
Energy Intensity of Indian Manufacturing Firms – Effect of Energy Prices, Technology and Firm Characteristics

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Organization of Presentation

- Significance of the Issue
- Trends in Energy Intensity – effect of energy price hikes – industrial composition effect
- Inter-state variation in energy intensity of manufacturing plants – correlation with regional variation in energy prices
- Assessing the contribution of technological progress to energy saving – estimated energy demand function from industry-wise panel data
- Firm level (cross-sectional) analysis – influence of firm characteristics on energy intensity
- Conclusions



Significance of the Issue

CO₂ Emissions and Climate Change

- Some recent studies have indicated that inconceivable catastrophic changes in the environment will take place if the global temperatures increase by more than 2° C.
- Studies have concluded that if CO₂ emissions are halved by 2050 compared to 1990 levels, global warming can be stabilized below two degrees.
- But, can this be achieved, when CO₂ emissions have been rising rapidly/ accelerating in the recent past?
- The annual growth rate of CO₂ emissions at the global level in the 1990s was about 1%, while it was 3% per year in period 2000 to 2008 – China and US are major contributors.

Outcome of Climate Change Summit in Copenhagen, December 2009

- Some forward movement. US has agreed to cut its greenhouse gas emissions by roughly 17% by 2020, compared to 2005 levels.
- China's CO₂ emissions have been growing at the rate of about 10% per annum. China has declared that by 2025 it will bring down the carbon intensity of its economy by 40 to 45% below the 2005 level.
- India has similarly announced a unilateral climate mitigation measure to reduce its carbon intensity level by 20 to 25% over the next 11 years.
- In this context, a study of energy intensity of Indian manufacturing firms, especially what factors determine energy intensity, assumes considerable significance.

