Impact of local public goods on agricultural productivity growth in the U.S.

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The views expressed herein are those of the authors,
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Introduction (I)

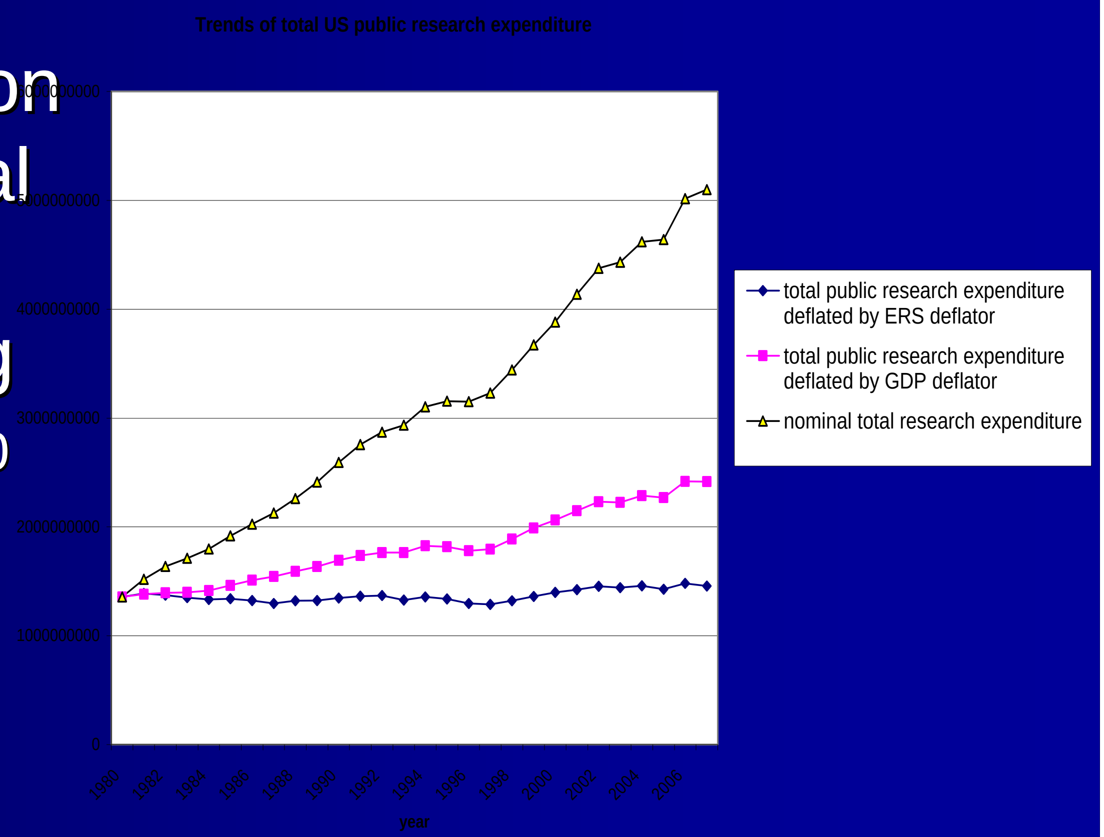
- Public investment in R&D makes a great contribution to productivity growth (Evenson, 2001).
- Evidences of technology “spillovers” across geographical boundaries.
- Internal rates of return to Federal-State agricultural research are within the range of 19% to 95% (Fuglie and Heisey, 2007).

Introduction (II)

