

U.S. Agricultural Productivity and Returns to Research

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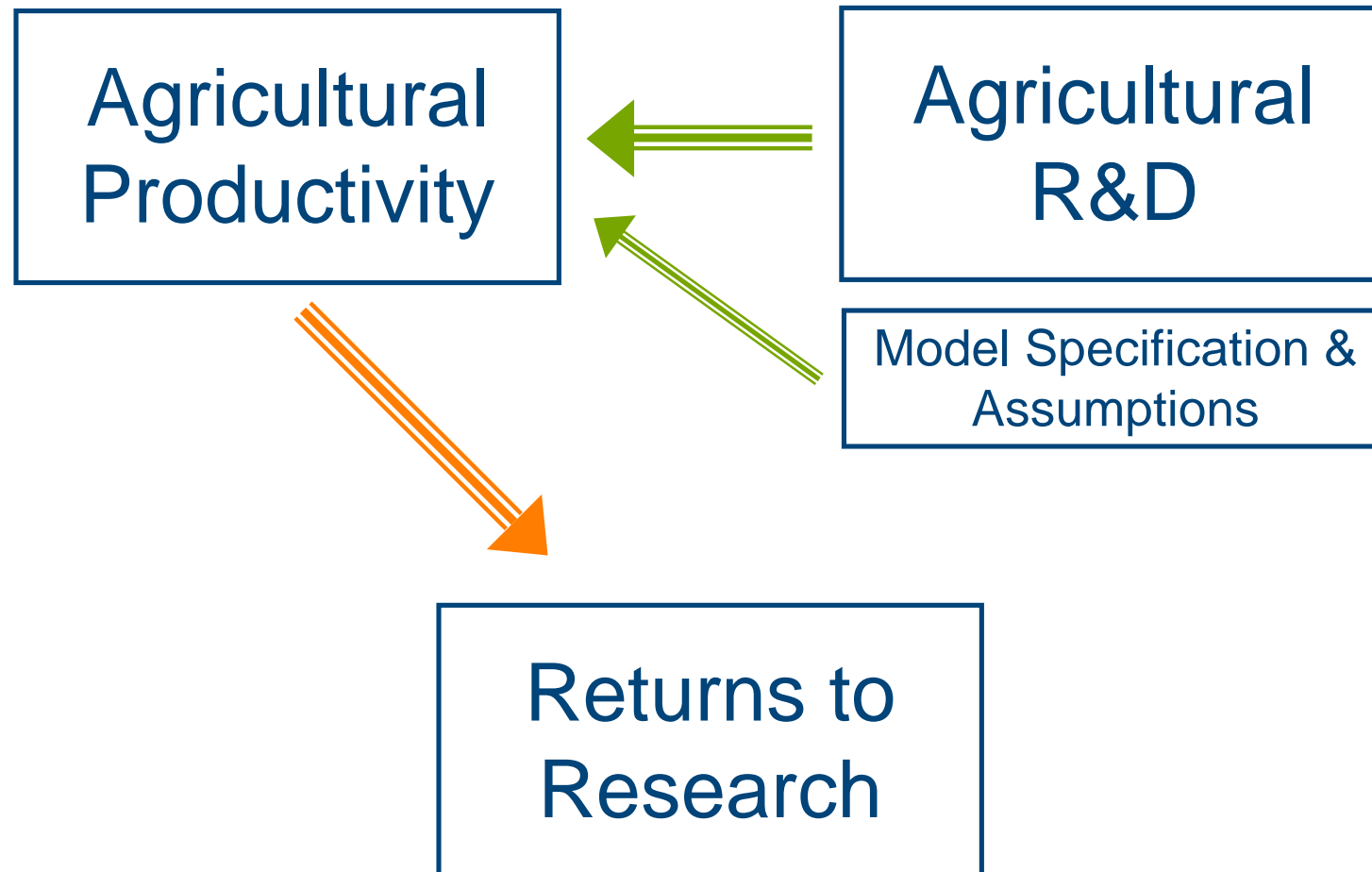


Matt Andersen

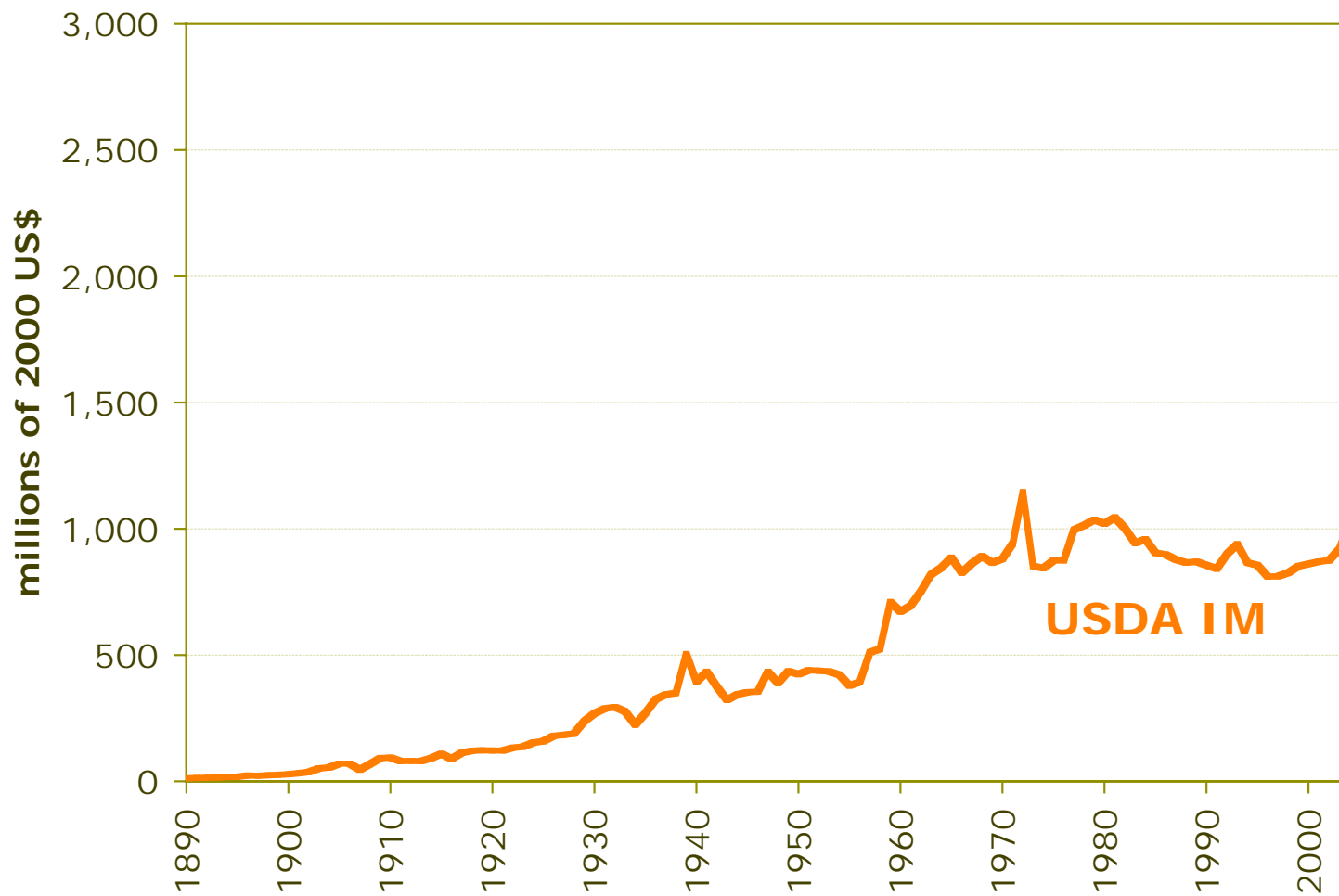
Jennifer S. James

Food & Fuel: The Implications for Agricultural Research Policy
June 4-6, 2007, University of Saskatchewan, Saskatoon