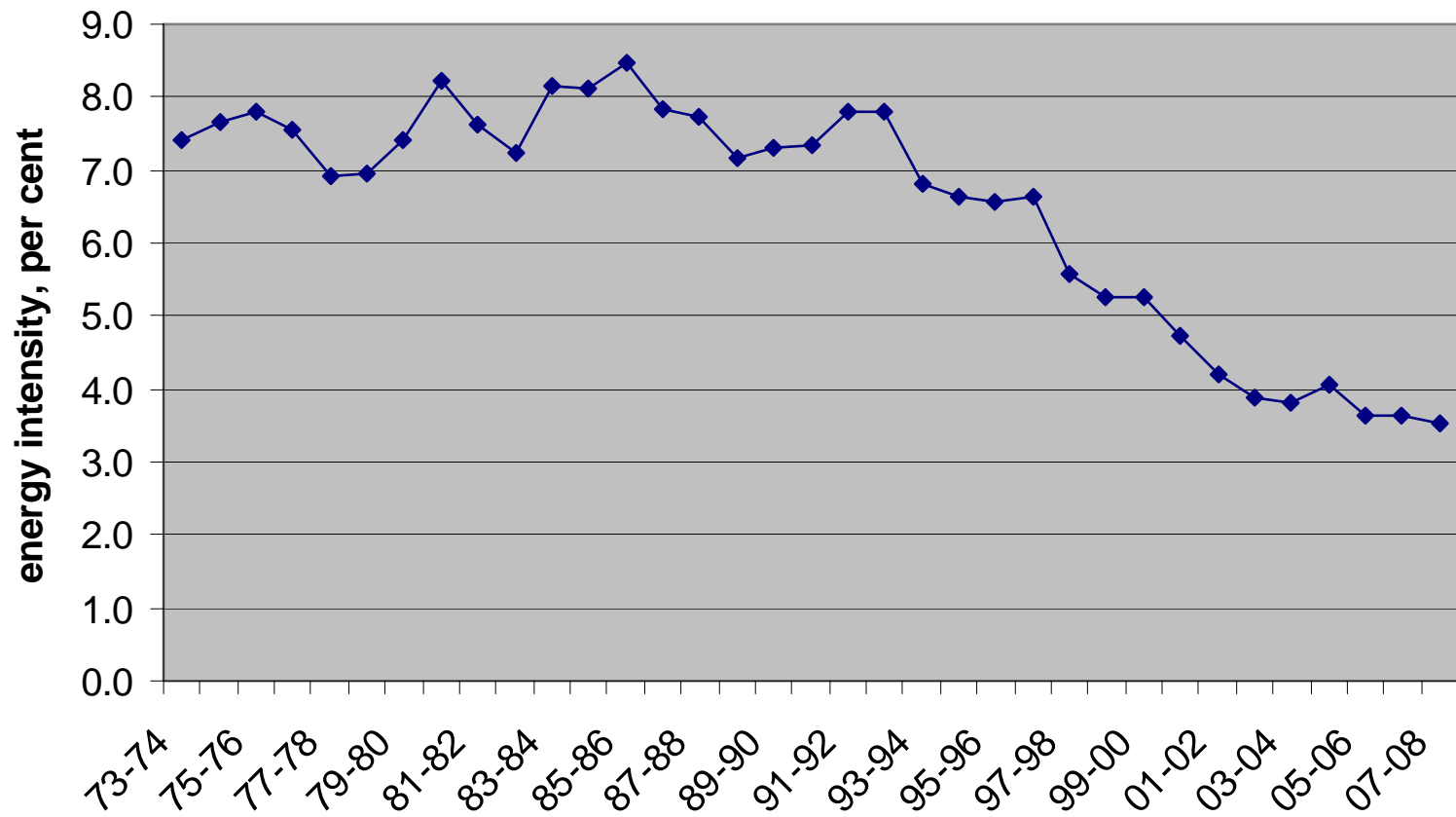


Trends in energy intensity

Trends in energy intensity – organized manufacturing in India

- During 1973-74 to 1992-93 (a twenty year period), energy intensity remained by and large within the range of 7 to 8%. There was no upward or downward trend.
- In the period after 1992-93, there was a clear downward trend in energy intensity.
- The trend growth rate in the period 1992-93 to 2007-08 was -5.4% per annum.

Fig. 1: Energy Intensity (ratio of energy cost to value of output, both deflated), Indian Manufacturing, 1973-74 to 2007-08