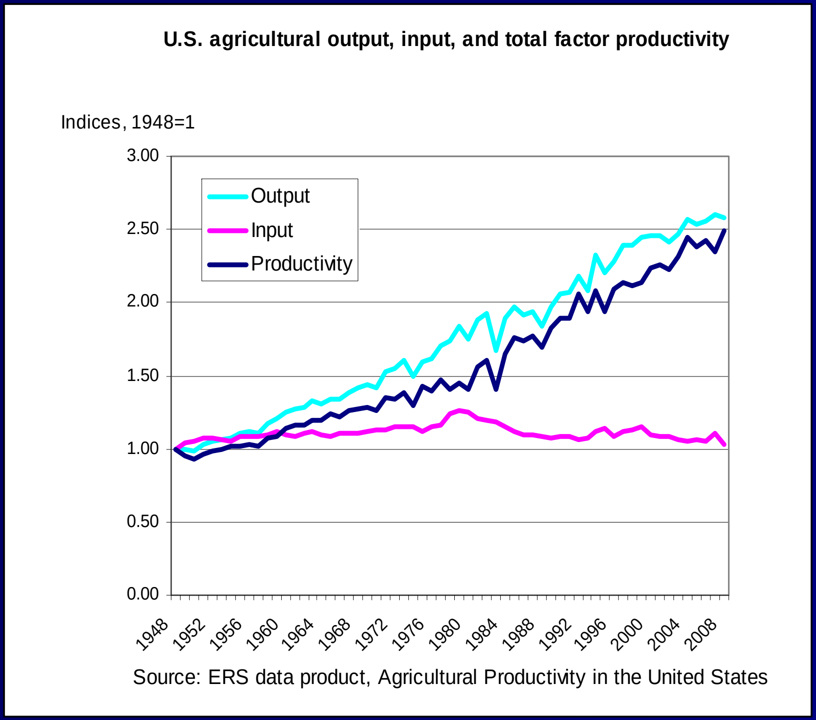
- Previous studies can be summarized into four main categories:
  - International vs. domestic or regional studies;
  - Patents vs. weighted lagged R&D expenditures as a measurement of technological stock;
  - Individual commodities and research programs vs. aggregate outputs and aggregate research expenditures;
  - Incorporating R&D stock in the estimation of technology vs. analyzing the contribution of the R&D stock on a pre-constructed productivity index.

Introduction (III)

- Recent concern on public agricultural research investment being flat (Alston et al. 2010 among others)



Introduction (IV)



- **Annual growth rate (1948-2008)**

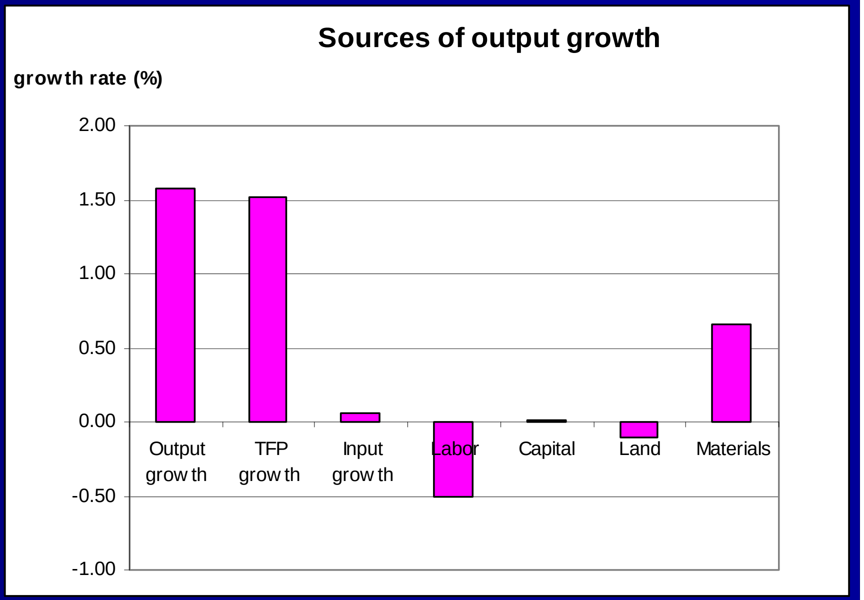
  Input—0.06%
  Output—1.58%
  Productivity—1.52%

- **In 2008**

  Output is 158% above its level in 1948
  Input is 3.5% above its level in 1948
  productivity is 149% above its level in 1948

