Productivity Dispersion and Input Prices: The Case of Electricity

Steven J. Davis - *University of Chicago and NBER*
Cheryl Grim - *U.S. Census Bureau*
John Haltiwanger - *University of Maryland and NBER*

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Background

- Prior research (Davis and Haltiwanger, 2001) shows that it is important to consider aggregate and allocative effects of oil price shocks
  - Positive oil shocks have adverse aggregate effect
  - Positive and negative shocks have allocative effect
    - Allocative effects in turn yield adverse aggregate effect
  - Implication: Asymmetric effects of positive and negative oil price shocks on macroeconomy
- Underlying these findings are allocative effects
  - Changes in product mix (e.g., types of cars) and changes in production processes in response to changes in energy prices.
- Today's paper – looking more deeply at the factors underlying these allocative effects
  - Not looking at oil shocks directly but rather at electricity prices and differences across industrial producers in the prices they pay and their energy efficiency.

Firm level Heterogeneity

- Within narrowly defined industries, there is tremendous heterogeneity in the growth and productivity of firms
  – Interquartile range of TFP is 50 log points
  – Firms choosing different products, locations, processes in a constantly changing economic environment
  – High pace of output and input reallocation
    - Markets reallocating to more profitable and productive, but not instantaneously (takes time and resources – frictions are non-trivial)
  – One potentially important component is differences in electricity prices and electricity productivity

Data

- PQEM Database: Annual customer-level data on price per kWh and purchase quantity for about 50,000 U.S. manufacturing plants per year
- Available years: 1963, 1967, 1972-2000 (currently being updated to 2006)
- Final number of observations: ~1.5 million
- Also, consider subset of homogenous product industries

Electricity Productivity

Electricity productivity for plant *e* in year *t*:

$$\varphi_{et} = \frac{VA_{et}}{EE_{et}} = \frac{VA_{et}}{P_{et} KW_{et}}$$

VA_{et} = real value added

EE_{et} = expenditures on electricity

KW_{et} = quantity of purchased electricity

P_{et} = price per physical unit of electricity

Decomposition

Taking the natural log of electricity productivity and decomposing:

$$\log(\varphi_{et}) = \log\left(\frac{VA_{et}}{EE_{et}}\right) = \log\left(\frac{VA_{et}}{KW_{et}}\right) - \log(P_{et}) \equiv \gamma_{et} - p_{et}$$

γ_{et} = electricity physical efficiency

p_{et} = electricity price "efficiency"

Price "efficiency" is simply price. It reflects past and current choices of location, scale and technology.

Basic Facts

Log Deviation (from Industry Mean) Sample Weighted Statistics				
	Electricity Productivity	Physical Efficiency	Price per kWh	Labor Productivity
	Primary Analysis Sample			
Standard Deviation	0.87	0.92	0.38	0.66
90-10 Differential	1.96	2.13	0.86	1.44
	Homogeneous Products Sample			
Standard Deviation	0.85	0.91	0.38	0.69
90-10 Differential	1.94	2.12	0.87	1.44

Relationship Between Physical Efficiency and Price

Hypotheses

- A plant that is more efficient in terms of physical efficiency will also be more efficient in terms of price.
- There is a tradeoff between electricity physical efficiency and price. This tradeoff will be more important in electricity intensive industries.

Physical Efficiency/Price Tradeoff

Plant-level least squares regression:

$$\tilde{\gamma}_{ei} = \alpha_i + \beta_i \tilde{p}_{ei} + \varepsilon_{ei}$$

e indexes plants

i indexes 4-digit SIC industries

$\tilde{\gamma}_{ei}$ = natural log of plant physical efficiency deviated from its’ industry-year mean

$\tilde{p}_{ei}$ = natural log of plant price deviated from its’ industry-year mean