Fall in Energy Intensity, alternate estimate

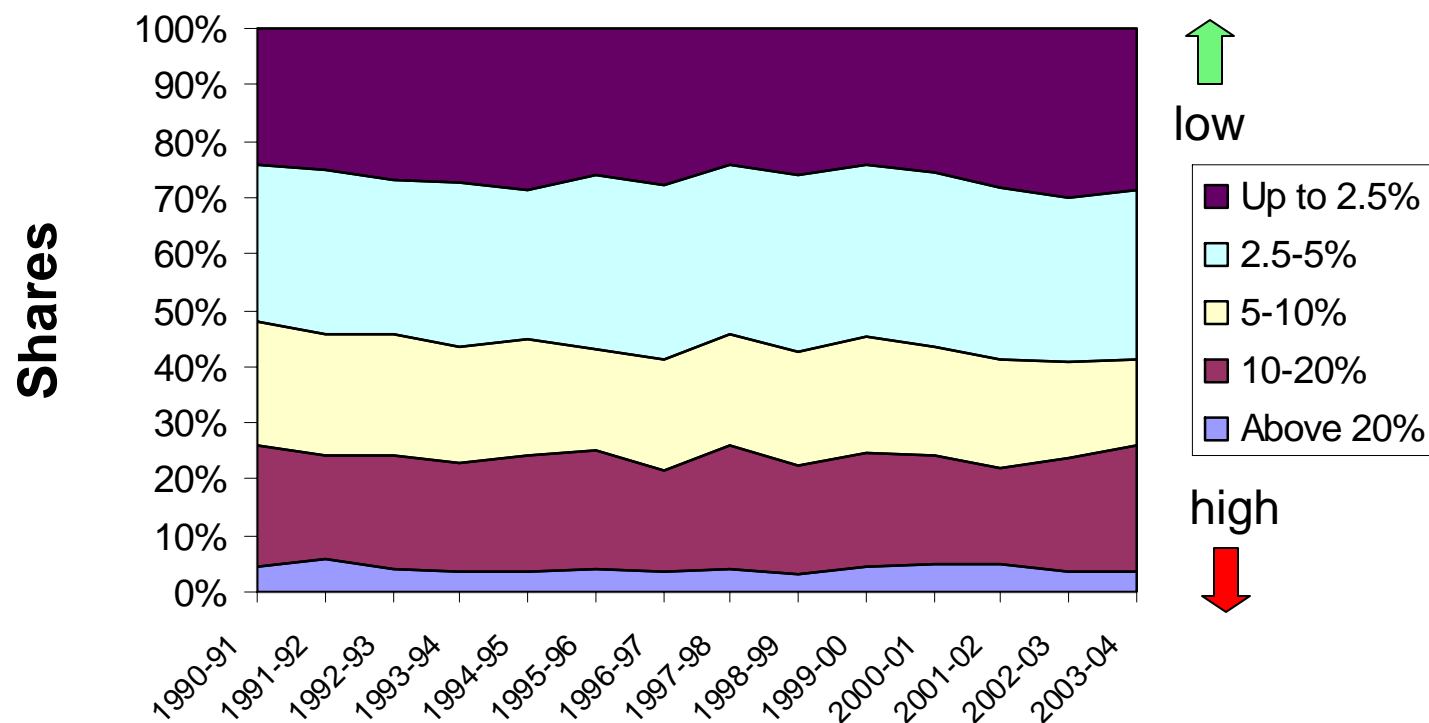
- According to Ray and Reddy (2007), energy intensity of Indian manufacturing declined
 - from **787 TJ per billion Rupees of output** in 1992
 - to **547 TJ per billion Rupees of output** in 2002.
 - The annual rate of fall in energy intensity was 3.6%.
- The ratio of energy cost of value of output (both deflated) fell at the rate of -6.3% per annum in the period 1992-93 to 2002-03.