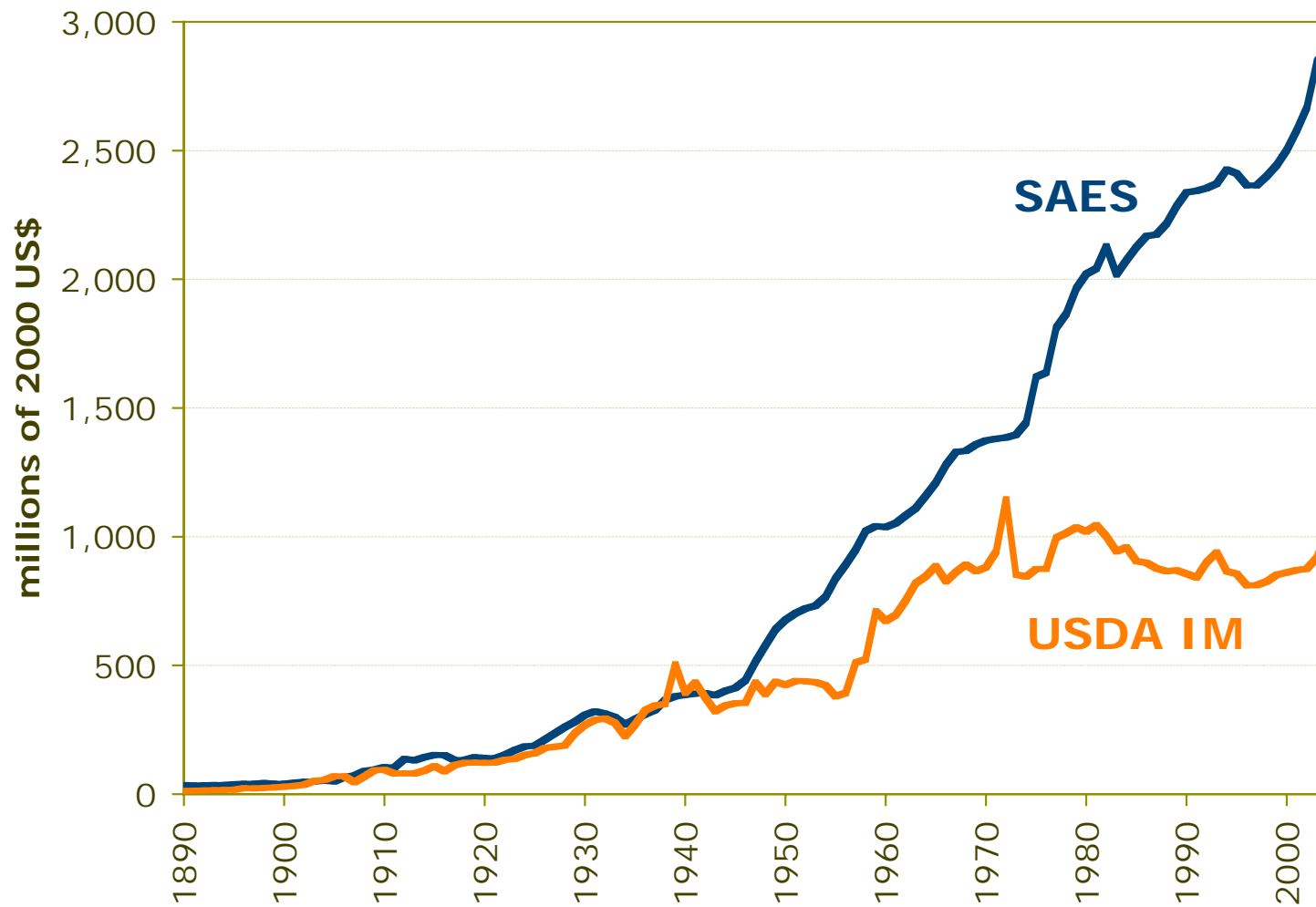
Overview



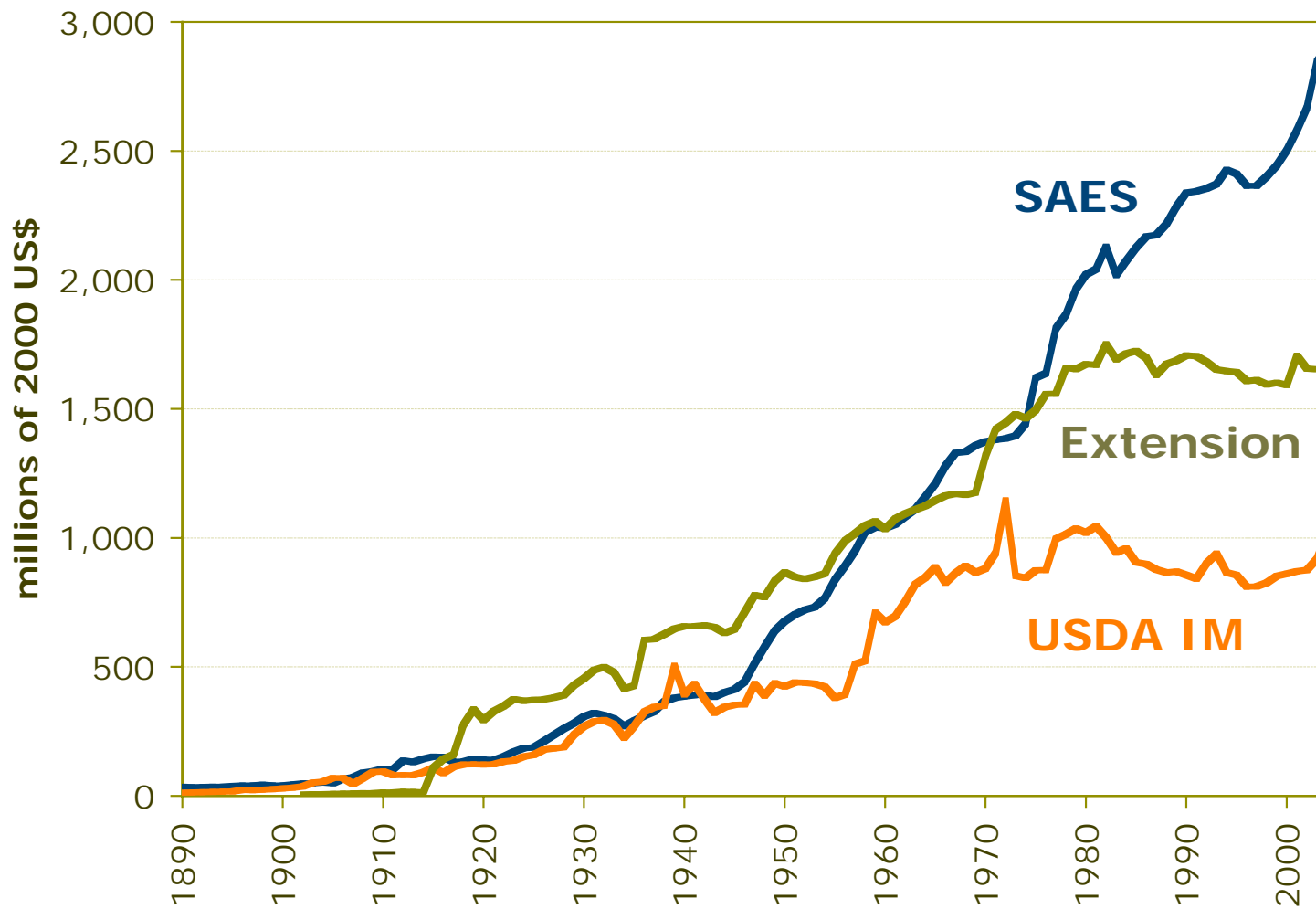
U.S. Public R&D Funding, 1890-2004



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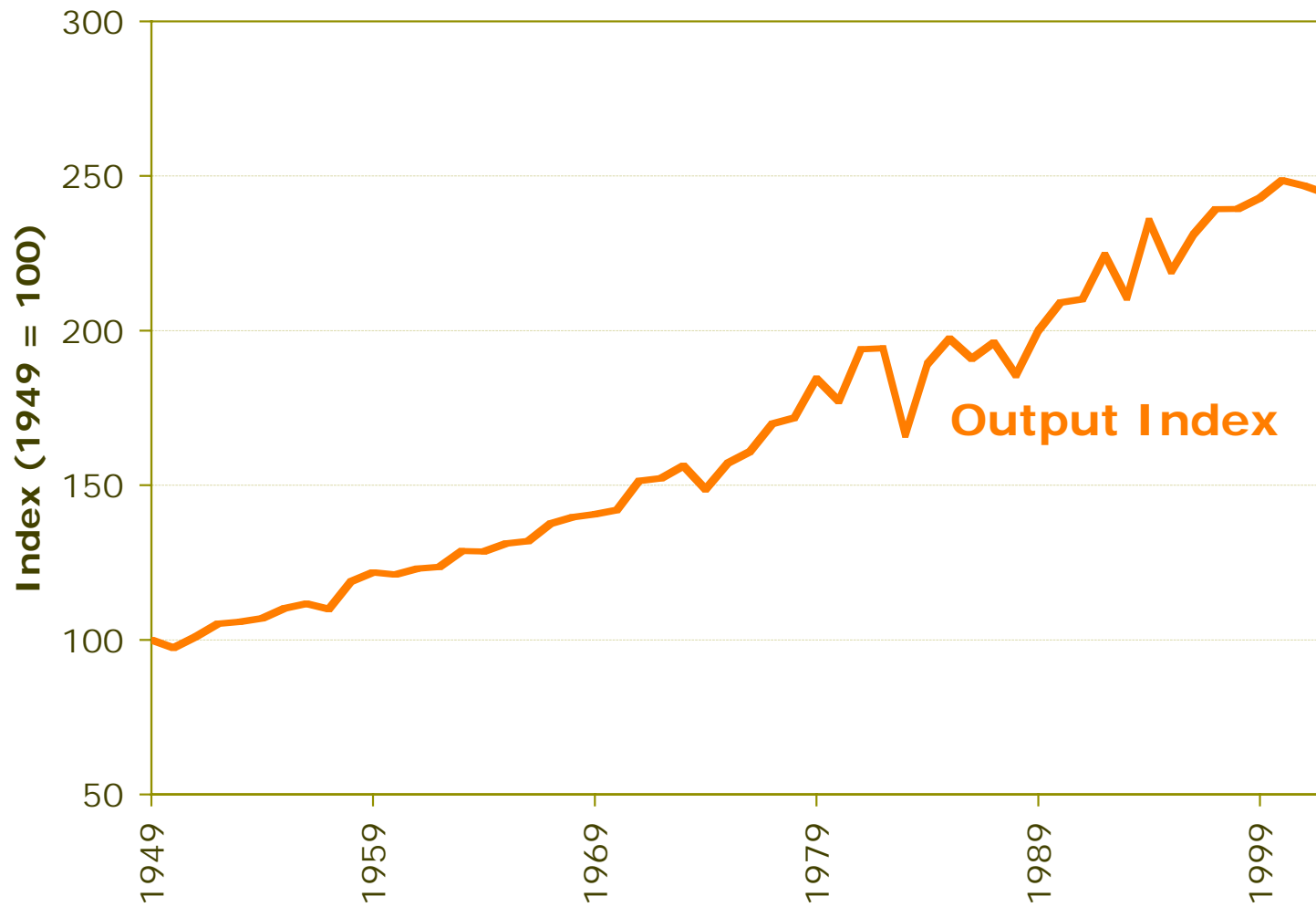
U.S. Public R&D Funding, 1890-2004



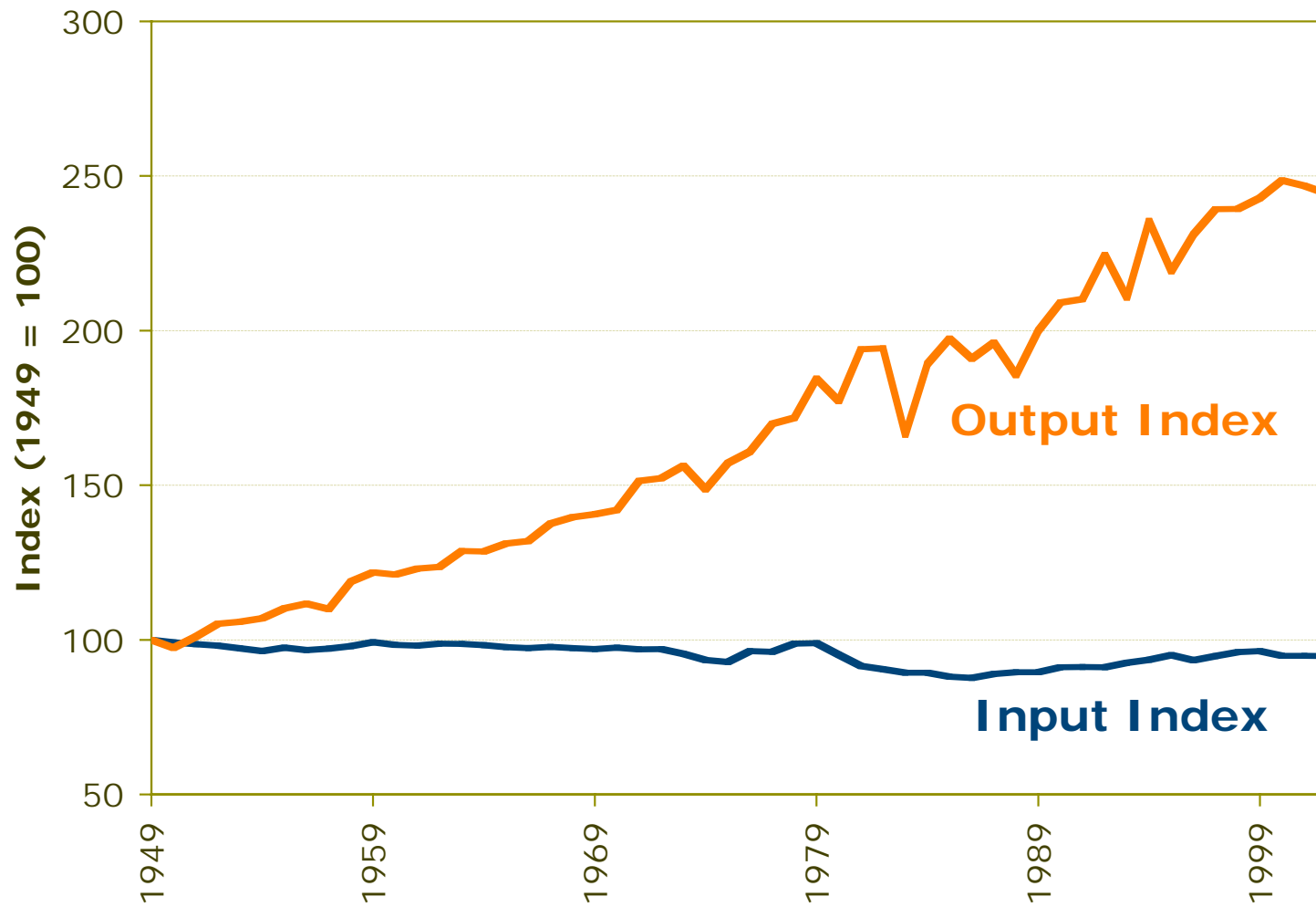
U.S. Agricultural Productivity

- **Productivity Data**
 - Based on input and output quantities
 - Started with data from Aquaya, 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