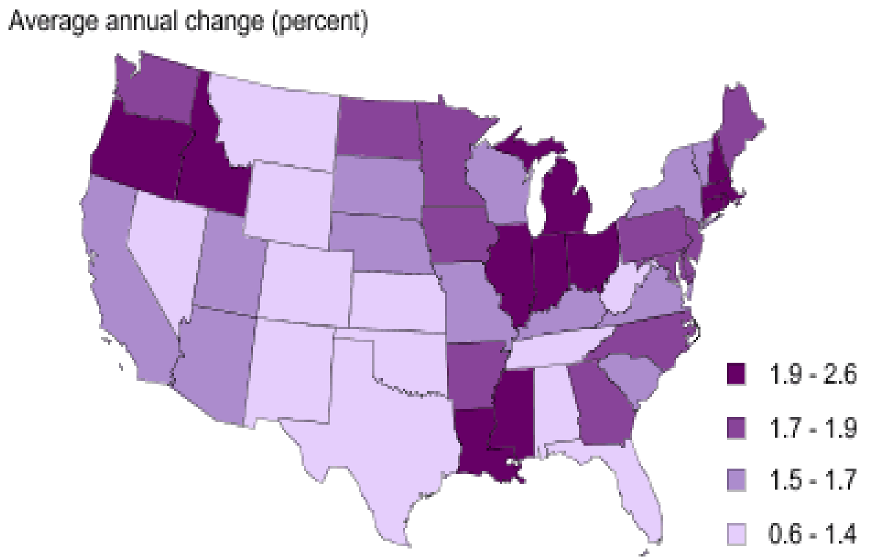
Introduction (V)

Sources of farm output growth (1948-2008)		
Sources of growth	**average annual growth rate (%)**	
Output growth	1.58	
Sources of growth		
Input growth	0.06	
Labor		-0.51
Capital		0.01
Land		-0.10
Materials		0.66
Productivity growt	1.52	
Source: Economic Research Service, USDA		



Introduction (VI)

Change in agricultural productivity by State, 1960-2004



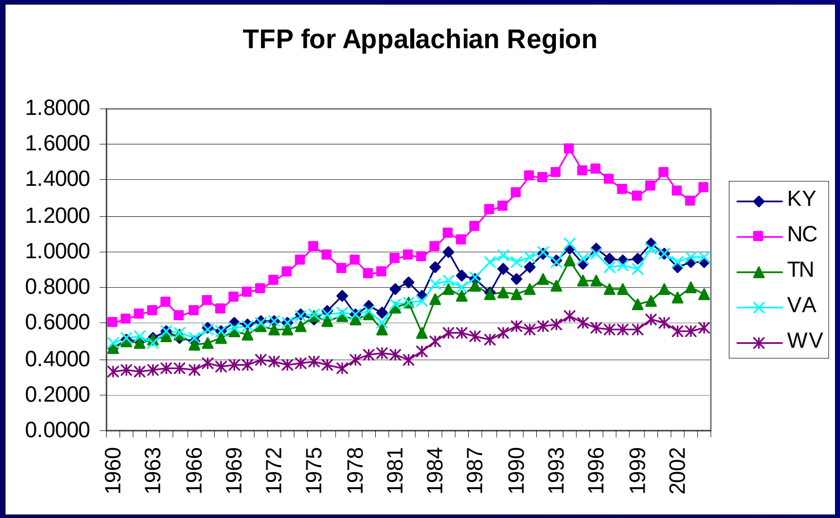
Source: ERS data product, Agricultural Productivity in the United States.
Average annual growth for the U.S. was 1.76 percent for the period 1960-2004.