What caused the fall in energy intensity?

- Does not seem to have been caused by changes in the industrial structure
- Seems attributable, at least in part, to hikes in the real price of energy

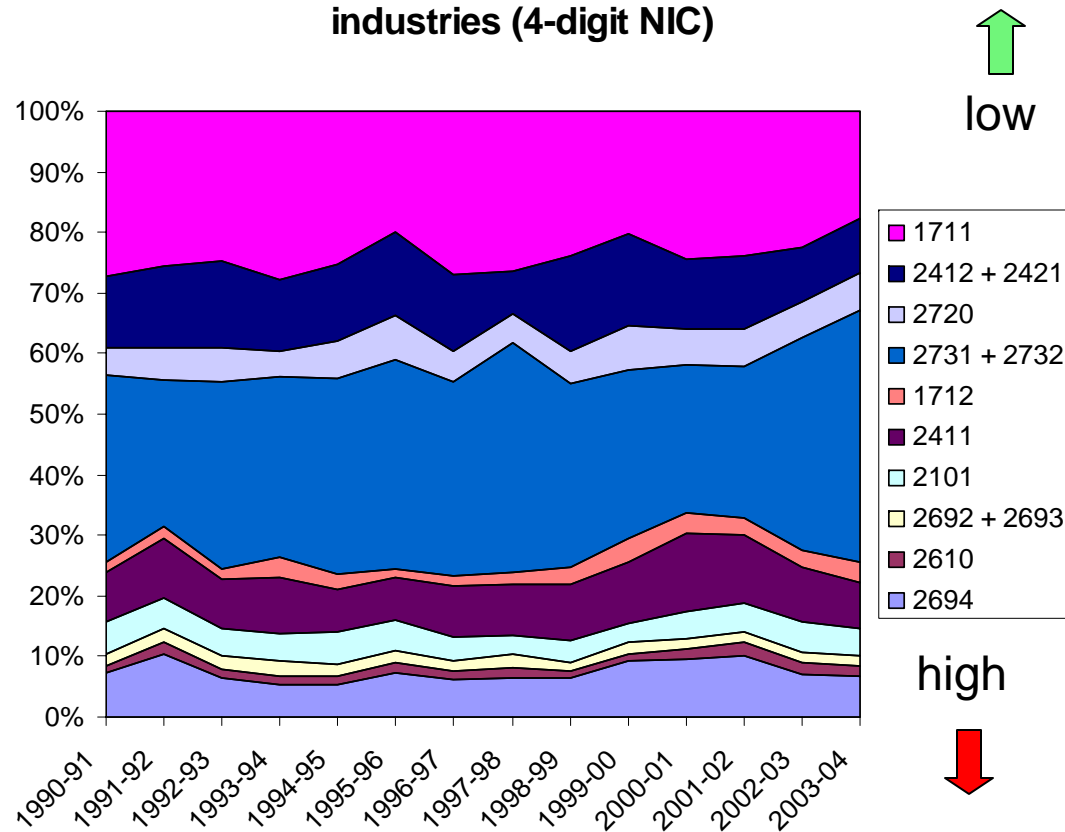
Changes in industrial composition

Fig. 3: Value added share of industries classified according to energy intensity



Changes in output shares of high energy intensive industries (within group)