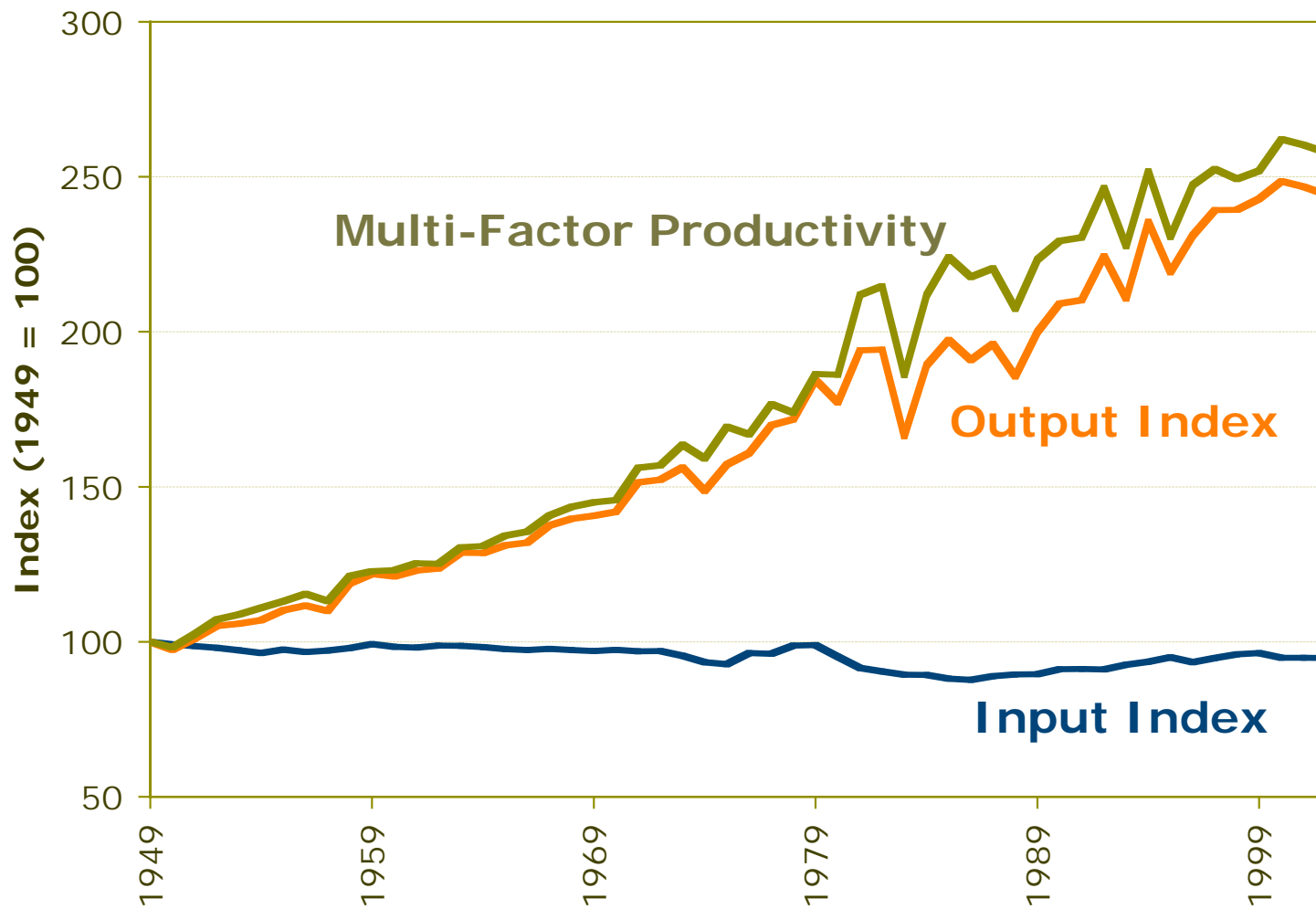
U.S. Agricultural Productivity, 1949-2002



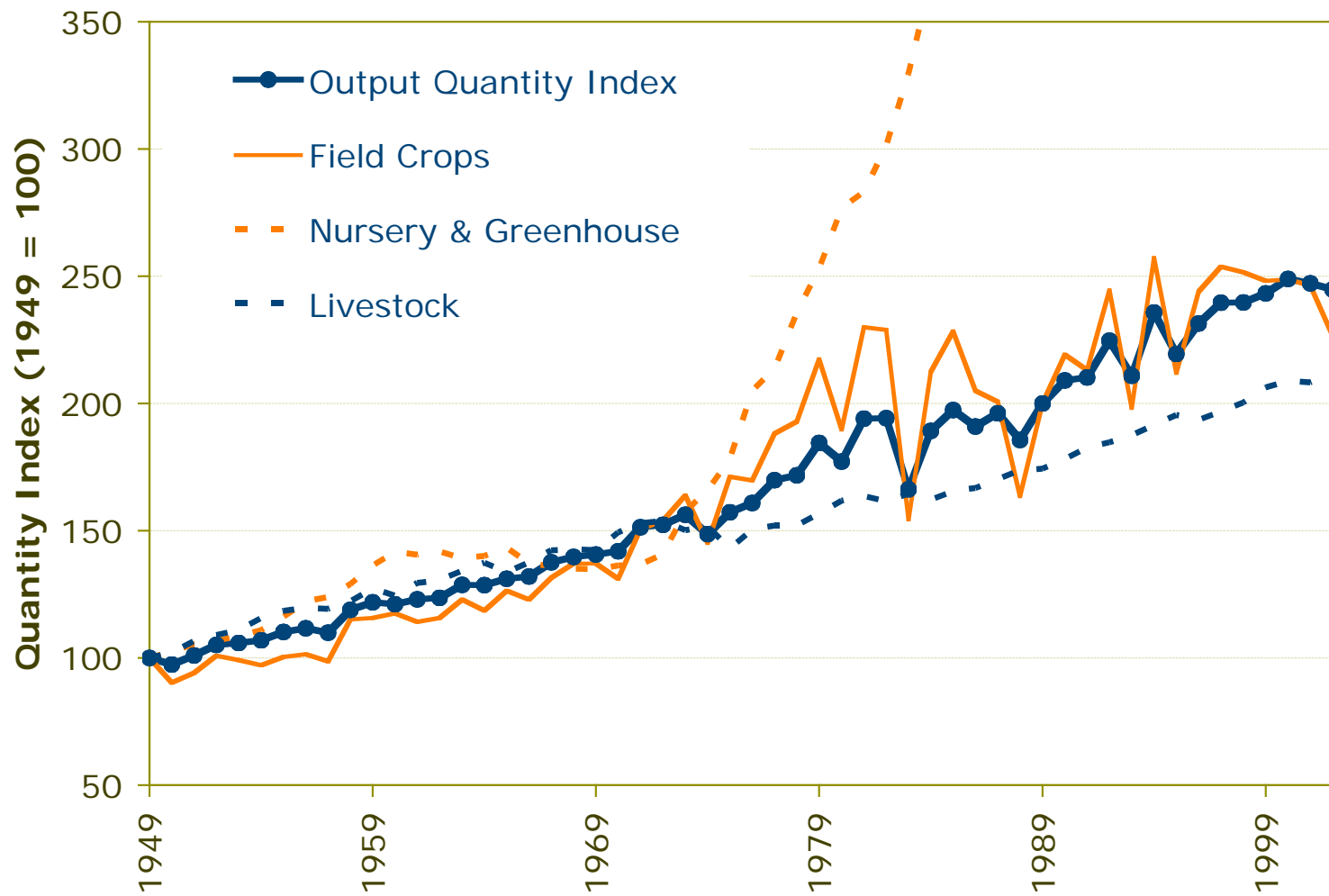
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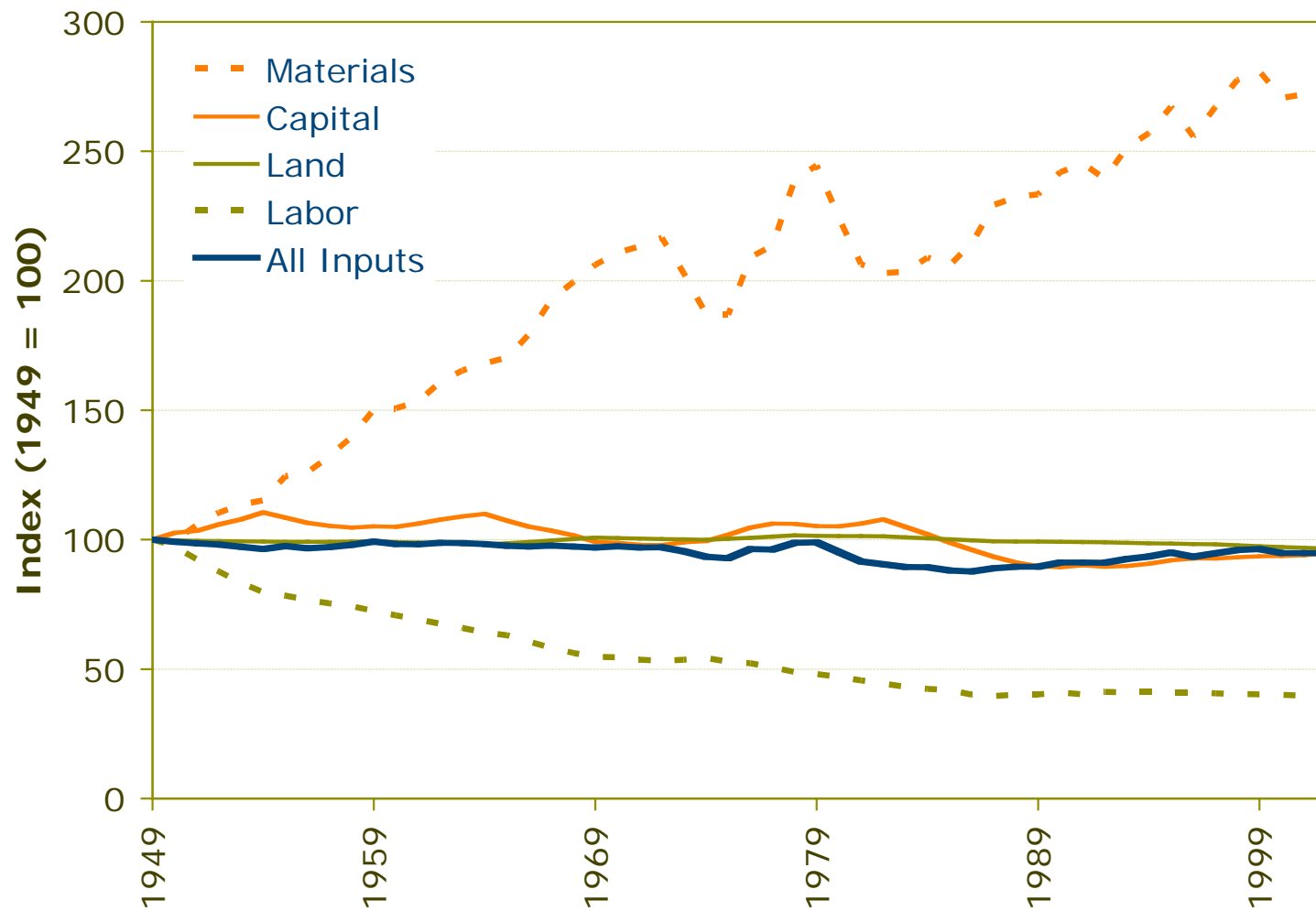
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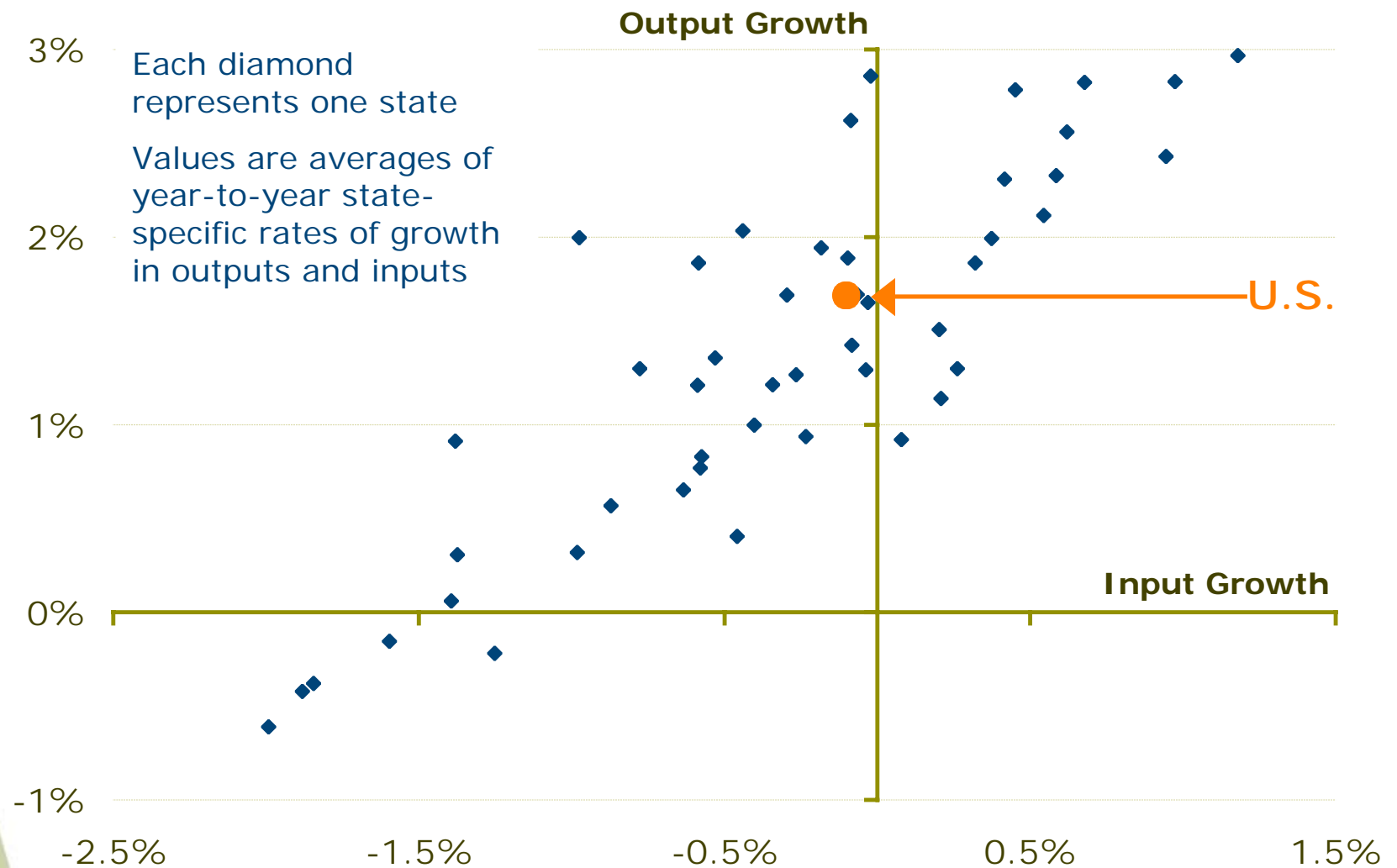
Output Indexes in U.S. Agriculture



