Productivity Dispersion and Input Prices: The Case of Electricity

By Steven J. Davis, Cheryl Grim and John Haltiwanger

September 6, 2007

Disclaimer: This work is unofficial and thus has not undergone the review accorded to official U.S. Census Bureau publications. The views expressed are those of the authors and not necessarily those of the Census Bureau. This presentation has been screened to ensure no confidential data are revealed.

Motivation

- There are large measured productivity differences across plants even in narrowly defined industries.
- How can plants seemingly competing in the same market exhibit such large productivity dispersion?
  - Emerging literature (e.g., Foster et al. (2001,2005), Syverson (2004a, 2004b))
  - Frictions
    - Adjustment, entry/exit
    - Market structure (differentiated products)
- Focus has been on TFP, labor productivity and output prices
- Our contribution: Electricity productivity decomposed into physical efficiency and price "efficiency"

Overview

- Data and Measures
- Basic Facts: Dispersion in Electricity Productivity Measures
- Relationship Between Electricity Physical Efficiency and Price
- Competition Effects on Productivity and Price Dispersion
- Conclusions

Data: Primary Analysis Sample

- 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
- Excluded:
  - Part-year observations
  - Observations with non-positive value added (our measure of output for this paper)
  - Observations in industries where non-positive value added represents > 5% of the total value of shipments.
  - Observations in industries with “miscellaneous” or “not elsewhere classified” in the name
- Final number of observations: ~1.5 million

Data: Homogeneous Products Sample

- Purpose: Test for whether primary sample results are driven by product heterogeneity and quality differences within narrowly defined (4-digit SIC) industries.
- Use Foster et al. (2005) data to identify plants producing the following homogeneous products
  - Corrugated and solid fiber boxes, hardwood plywood, ice, motor gasoline, ready-mixed concrete, roasted coffee and white pan bread
- Final number of observations: 48,081

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

Basic Facts: Homogeneous Products

Product	Sample Weighted Standard Deviation of Log Deviations			
	Electricity Productivity	Physical Efficiency	Price per kWh	Labor Productivity
Boxes	0.68	0.75	0.33	0.45
Plywood	0.59	0.61	0.35	0.48
Ice	1.05	1.03	0.33	0.64
Gasoline	1.13	1.20	0.36	0.64
Concrete	0.88	0.96	0.36	0.76
Coffee	1.09	1.02	0.93	1.14
Bread	0.60	0.63	0.31	0.54