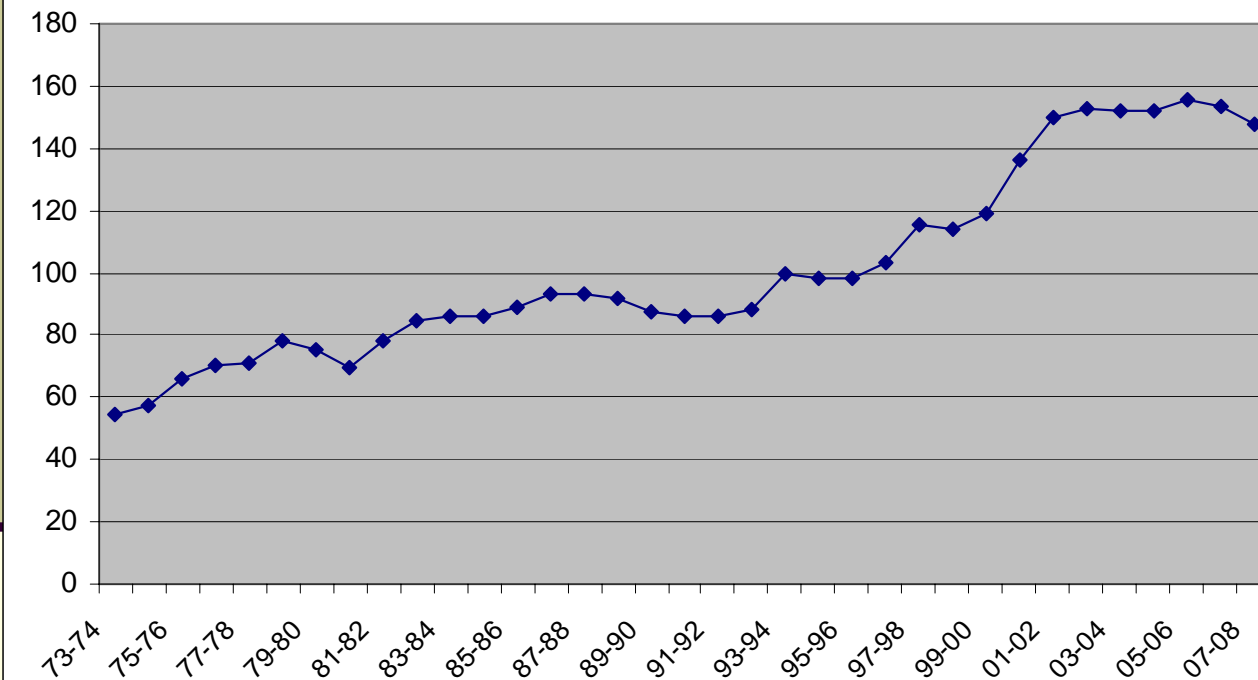
Fig. 4: Value added shares of high energy intensive industries (4-digit NIC)



It seems that changes in industrial structure would not provide adequate explanation for the observed decline in energy intensity in Indian manufacturing in the period since 1992

Trends in Real Price of Energy

Fig. 2: Real Price of Energy (Index, 1993-94=100), Indian Manufacturing, 1973-74 to 2007-08



The trend growth rate in the real price of energy was 2.3% per annum during 1973-74 to 1992-93, and 4.1% per annum during 1992-93 to 2007-08

Regression

$$\ln EI = 4.52 - 0.63 \ln REP + 0.043 T - 0.0014 T^2$$

(-4.9) (7.1) (-9.8)

$$n=35 \quad R^2=0.96 \quad DW=1.79$$

EI= energy intensity; REP=real price of energy (energy price divided by the wholesale price index for manufacturing); T=time