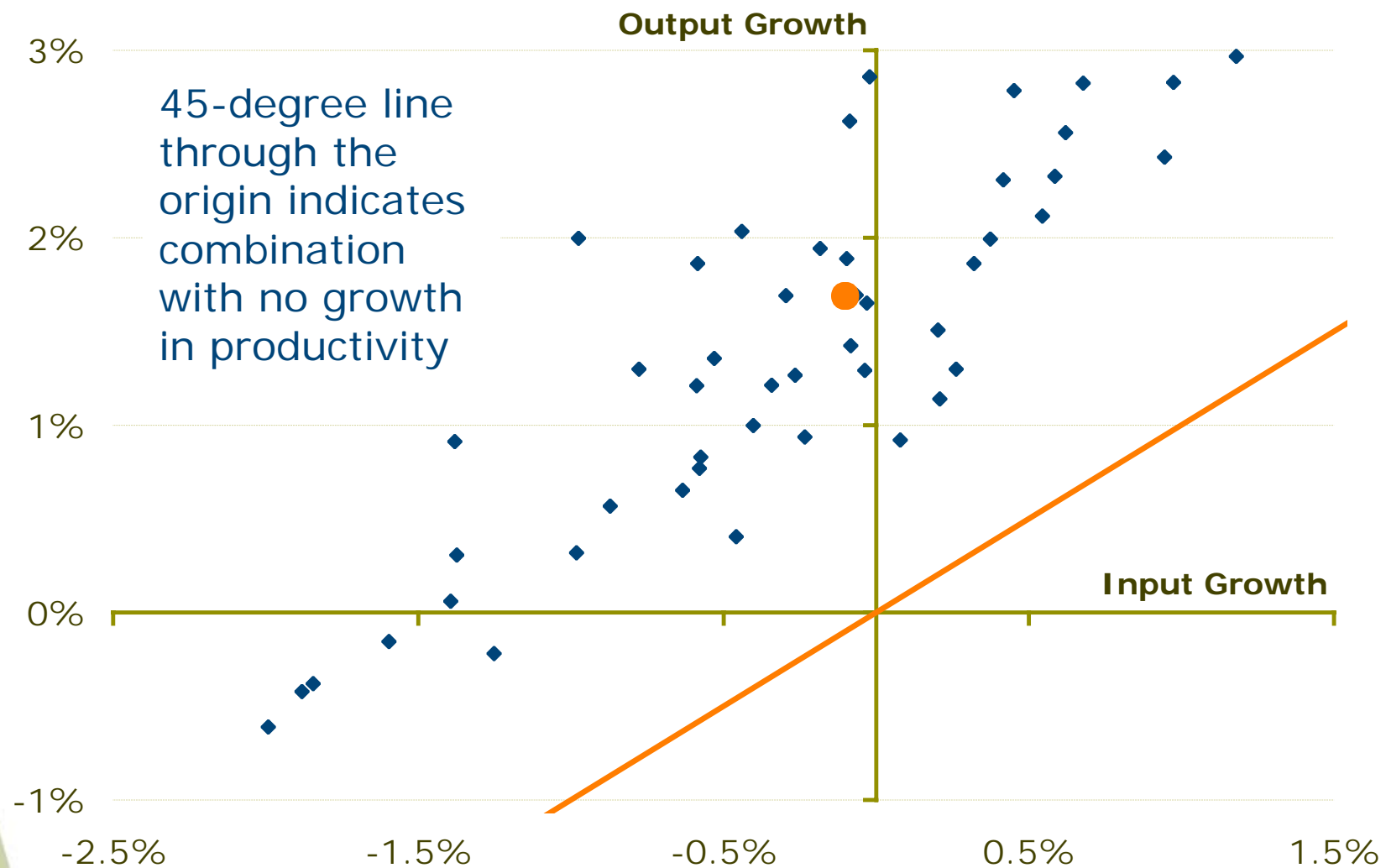
Input Indexes in U.S. Agriculture



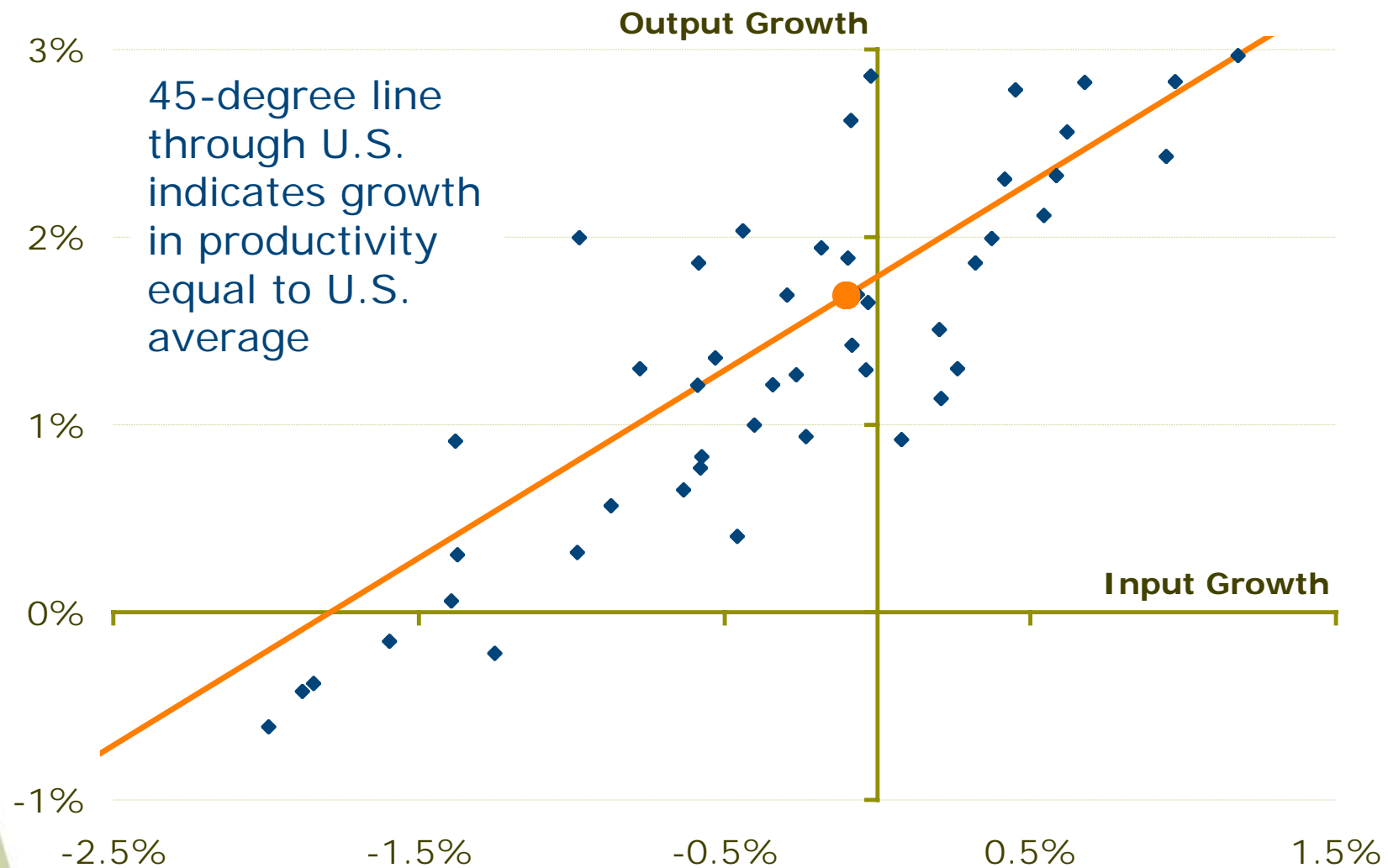
State-Specific Growth in Inputs and Outputs, 1950-2002



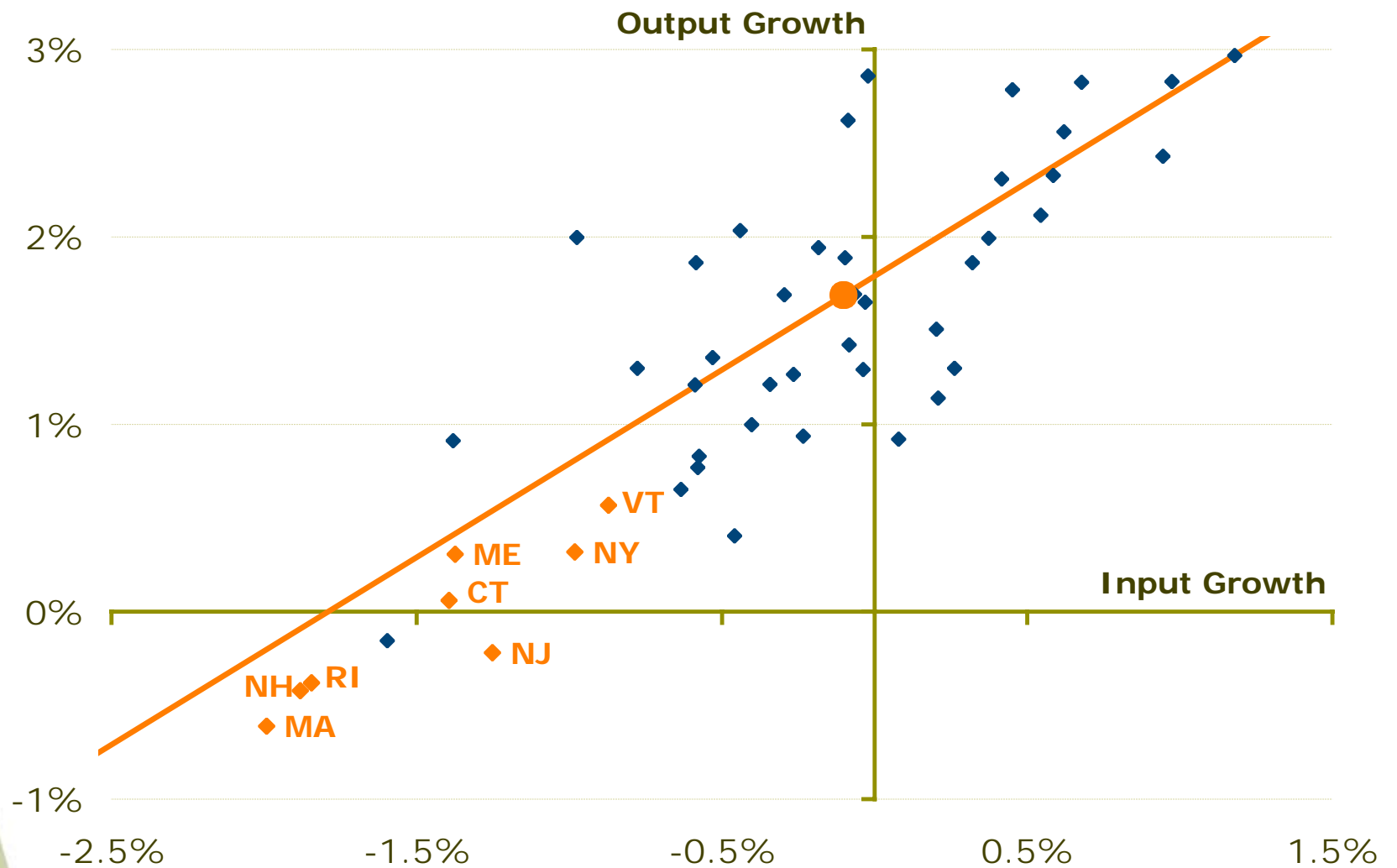
State-Specific Growth in Inputs and Outputs, 1950-2002



