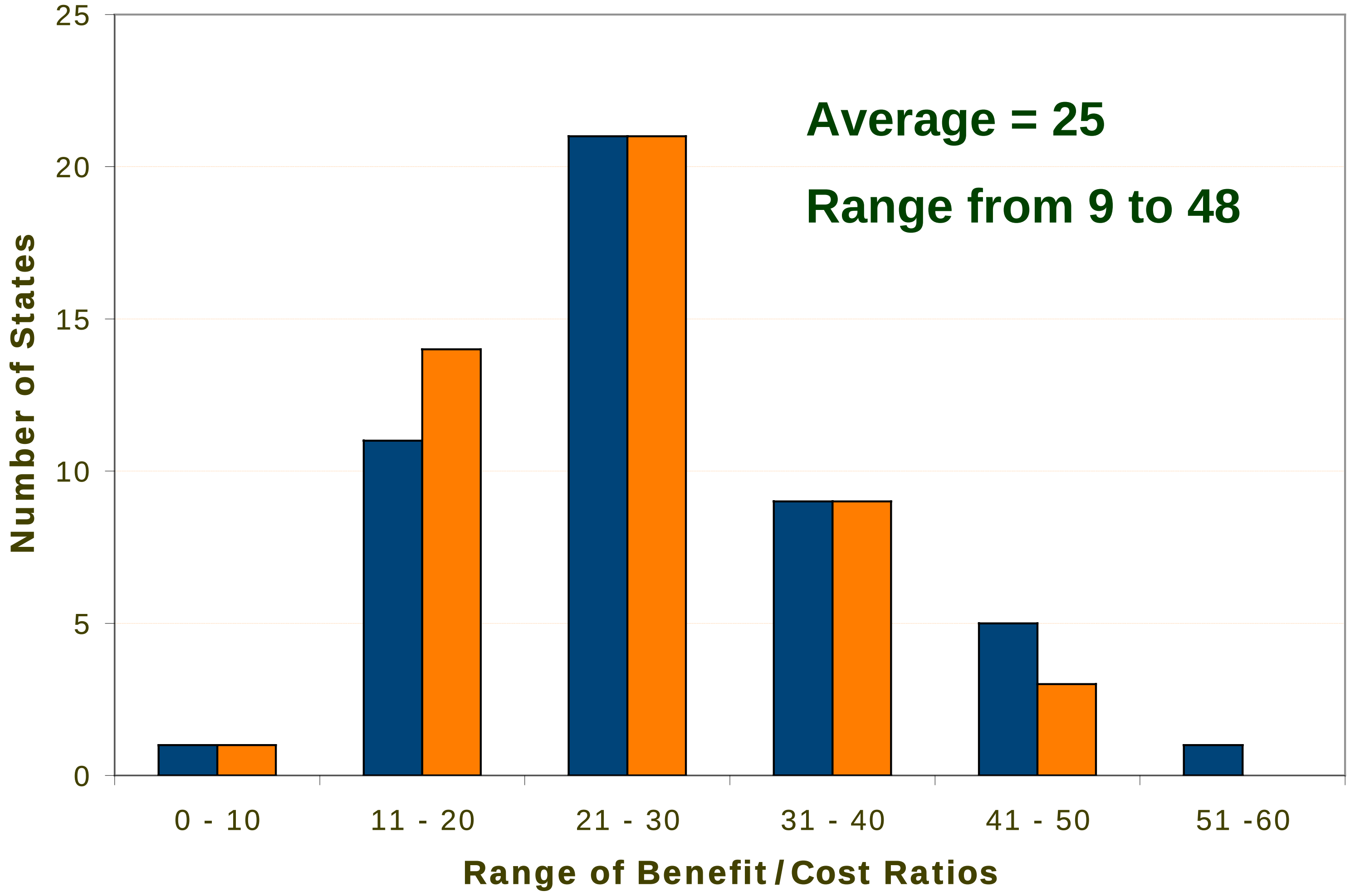
Private Benefit/Cost Ratios

Linear Model (in orange)



Social Benefit/Cost Ratios

Linear Model (in orange)



Concluding Thoughts

- Evaluate effects of specification choices
  - Functional form
  - Lag structure (gamma shapes, trapezoid)
  - Number of years of spending data included in stocks
  - Whether benefits from extension spillover to other states
  - How spillin weights are calculated
  - Data included in estimation
- Results are quite sensitive to lag specification

Concluding Thoughts (cont.)

- Regardless of Specification Choices
  - Private Benefit/Cost ratios are quite high for most states
    - Implies underinvestment from “private” perspective
  - Social Benefit/Cost ratios are generally much larger than private
    - Broader perspective indicates higher potential returns for increased spending on R&D
    - Degree of underinvestment is greater from national perspective
  - HOWEVER, private and social effects are difficult to separate due to multicollinearity inherent in data
- Relative Benefit/Cost ratios across states suggest less-than-optimal allocation of research funding among states