Figure 2: Estimated Physical Efficiency Elasticity

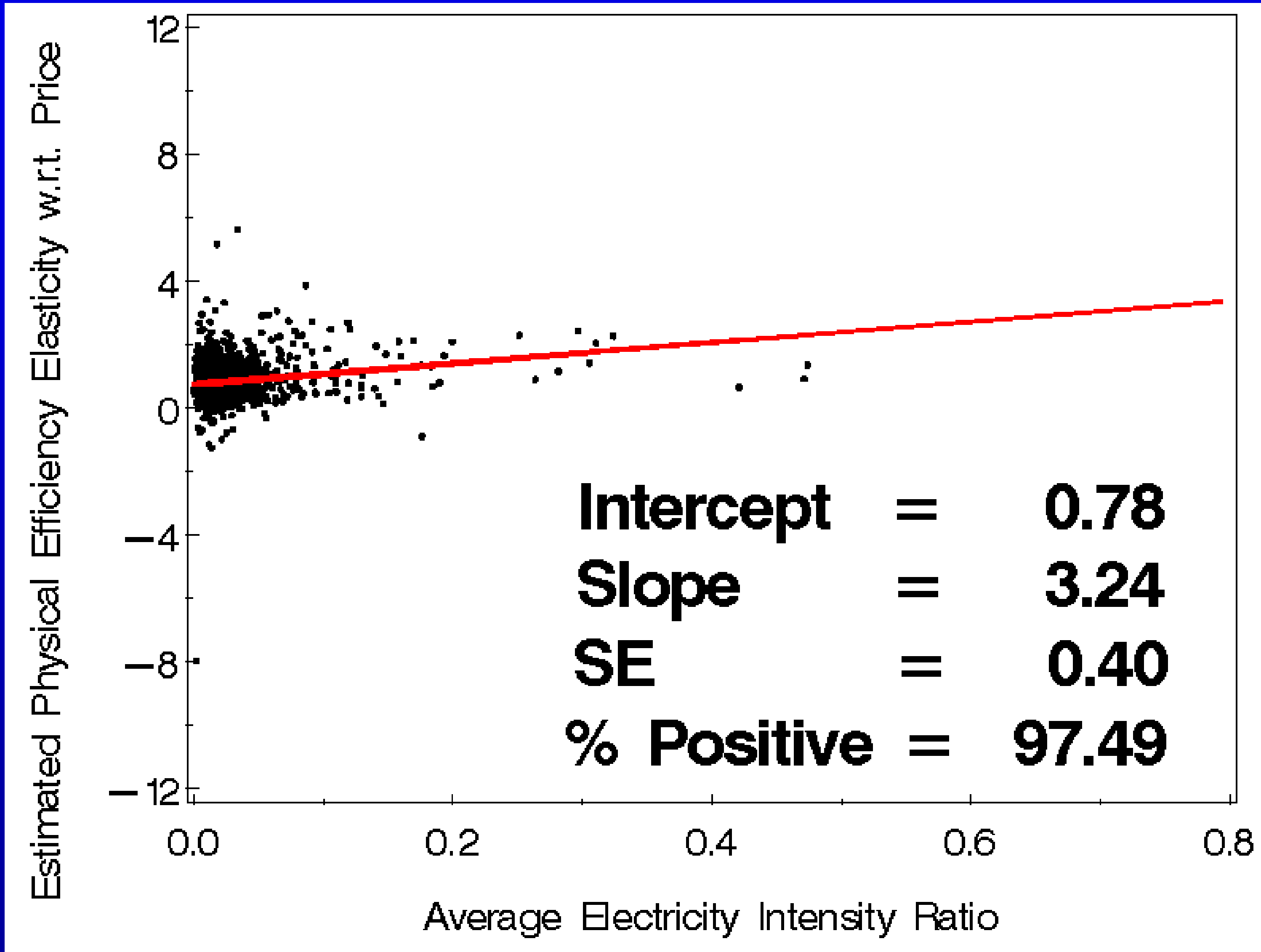
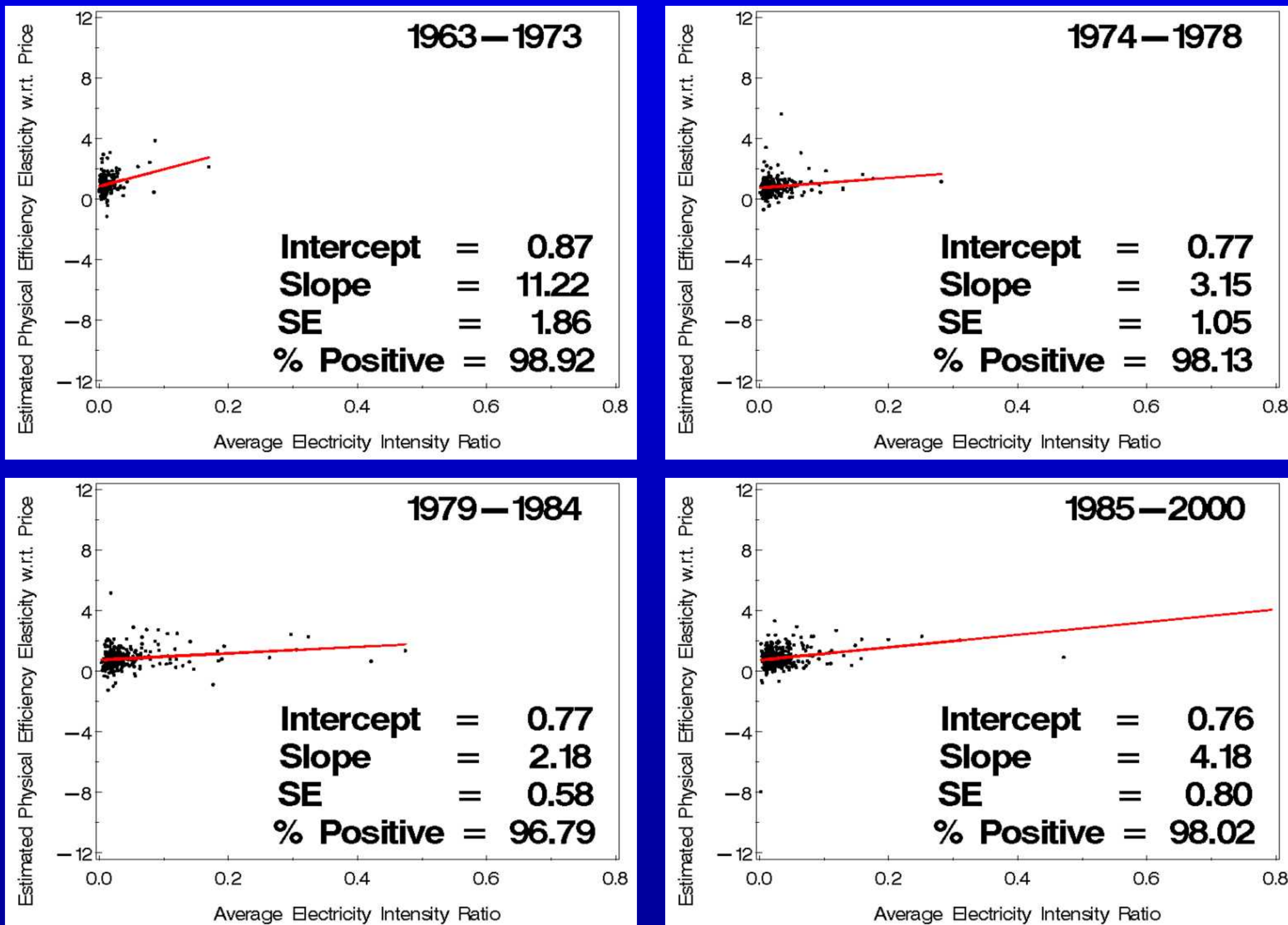