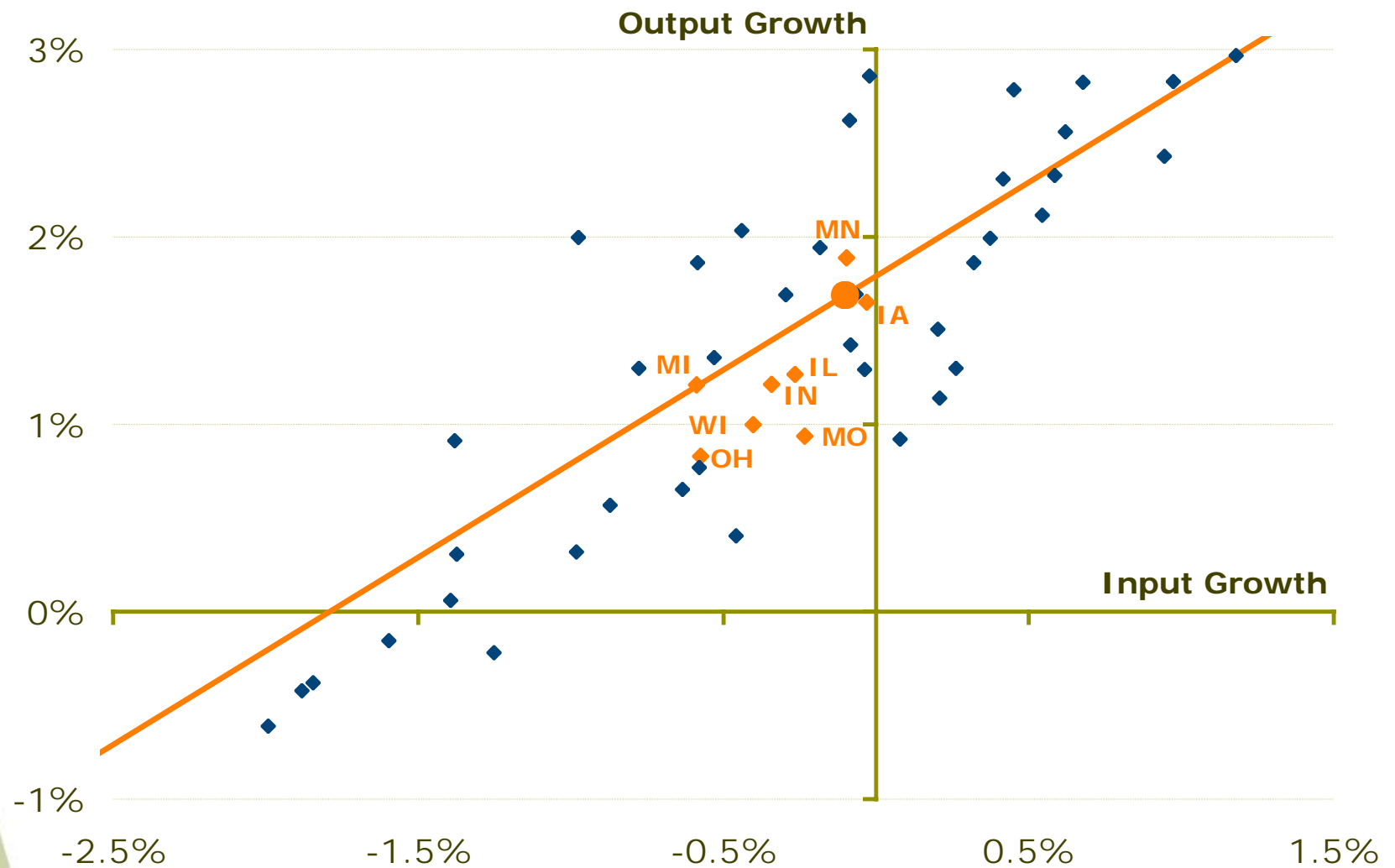
State-Specific Growth in Inputs and Outputs, 1950-2002



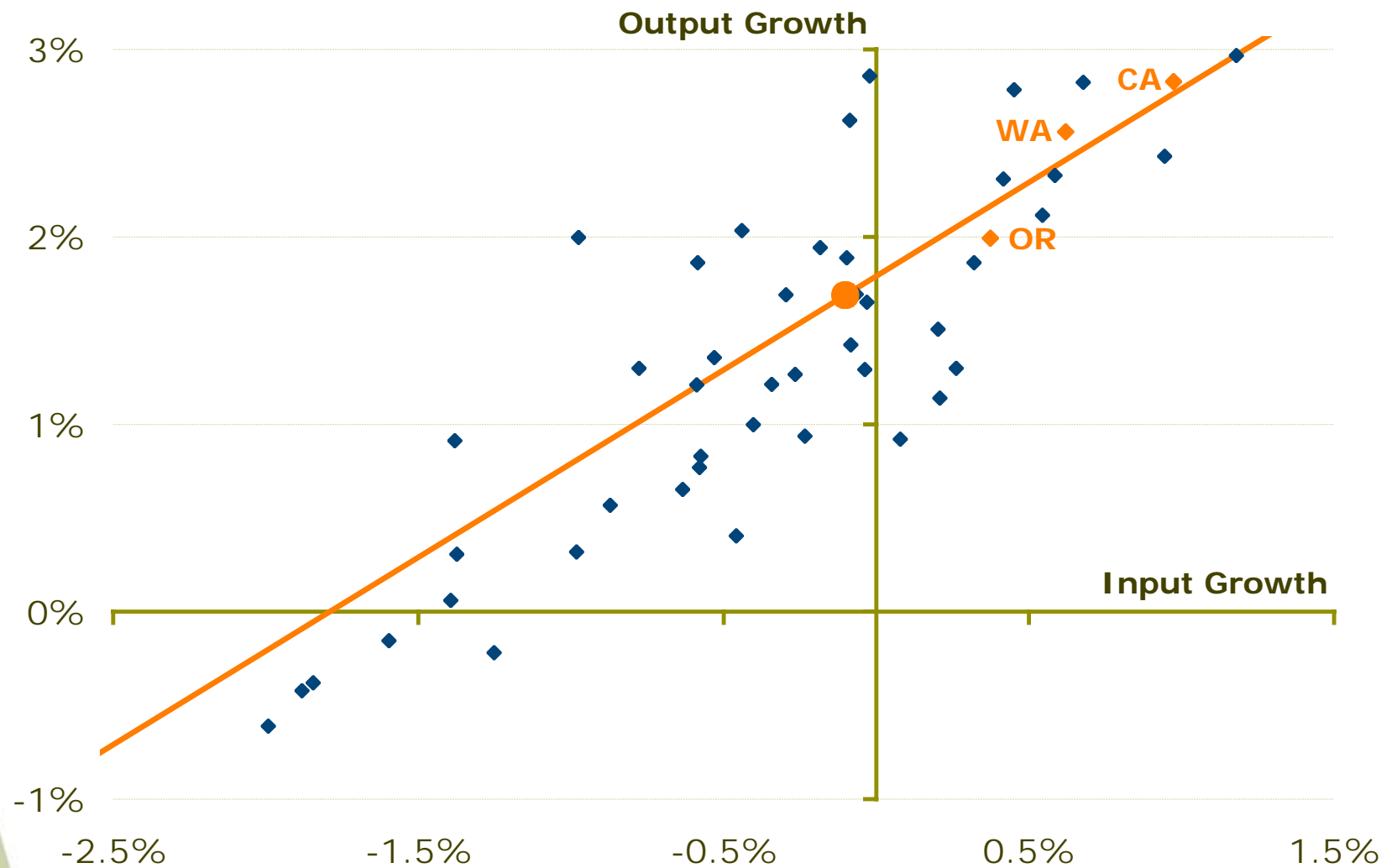
Spatial Patterns of Input and Output Growth Northeastern States



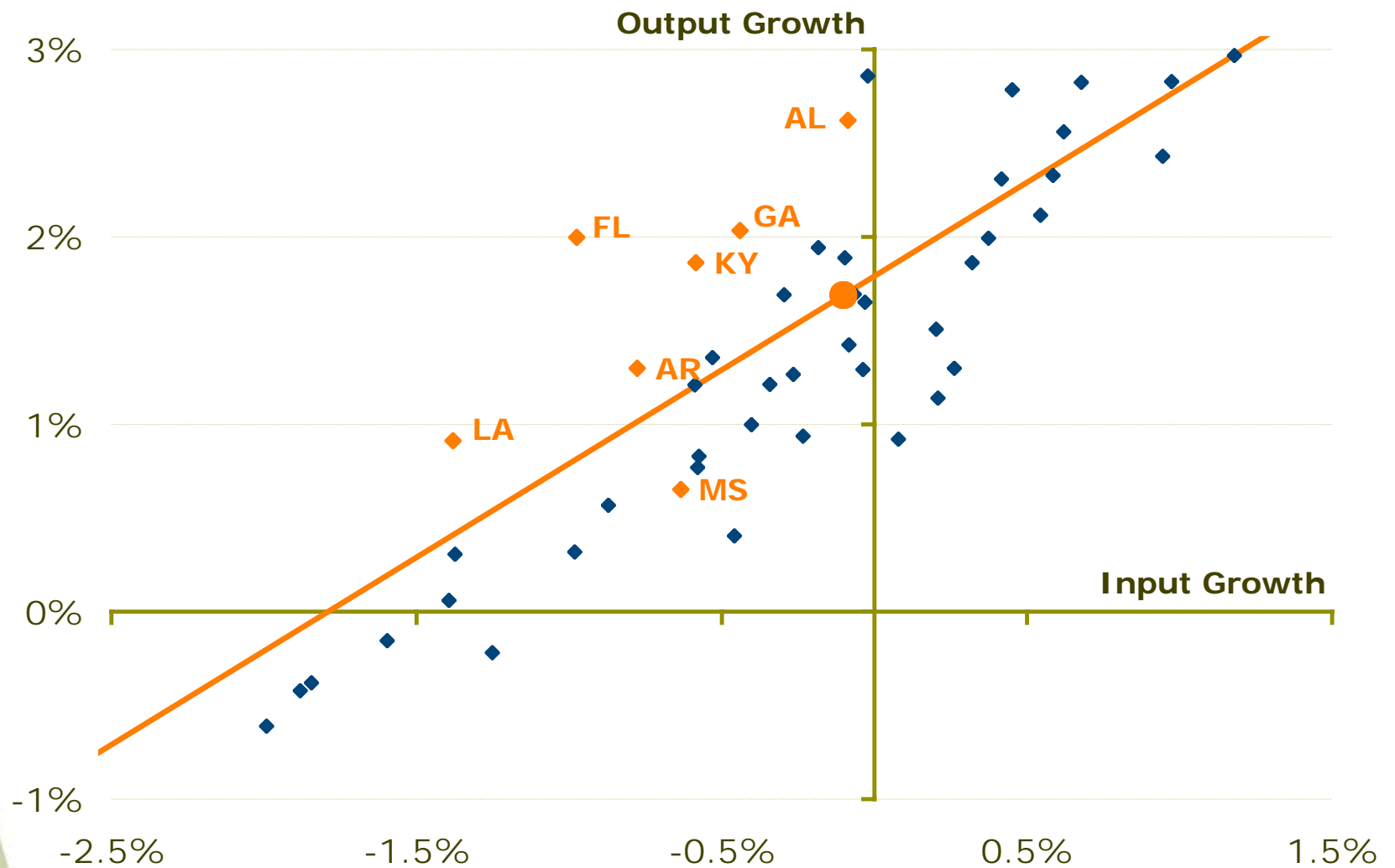
Spatial Patterns of Input and Output Growth Corn Belt & Lake States