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

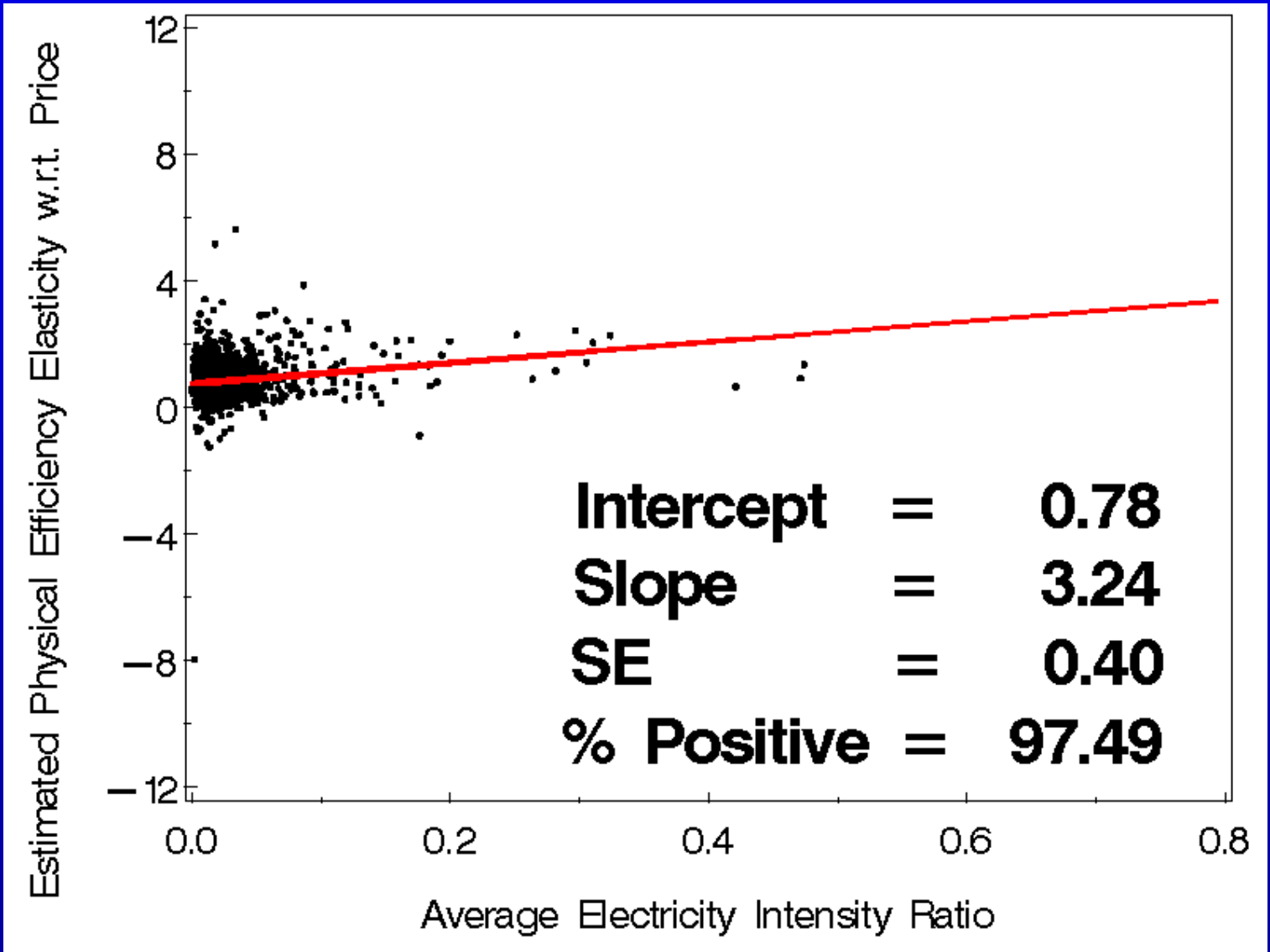
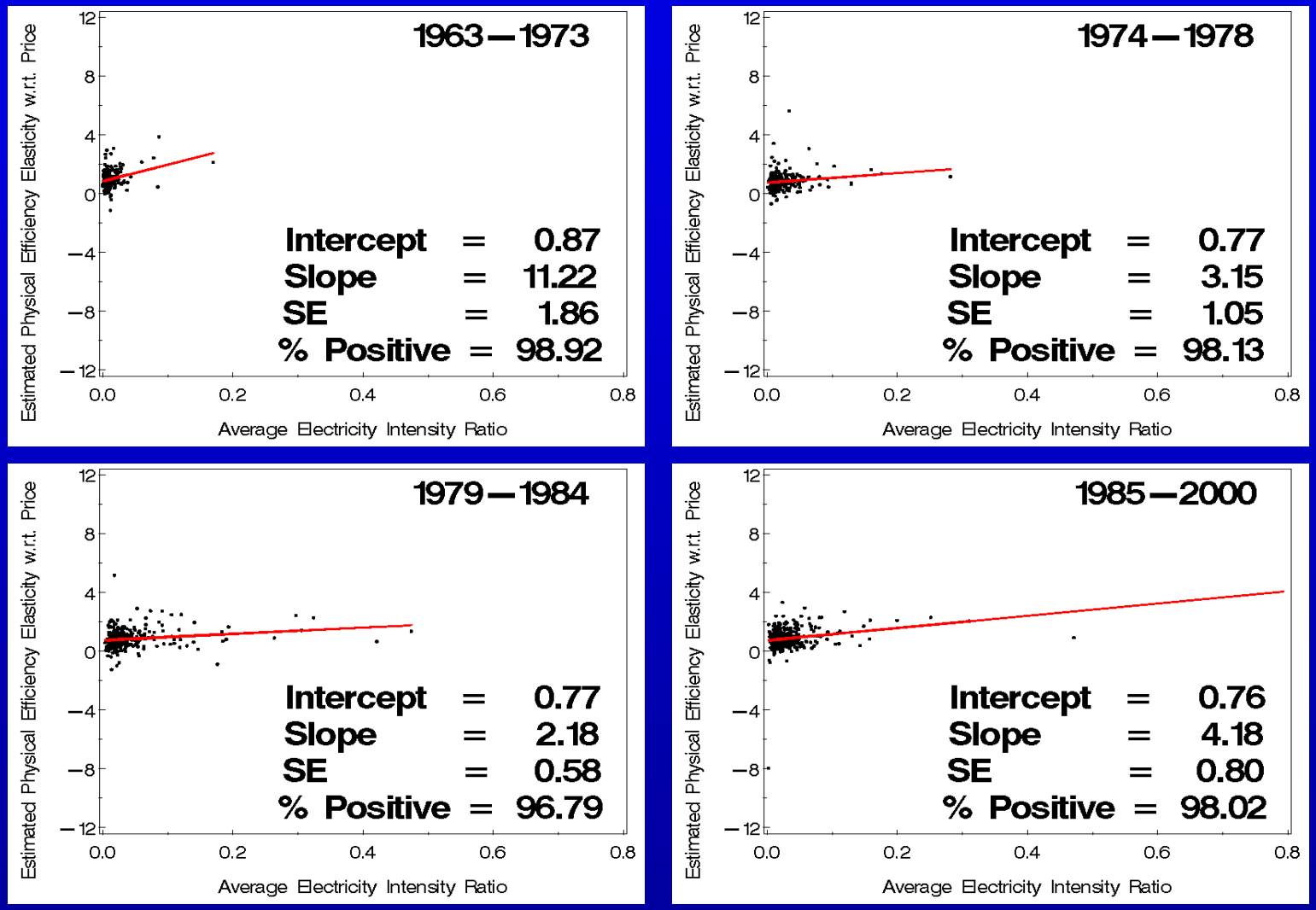