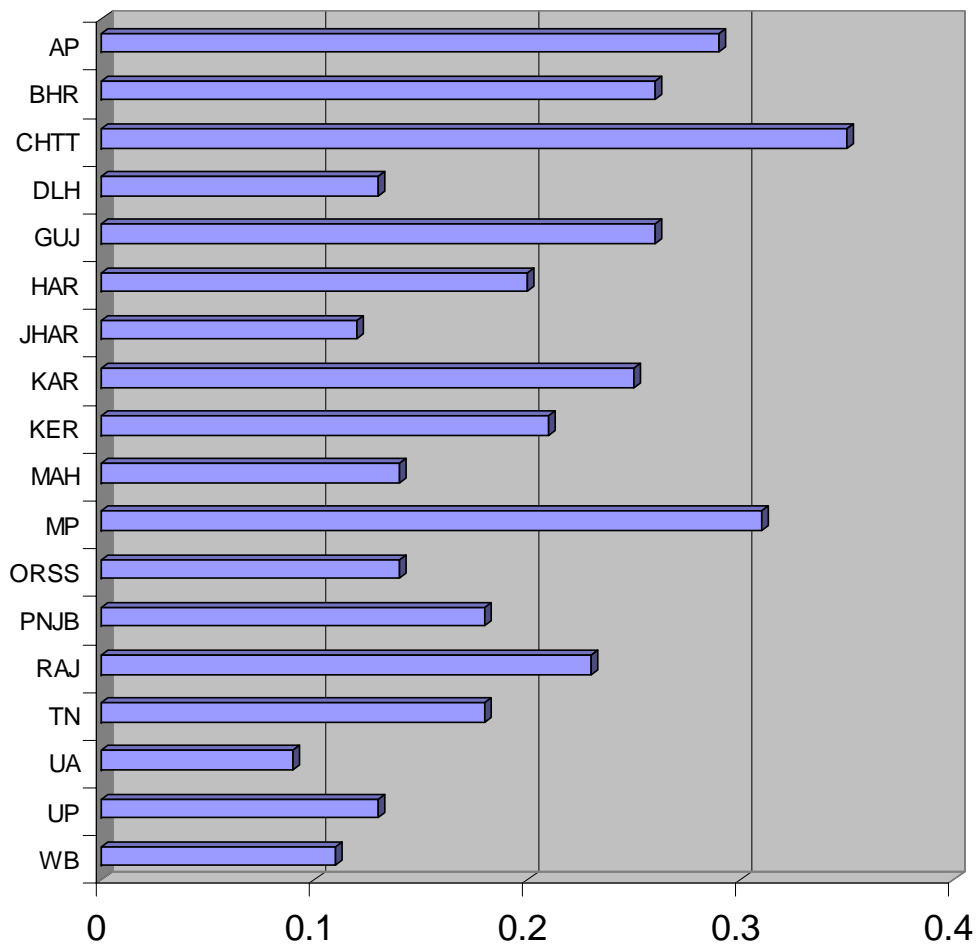


Inter-state variation in energy intensity of manufacturing plants

Inter-state variation in energy use efficiency

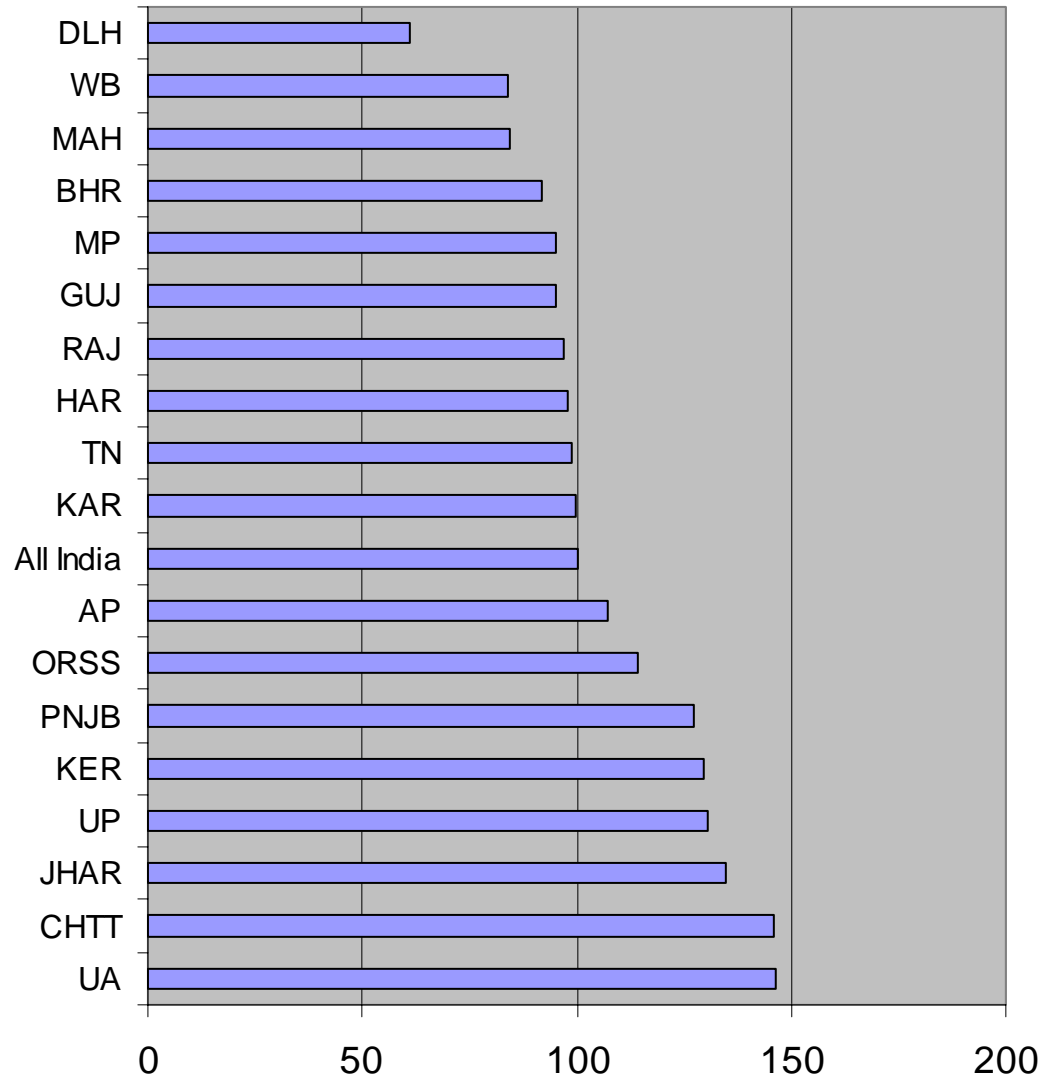
- Energy intensity of manufacturing varies significantly across states.
- In terms of the overall index, energy productivity or energy use efficiency is **relatively higher** in
 - Maharashtra, Madhya Pradesh, West Bengal and Delhi (the index is less than one),
- and **relatively lower** in
 - Chattisgarh, Jharkhand, Kerala, Punjab, Uttar Pradesh and Uttarakhand

Energy intensity, cement + other non metallic mineral products except glass, by state