Spatial Patterns of Input and Output Growth Pacific States

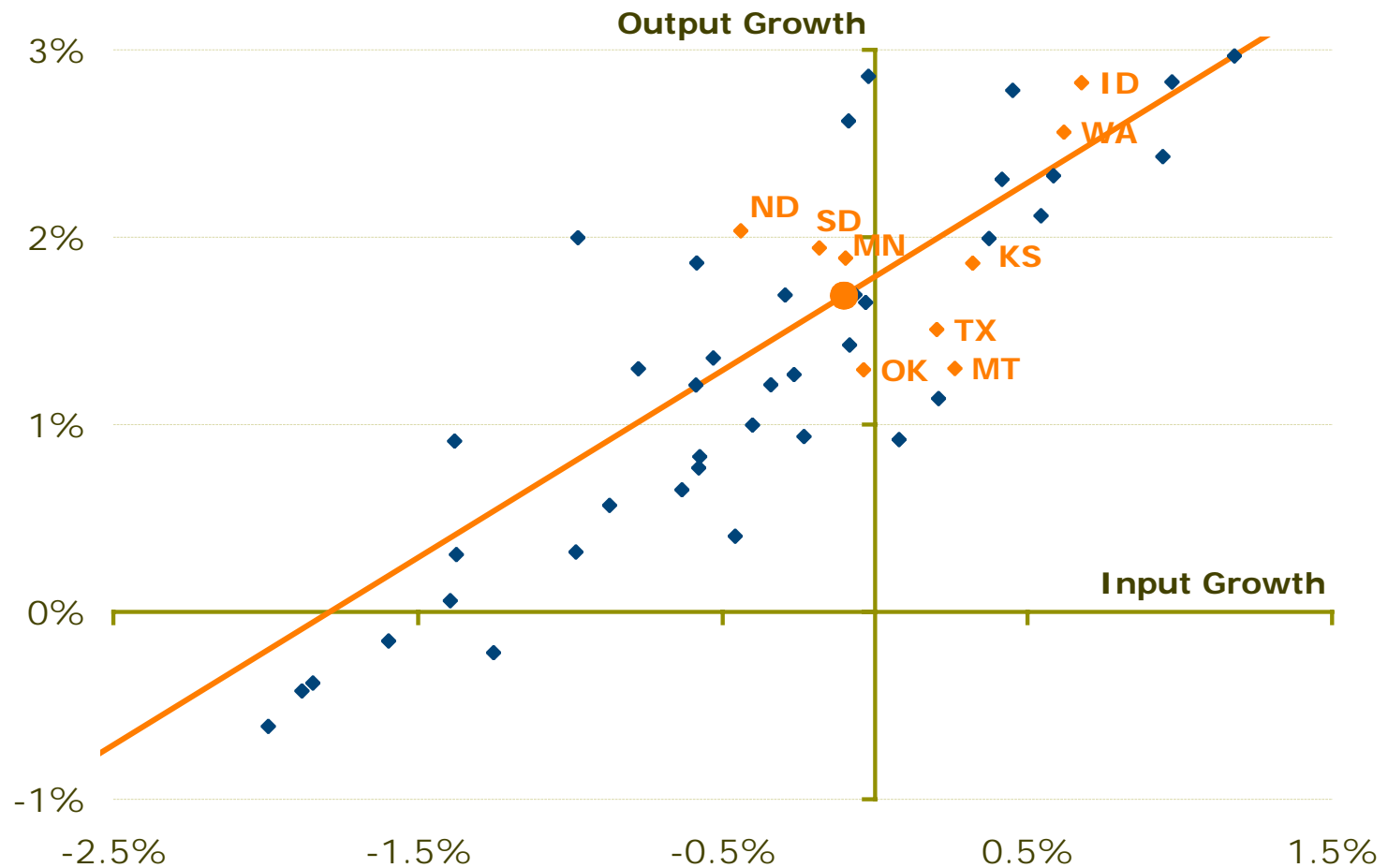


Spatial Patterns of Input and Output Growth Southern States

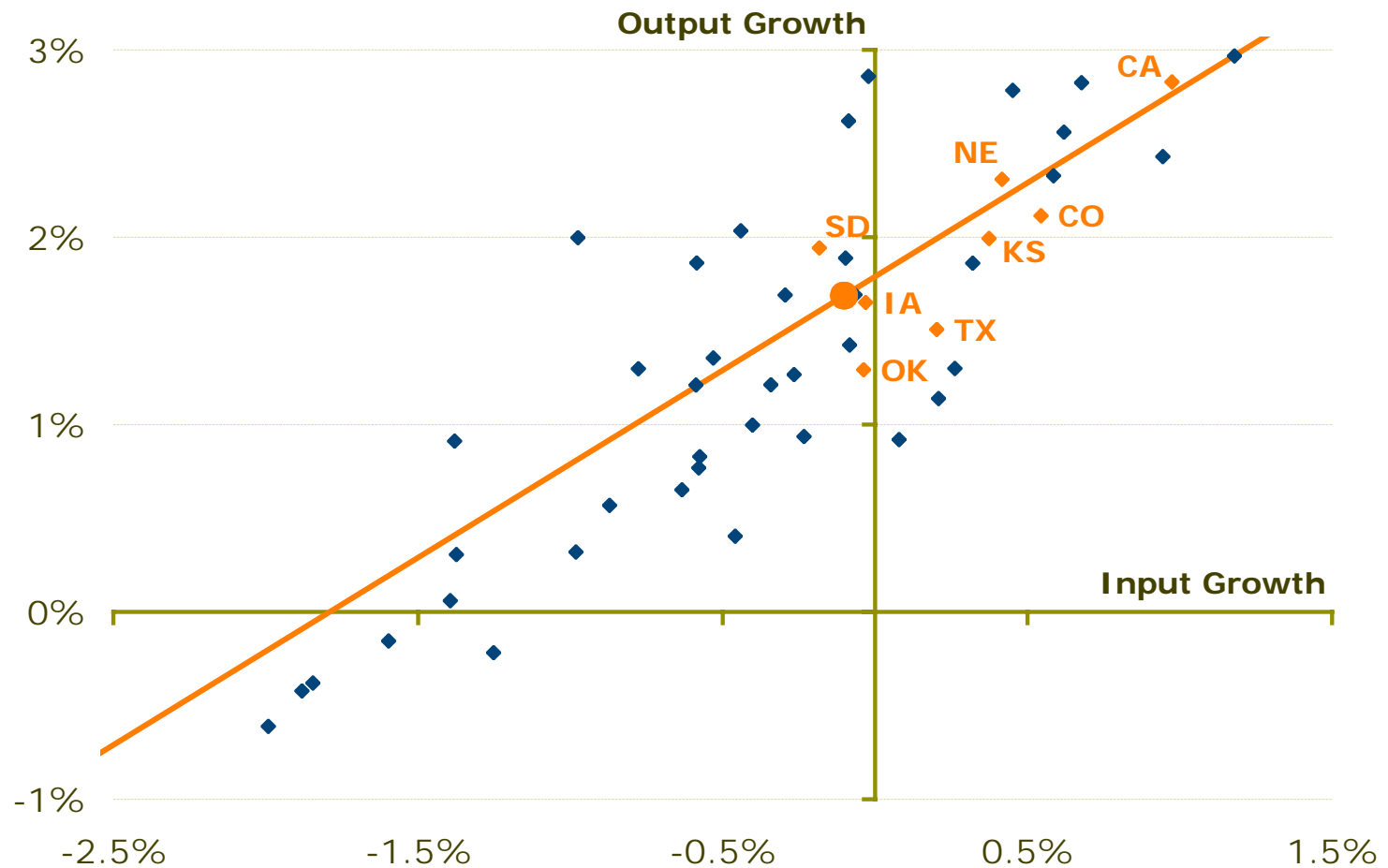


Spatial Patterns of Input and Output Growth

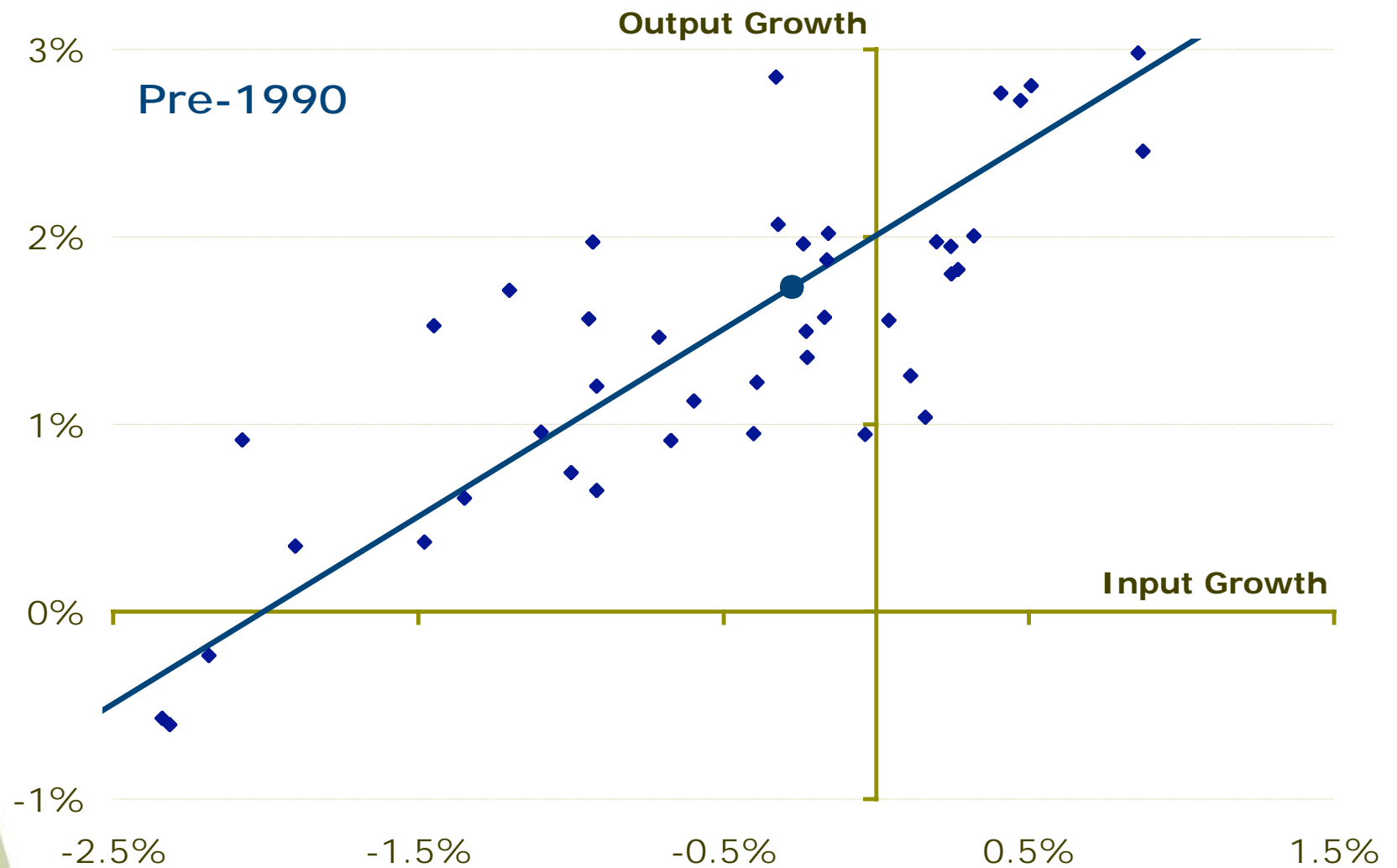
Big Wheat-Producing States



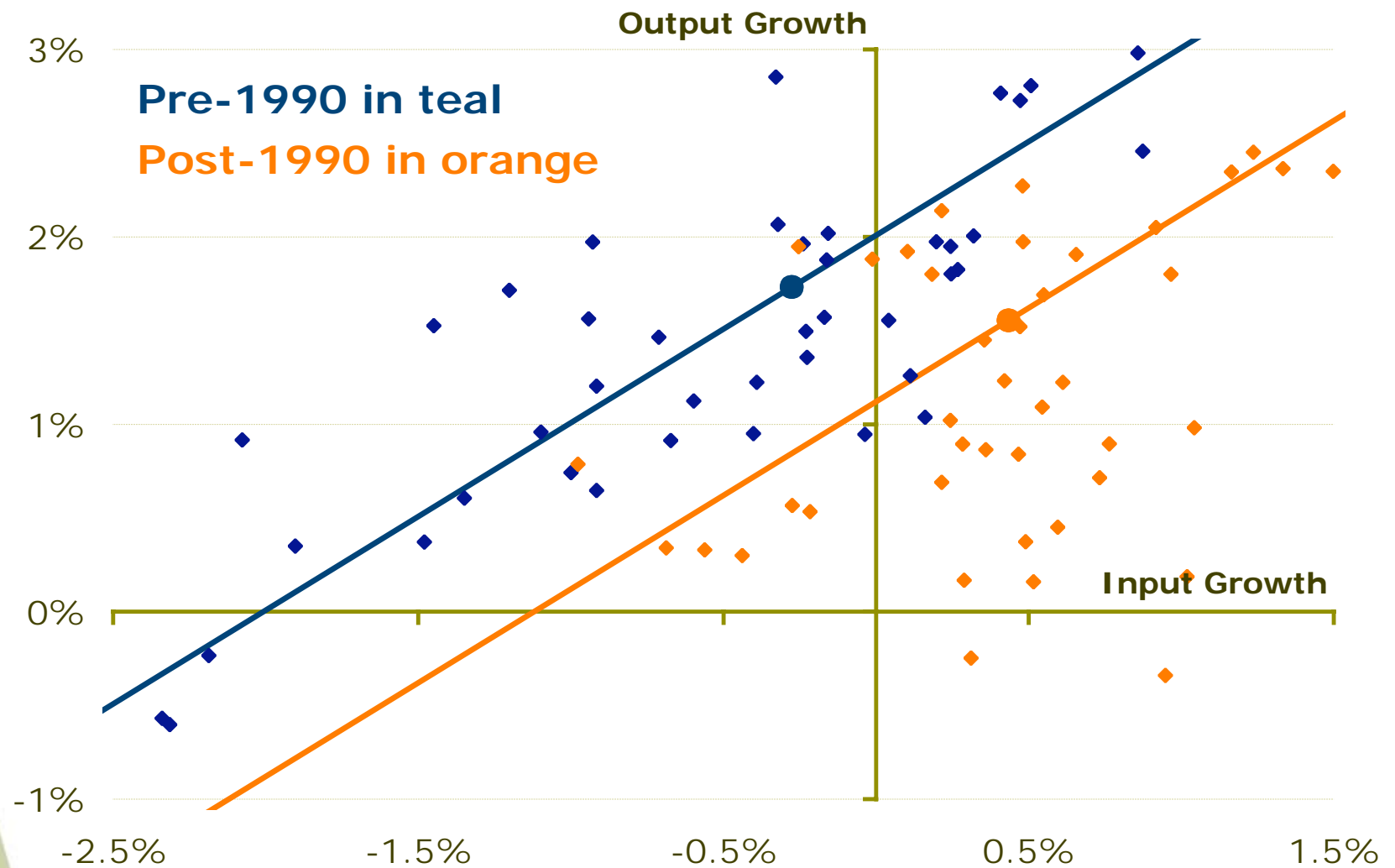
Spatial Patterns of Input and Output Growth Big Beef-Producing States