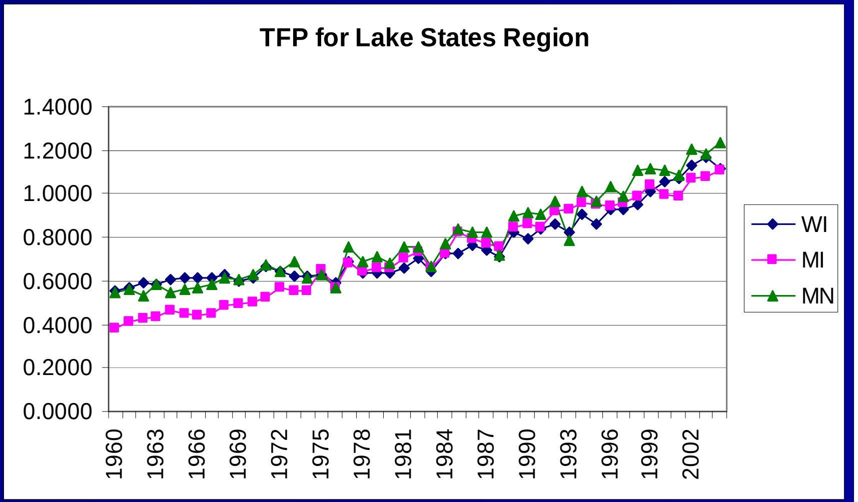
- Every State exhibited a positive average annual rate of productivity growth for the 1960-2004 period.
- Average annual rates of growth ranged from 2.6 percent for Oregon to 0.5 percent for Oklahoma.
- California and Florida had the highest relative levels of productivity in 2004

Introduction (VII)

- USDA Farm Production Regions

Introduction (VIII)





- Why productivity growth for some states is faster than for others in the same production region?
- Through which channels was technology disseminated?

Objectives

- To examine the impact of public R&D on US agriculture productivity growth using a cost function measurement.
- To identify the role of the extension service, transportation network, and labor quality in the process of technology dissemination.
- To understand the real internal rates of return to public R&D using alternative spillin measurements based on both geographical location and production mix.

Model (I)

- Cost function
- Shephard’s lemma- inputs shares functions

$$\ln TVC = \alpha_0 + \sum_{D=1}^{48}\sum_{i=1}^{N} \alpha_{Di} Dum_D \ln w_i + \sum_{j=1}^{M} \beta_j \ln y_j + \sum_{l=1}^{L} \gamma_l \ln K_l + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \alpha_{ij} \ln w_i \ln w_j + \frac{1}{2}\sum_{i=1}^{M}\sum_{j=1}^{M} \beta_{ij} \ln y_i \ln y_j + \frac{1}{2}\sum_{i=1}^{L}\sum_{j=1}^{L} \gamma_{ij} \ln K_i \ln K_j +$$

$$\sum_{i=1}^{N}\sum_{j=1}^{M} \delta_{ij} \ln w_i \ln y_j + \sum_{i=1}^{N}\sum_{j=1}^{L} \theta_{ij} \ln w_i \ln K_j + \sum_{i=1}^{M}\sum_{j=1}^{L} \phi_{ij} \ln y_i \ln K_j + \sum_{s=1}^{T} \xi_S \ln E_s \ln K_{RD} + \sum_{s=1}^{T}\sum_{i=1}^{N} \rho_{is} \ln E_s \ln w_i + \sum_{i}^{N} \rho_{iW} \ln W \ln w_i \qquad (1)$$

$$S_i = \sum_{D=1}^{48} \alpha_{Di} Dum_D + \sum_{i=1}^{N} \alpha_{ij} \ln w_j + \sum_{j=1}^{M} \delta_{ij} \ln y_j + \sum_{l=1}^{L} \theta_{ij} \ln K_j + \sum_{i=1}^{T} \rho_{is} \ln E_s + \rho_{iW} \ln W \qquad (2)$$

Model (II)

$$x \in \{T, L, M, CP\}, y \in \{LV, CO, FR\}, K \in \{RD\}, E \in \{ET, LQ, RO, SRD\} \quad (3)$$

T: Land; L: Labor; M: Materials; CP: Capital;
LV: Livestock; CO: Crop; FR: Farm Related outputs;
RD: public agricultural R&D stocks;
ET: extension service index;
LQ: labor quality index;
RO: road density index;
SRD: R&D spillins;

Symmetry constraints: $\alpha_{ij}=\alpha_{ji}$; $\beta_{ij}=\beta_{ji}$; $\gamma_{ij}=\gamma_{ji}$ (4)