Figure 3: Estimated Physical Efficiency Elasticity



Results robust to IV estimation

Competition Effects on Productivity and Price Dispersion

- In a more competitive environment, there will be less dispersion as high cost (high price) and low physical efficiency plants are selected from the market. (Closely related to Syverson (2004))
- Hypothesis

  For local goods, dispersion in electricity productivity, physical efficiency and prices will decline with the number of local producers in the industry.

Table 6: Local Market Competition Effects

	Electricity Productivity (1)	Electricity Price (2)	Electricity Physical Efficiency (3)	Labor Productivity (4)
Decline in within industry dispersion from increased density of local market for locally traded goods	-8.27	-4.38	-9.34	-8.66

Conclusions

- U.S. manufacturing plants exhibit large dispersion in electricity productivity, physical efficiency and prices - even within narrow industries.
- There is a positive tradeoff within industries between electricity physical efficiency and price.
- This tradeoff is more pronounced in electricity intensive industries.
- An increase in local market density for locally traded goods yields a reduction in the dispersion of electricity productivity and physical efficiency.

Implications

- Aggregate response to changes in energy prices will reflect complex substitution response at firm level.
  - Firms choose different products, processes and locations
  - Large differences in energy efficiency and energy costs
  - Rising energy prices will yield substitution response but only slowly as mix of products, processes, locations and firms change in response to changing prices
  - Next steps: Trace out dynamic response of firms to changes in energy prices