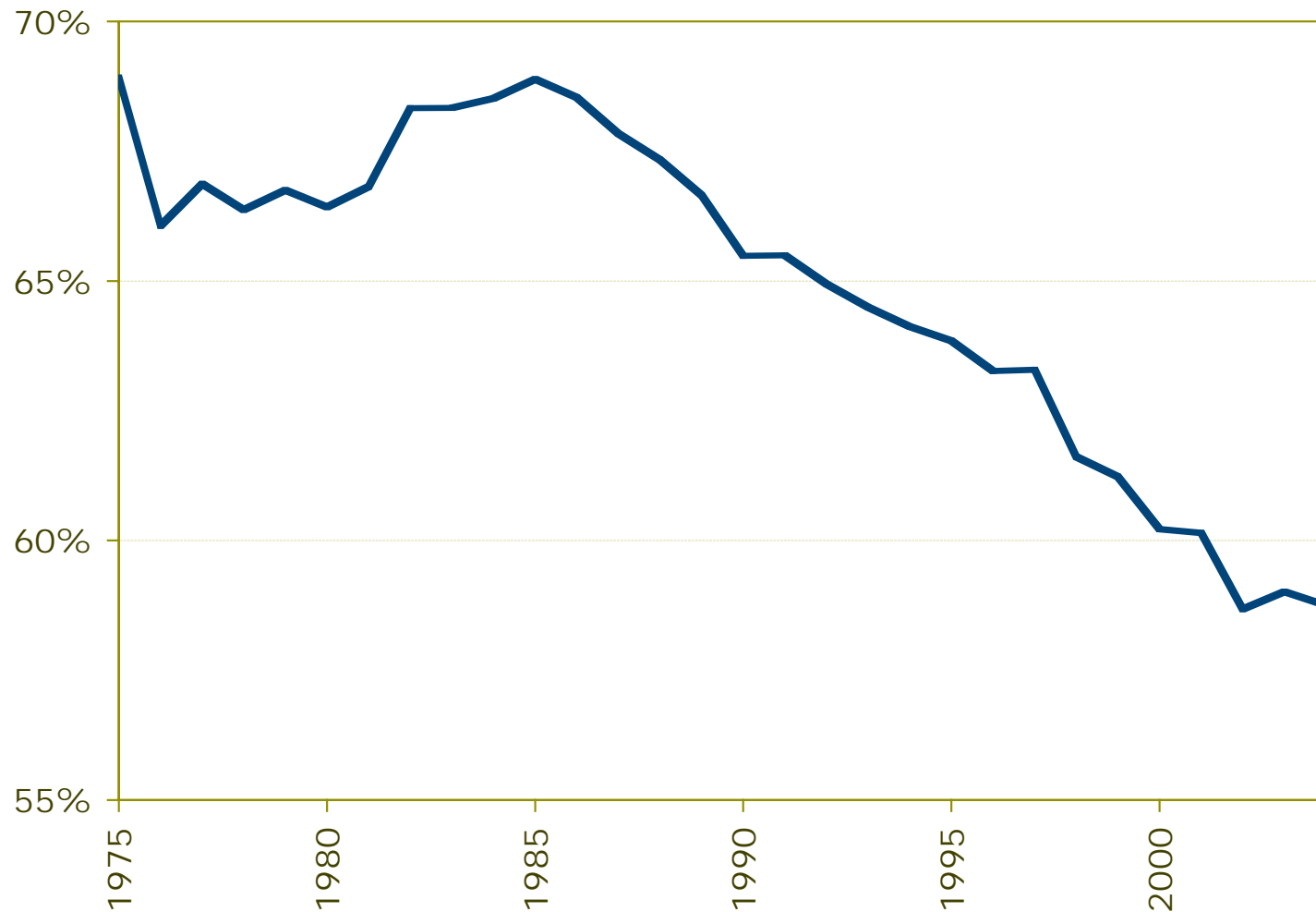
Temporal Patterns of Input and Output Growth, Pre- and Post-1990



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

$$\text{MFP}_{it} = f(\text{R\&D Spending, other factors})$$

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

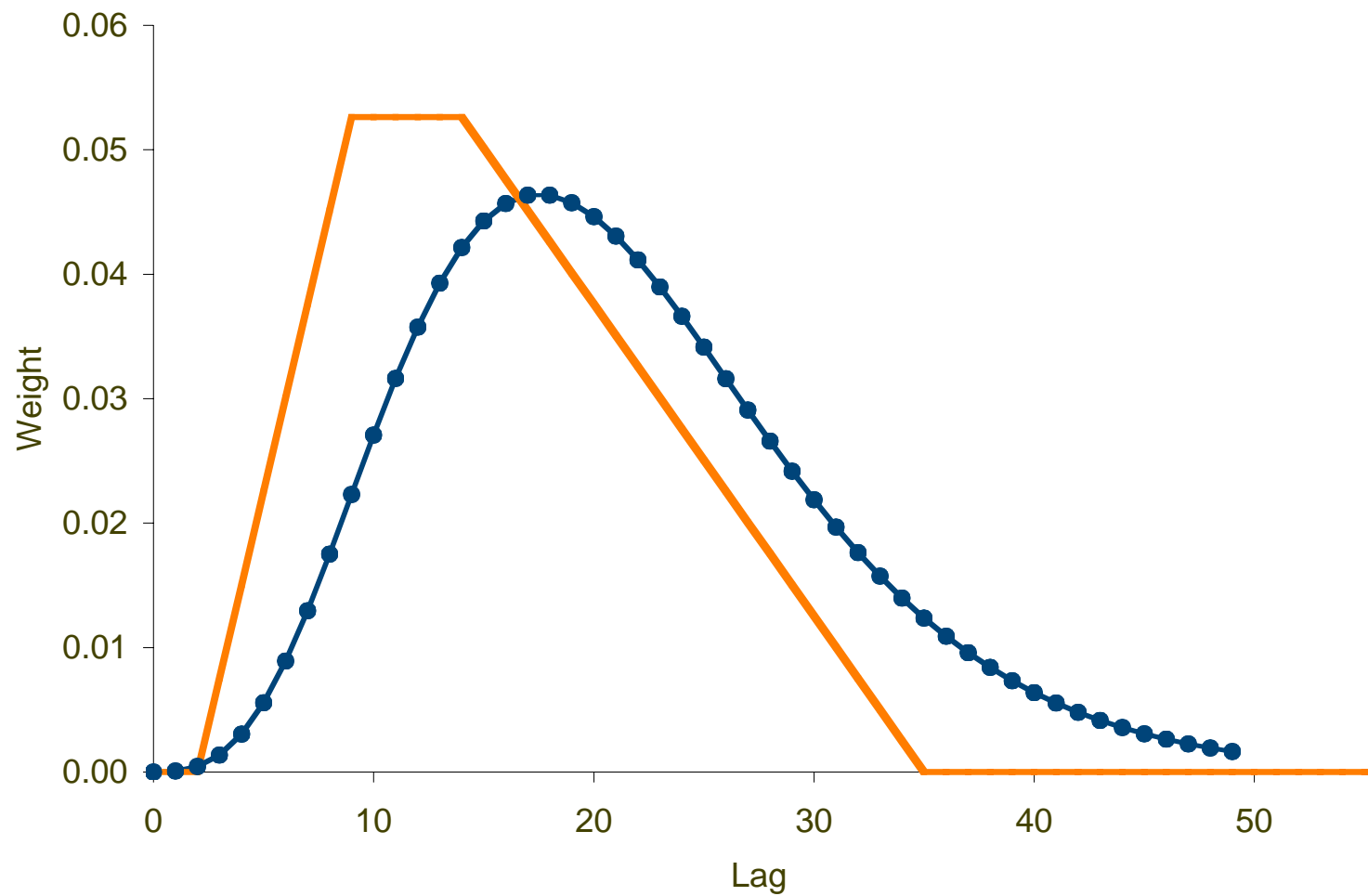
$MFP_{it} = g$ (Knowledge Stocks, Other Factors)

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

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

- Linear functional form

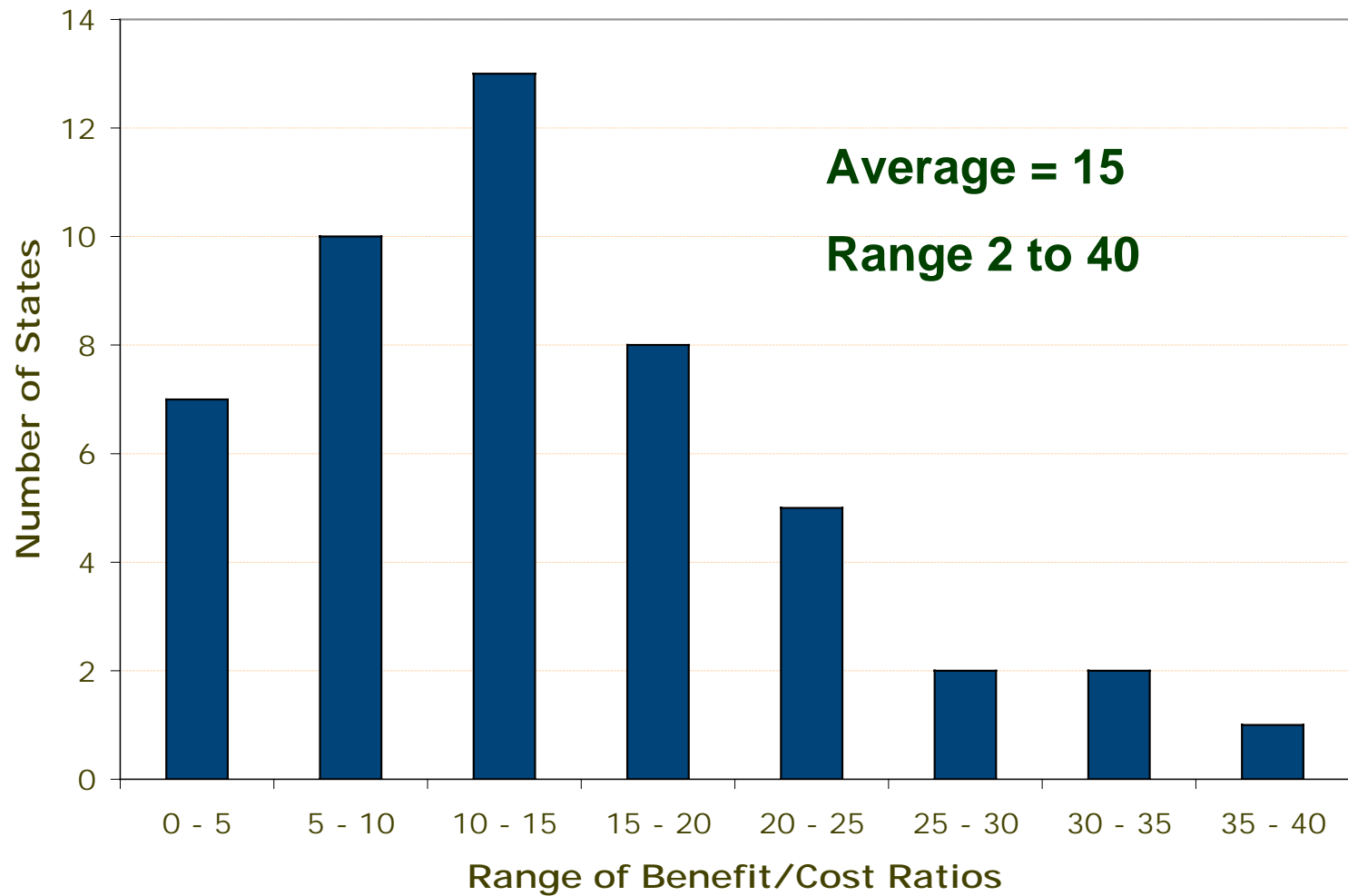
$$\text{MFP}_{it} = a_i + 0.00000057 * \text{Own-State Stock} + 0.000000072 * \text{Spillin Stock}$$