Homogeneity of degree one in variable input prices requires:

$$\sum_{i=1}^{N} \alpha_{Di} = 1, \sum_{i=1}^{N} \alpha_{ij} = \sum_{i=1}^{N} \delta_{ij} = \sum_{i=1}^{N} \theta_{ij} = \sum_{i=1}^{N} \rho_{iS} = \sum_{i=1}^{N} \rho_{iW} = 0 \quad (5)$$

Model (III)

- Internal Rate of Return (IRR)

$$1=\sum_{\tau=0}^{s}\frac{-\Delta TVC_{t_0+\tau}}{\Delta RD_{t_0}}\frac{1}{(1+r)^{\tau}}=\sum_{\tau=0}^{s}\frac{-\Delta TVC_{t_0+\tau}}{\Delta K_{RD_{t_0+\tau}}}\cdot\frac{\Delta K_{RD_{t_0+\tau}}}{\Delta RD_{t_0}}\cdot\frac{1}{(1+r)^{\tau}}$$

- IRR with social benefit

$$1=\sum_{\tau=0}^{s}\frac{-\Delta TVC_{t_0+\tau}}{\Delta RD_{t_0}}\frac{1}{(1+r)^{\tau}}+\sum_{j\neq i}\sum_{\tau=0}^{s}\frac{-\Delta TVC_{j}}{\Delta SRD_{ij}}\frac{1}{(1+r)^{\tau}}$$

$$=\sum_{\tau=0}^{s}\frac{-\Delta TVC_{t_0+\tau}}{\Delta K_{RDt_0+\tau}}\cdot\frac{\Delta K_{RDt_0+\tau}}{\Delta RD_{t_0}}\cdot\frac{1}{(1+r)^{\tau}}+\sum_{j\neq i}\sum_{\tau=0}^{s}\frac{-\Delta TVC_{jt_0+\tau}}{\Delta KSRD_{jt_0+\tau}}\cdot\frac{\Delta KSRD_{jt_0+\tau}}{\Delta RD_{t}}\cdot\frac{1}{(1+r)^{\tau}}$$

Data (I)

- Annual aggregate data for the 48 contiguous states in U.S.
- Time period: 1980-2004.
- Output quantities—the output data were constructed as longitudinal indexes
- Input prices—Multilateral input price indexes were computed from Tornqvist indexes (Ball et al. (1999))

Data (II)- own R&D

Using a trapezoidal-weight pattern with a

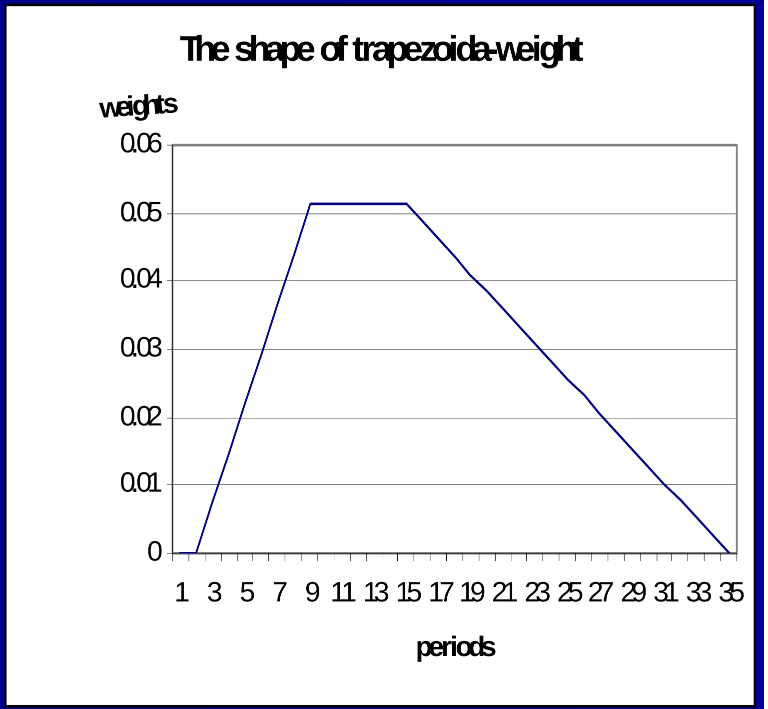
2 year gestation period,

7 years of increasing impacts,

6 years of maturity with constant weights, and

20 years of decay with declining weights.