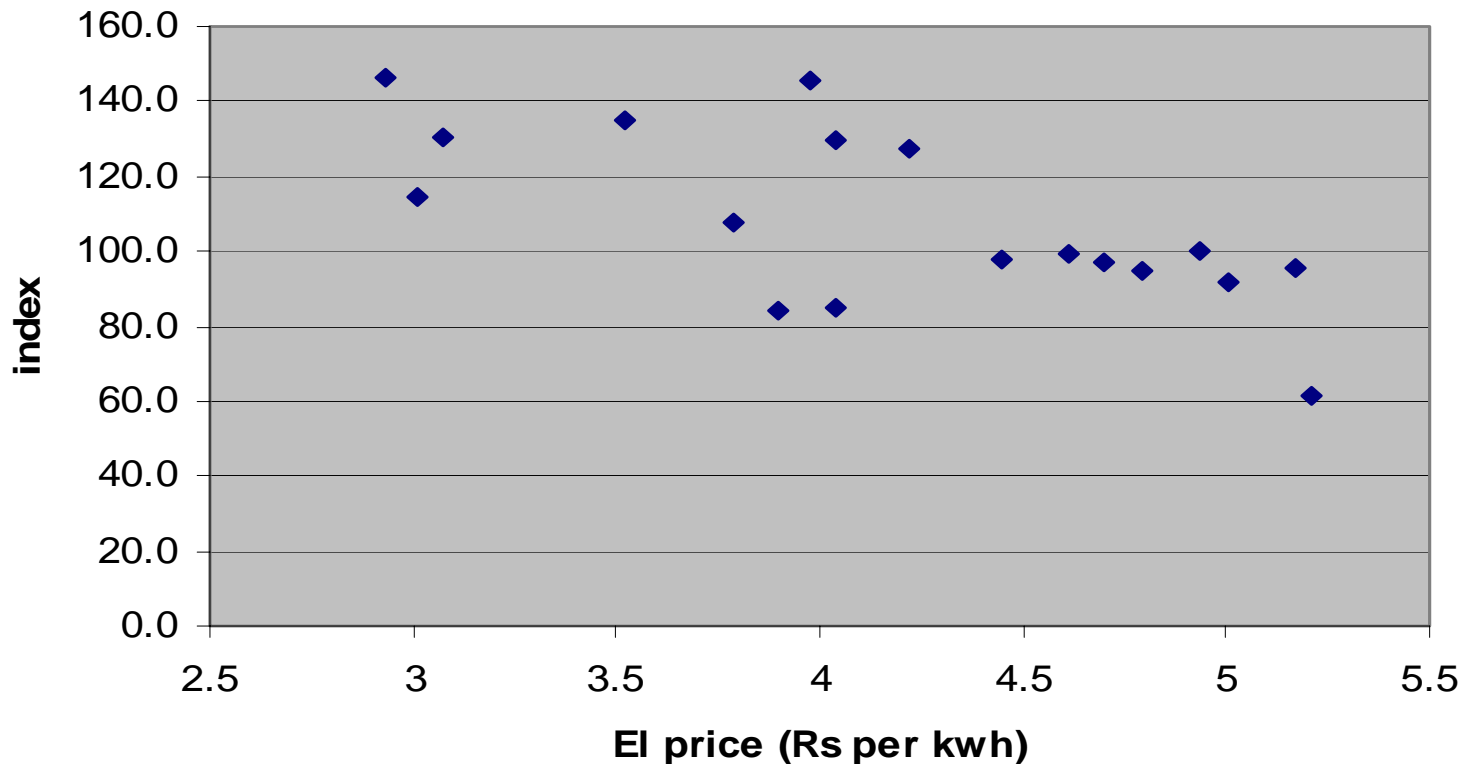
Energy intensity:
ratio of
energy cost
to value of
output

Energy intensity, manufacturing industries, Indian states



Energy intensity index, formed by taking energy intensity for each industry at All-India level as 100, then average across industries

**Fig. 5: Electricity Price and Energy Intensity
(overall index), Across 18 States**



A significant negative correlation (-0.68) is found between electricity price (unit price paid for electricity purchased) and the overall index of energy intensity.



Contribution of technological progress to energy saving



Model

- E energy and Y net output (value of output minus value of materials). P_E and P_L are prices of energy and labour input. P_Q is the output price index. A is the total factor productivity index (captures technological progress)

$$\ln E = \beta_0 + \beta_1 \ln(P_E / P_Q) + \beta_2 \ln(P_L / P_Q) + \beta_3 \ln(Y) + \beta_4 \ln A + u \quad \dots(4)$$

Data for 22 two-digit industries of ASI for the period 1980-81 to 2003-04 have been used to estimate the model

Energy Demand Function, Indian Manufacturing Industries, dynamic model, two step method

| Explanatory variables | Regressions | |
|---|----------------|----------------|
| | (1) | (2) |
| $\ln(P_E / P_Q)$ | -0.465 (-11.1) | -0.410 (-12.2) |
| $\ln(P_L / P_Q)$ | 0.092 (1.4) | 0.079 (1.9) |
| $\ln(Y)$ | 0.523 (11.1) | 0.675 (15.5) |
| t | 0.009 (1.4) | |
| $\ln(A)$ | | -0.205 (-2.6) |
| $\ln(E_{-1})$ | 0.330 (13.4) | 0.276 (8.2) |
| constant | 0.227 | -0.901 |
| Wald chi-square (prob.) | 1813.5 (0.000) | 4247.0(0.000) |
| Sargan test, Chi-sqr and probability | 21.5 (1.0) | 20.5(1.0) |
| Arellano-Bond test for zero autocorrelation in first-differenced errors, order 2, Chi-sqr and probability | 0.411 (0.68) | 0.209 (0.83) |
| No of observations | 528 | 506 |

Interpretation

- The real energy price has grown at the rate of about 5.3% per annum during 1992-93 to 2003-04. Thus, a sizeable part of the decline in energy intensity in Indian manufacturing in the post-1992 period may be attributed to hikes in the real price of energy.
- The coefficient of the TFP index is negative and statistically significant. This would imply that technological change to the extent it gets reflected in the TFP index contributed to the fall in energy intensity of Indian manufacturing.