Figure 3: Estimated Physical Efficiency Elasticity



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

Stage 1: Difference-in-Difference Specification

- Electricity Productivity
  - Regress log electricity productivity on a fully interacted set of industry*year effects
- Also examine
  - Electricity Price
  - Electricity Physical Efficiency
  - Labor Productivity

Difference-in-Difference Specification

$$abs(residual_{et}) = \alpha + \beta LOCAL_{et} + \gamma DENS_{et} + \delta\left(LOCAL_{et} * DENS_{et}\right) + \varepsilon_{et}$$

residual = residual from the stage 1 regression

LOCAL = 1 if the plant is in an industry where > 60% of goods are shipped < 100 miles and = 0 otherwise

DENS = 1 if the plant is in a CEA with 2+ plants producing in the same industry and = 0 otherwise

Table 4: Difference-in-Difference Results

	Electricity Productivity (1)	Electricity Price (2)	Electricity Physical Efficiency (3)	Labor Productivity (4)
Intercept	0.595 (0.002)	0.251 (0.001)	0.616 (0.002)	0.490 (0.001)
LOCAL	-0.043 (0.008)	0.004 (0.003)	-0.031 (0.008)	0.029 (0.006)
DENS	0.027 (0.002)	0.001 (0.001)	0.030 (0.002)	0.024 (0.002)
LOCAL DENS*	-0.056 (0.009)	0.001 (0.003)	-0.067 (0.009)	-0.046 (0.006)
Adjusted R^2	0.002	0.000	0.002	0.001
N	394,288	394,288	394,288	394,288

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.