(Huffman and Evenson ,1993, 1994; Huffman, McCunn, and Xu,2001)

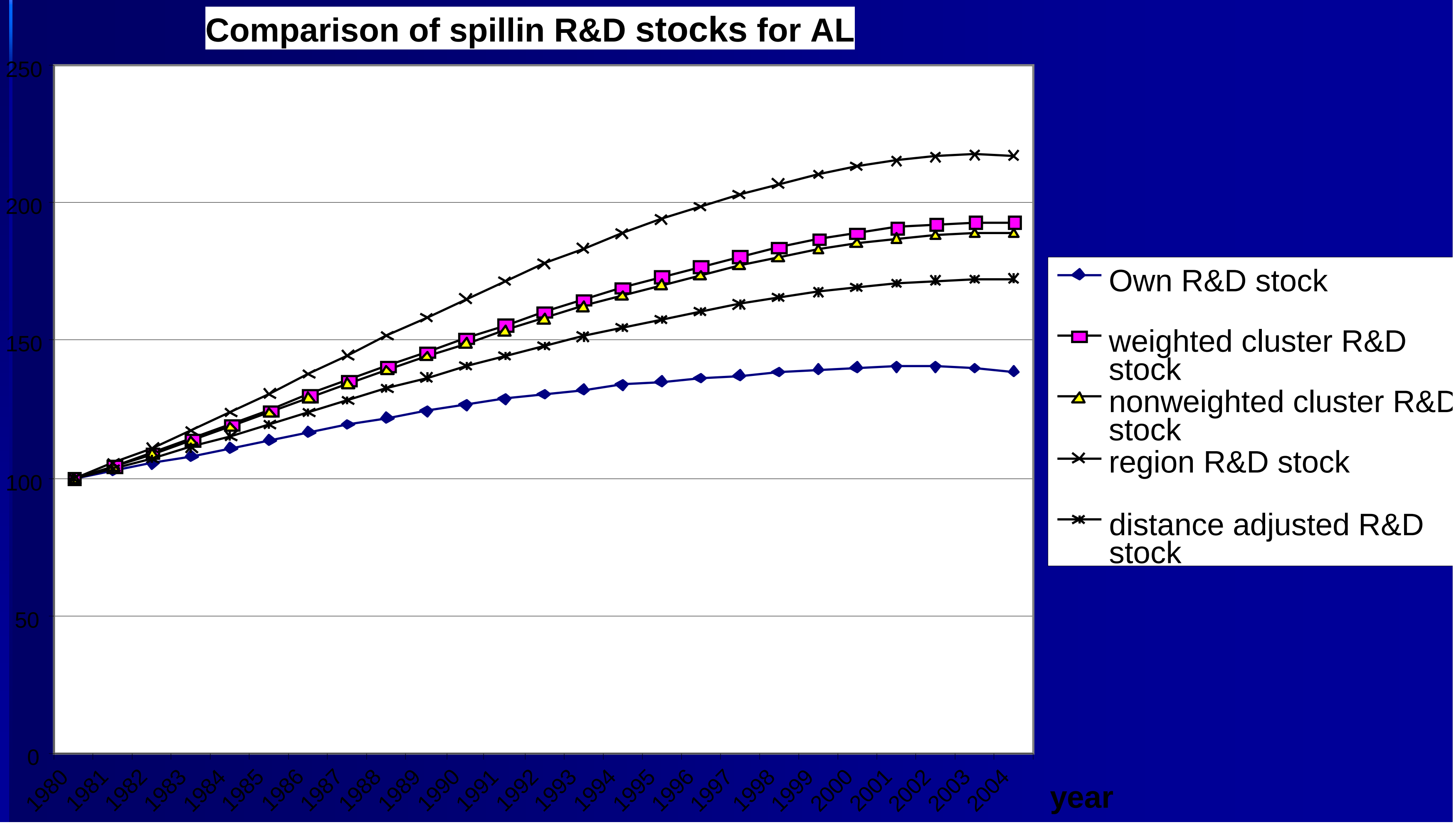


$i \neq j$

Data (III)- *R&D Spillins*

- $SRD_i = \sum w_{ij} RD_j$, $i \neq j$ (6)
  - Production region oriented: $w_{ij}=1$ for the spillins R&D generated by the same production region group.
  - Geographical distance oriented: $w_{ij}=1/\text{geo-dist}_{ij}$.
  - Output mix oriented: $w_{ij}=1$ for R&D spillins generated by the same output mix cluster.
  - Technical distance oriented: $w_{ij}=1/\text{Tech-dist}_{ij}$.

Data (IV)- *R&D Spillins*



Data (V)

- Extension Service- total FTE (full time equivalent) per farm
- Transportation network -road density index
- Labor quality index
- Weather-perceptions index

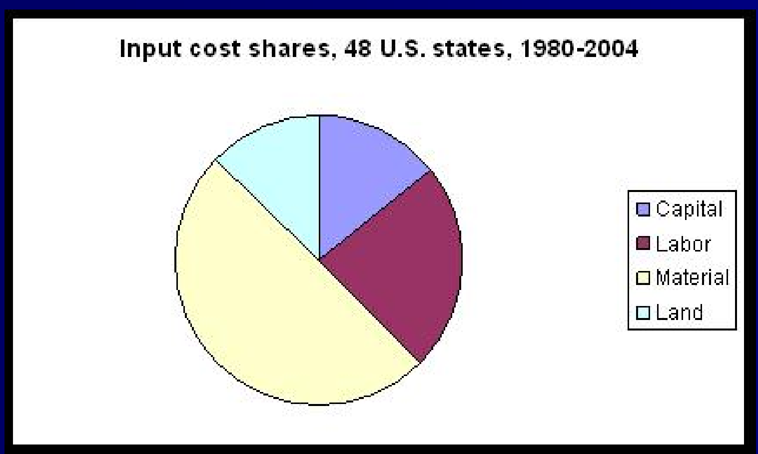
Data (VI)

- Data Sources
  - USDA/ERS
  - USDA/NASS
  - USDA/Cooperative Extension Service
  - Highway Statistics Publication
  - Current Population Survey

Data (VII)

Table 1 Cost shares statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
capital share	1200	0.142195	0.040412	0.054172	0.244674
labor share	1200	0.231886	0.07243	0.036472	0.489274
materia share	1200	0.497135	0.083202	0.232549	0.73927
land share	1200	0.128773	0.046774	0.028908	0.312015



- Material accounts for most of the cost share, followed by labor, capital and land