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)

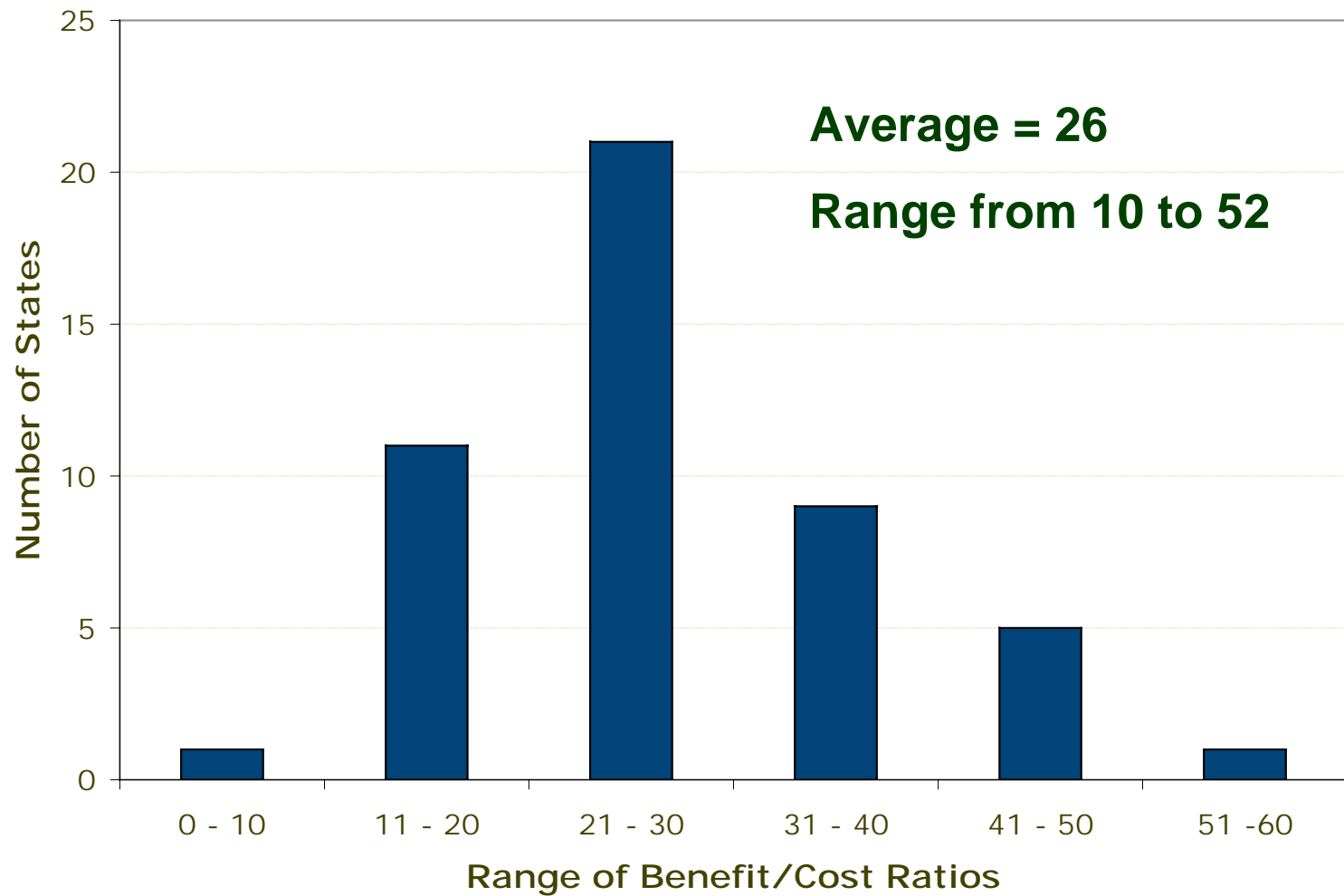
Private Benefit/Cost Ratios

Double-Log Model



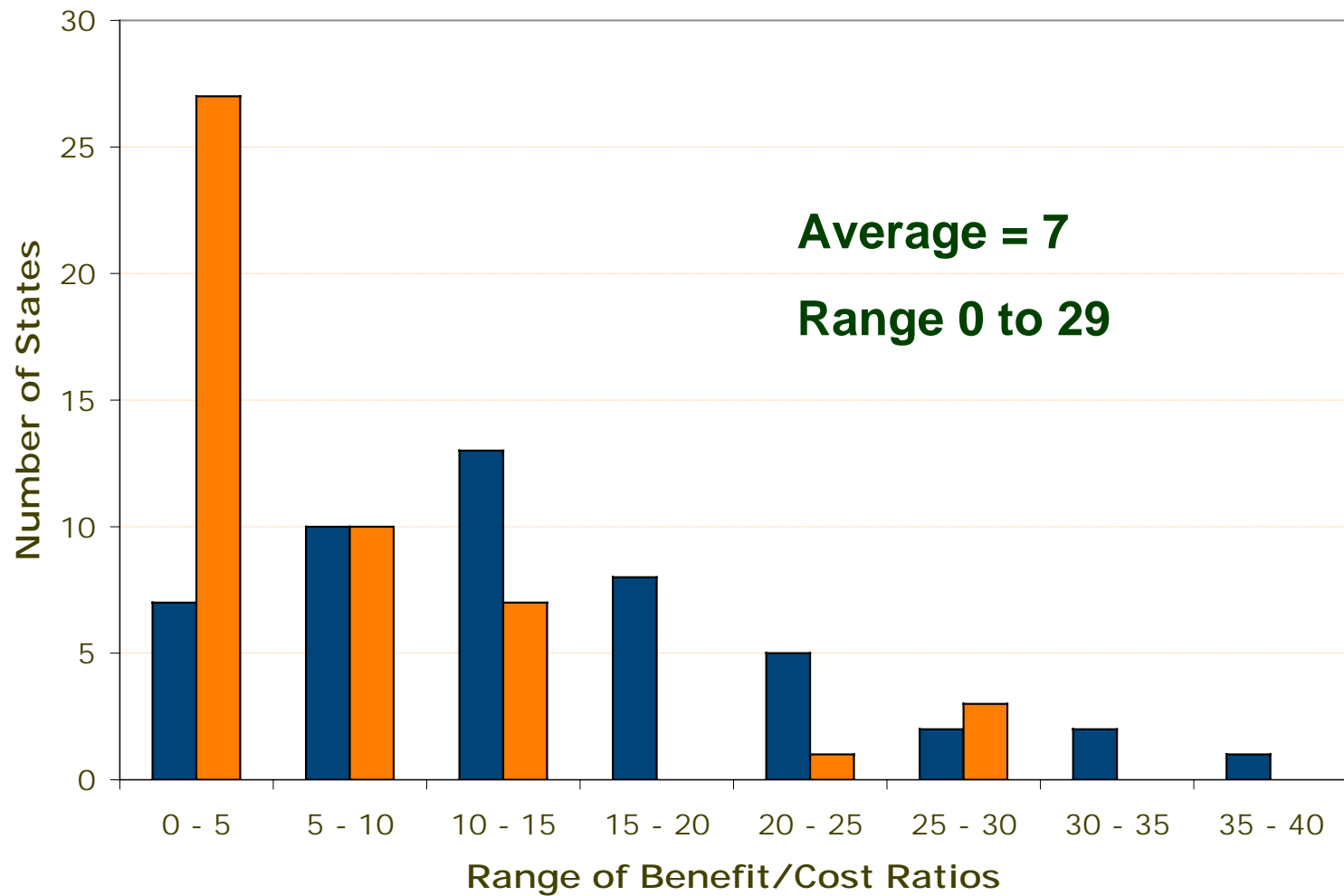
Social Benefit/Cost Ratios

Double-Log Model



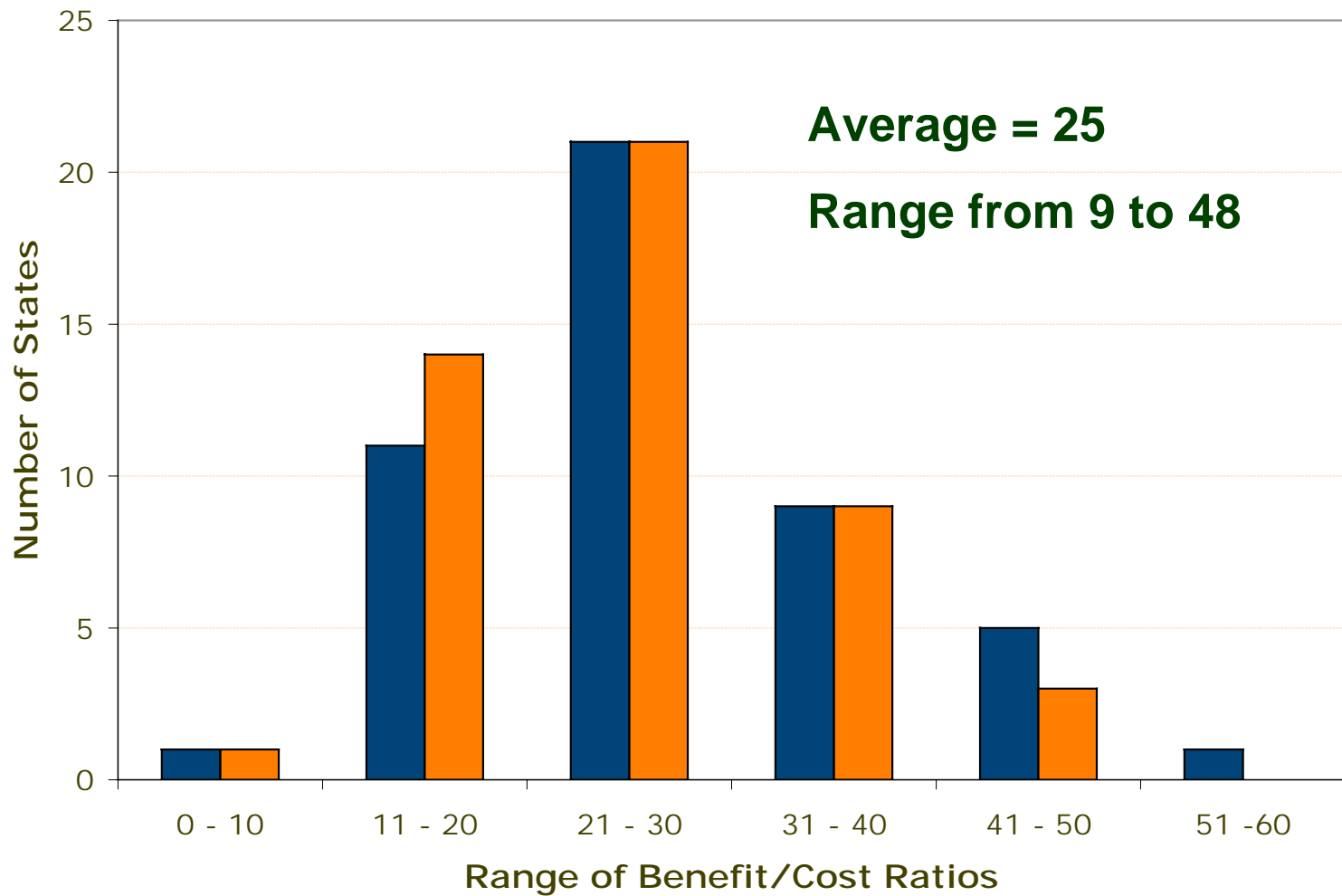
Private Benefit/Cost Ratios

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**