- Cost share for each input is varied among states

Results (I)

MODEL	FERD	FERDET	FERDRO	FERDLQ	FERDSR
production region	-0.1032	-0.0159	-0.0025	-0.0307	-0.0102
geographical distance	-0.0462	-0.0147	-0.0026	-0.0187	-0.0078
output mix	-0.1102	-0.0146	-0.0036	0.0204	-0.0037
technical distance	-0.1274	-0.0146	-0.0033	0.0236	-0.0024

Result (II)

Rate of return		
MODEL	own R&D	R&D spillins
production region	16.55	68.71
geographical distance	36.23	52.96
output mix	31.58	56.67
technical distance	36.79	60.29

- Rate of return for R&D expenditure is from 16.55%-36.79%
- With spillover effect, the rate of return is from 52.96%-68.71%
- Spillover effect from the same production region seems to dominate others.

Results (III)

- On average (production region):
- IRR from Own R&D—16.55%
- IRR with ET, RO, LQ—35.45%
- IRR with social benefits—68.71%

Conclusions

- Local public research expenditure has an average internal rate of return of 17%-37% through cost reduction benefits.
- With the interactive contribution of Extension Service, Transportation network, and Labor quality the internal rate of return of local R&D expenditure can be further increased.
- When considering the social benefits from the spillover effect, the IRR of R&D expenditures increases to an average of 53%-69%.

Q&A

Thank You!