Firm level study

Firm level study of energy intensity

- Two earlier studies done on this issue for Indian industry are: Kumar (2003) and Sahu and Narayana (2009).
- The approach taken and methodology employed in this study are similar.
- Cross section data for about 2800 manufacturing companies are taken for 2008-09 (if not available then for 2007-08, and if even that is not available, then data for 2006-07).

Firm level study of energy intensity

- Energy intensity is regressed on a set of explanatory variables. These include:
 - Firm size, vintage of plant and machinery, foreign ownership, export intensity, technology import intensity, R&D intensity, finished goods import intensity, and materials import intensity.

Model

$$E_{ijr} = \alpha + \beta' X_{ijr} + \sum \mu_j N_j + \sum \eta_r S_r + u_{ijr}$$

All firms

Energy intensity

Explanatory variables

Industry dummies

State dummies

$$E_{ijr} = \alpha + \beta' X_{ijr} + \gamma E_{j^*r}^* + \sum \mu_j N_j + \sum \eta_r S_r + u_{ijr}$$

Only domestic firms

Energy intensity of foreign firms; captures spillover effects

Results

- Regression results are reported in Table 6.
- Regression 3 is for only domestic firms.

| Explanatory variables | Regression 1 | Regression 2 | Regression 3 |
|---------------------------------------|-------------------|--|--|
| | All firms | Firms belonging to energy intensive industries | Domestic firms@ belonging to energy intensive industries |
| Firm size | -0.002 (-1.65)* | 0.0003 (0.13) | 0.0008 (0.32) |
| Export intensity | -0.006 (-1.10) | -0.023 (-1.97)** | -0.021 (-1.57) |
| Import of finished goods intensity | -0.020 (-1.16) | -0.049 (-2.27)** | -0.058 (-2.30)** |
| Raw materials import intensity | -0.025 (-2.13)** | -0.022 (-0.83) | -0.014 (-0.43) |
| Capital goods import intensity | 0.036 (0.82) | 0.027 (0.56) | 0.029 (0.43) |
| Technology import intensity | -0.083 (-3.75)*** | -0.135 (-2.29)** | -0.100 (-1.35) |
| R&D dummy (R&D intensity 1% or more) | -0.011 (-2.46)** | 0.001 (0.06) | 0.006 (0.23) |
| IT investment intensity | -0.148 (-5.80)*** | -0.267 (-1.71)* | -0.491 (-1.42) |
| Expenditure on repairs to sales ratio | 0.778 (4.67)*** | 0.726 (3.00)*** | 0.909 (2.63)*** |

| | | | |
|---|--------------------|-------------------|-------------------|
| Ratio of sales to fixed capital (gross block) | -0.005 (-11.33)*** | -0.008 (-7.09)*** | -0.007 (-4.41)*** |
| Age of the firm | 0.0002 (2.05)** | 0.0008 (3.25)*** | 0.0007 (2.43)*** |
| Foreign firm (dummy) | -0.002 (-0.45) | -0.014 (-2.03)** | |
| Advertisement intensity | -0.156 (-3.11)*** | -0.189 (-0.56) | -0.207 (-0.55) |
| Energy intensity of foreign firms in the industry and state | | | 0.246 (1.82)* |
| Industry dummies | Yes | Yes | Yes |
| State dummies | Yes | Yes | Yes |
| | | | |
| R ² | 0.317 | 0.279 | 0.277 |
| No. of observations | 2775 | 1074 | 813 |

@ Analysis confined to domestic firms having plants in one or more of 17 selected states.

Main findings

- In high energy intensive industries, large firm are not more energy efficient than small firms, but foreign firms have an advantage over local firms.
- Firms with relative older plant/machinery are less efficient in energy use
- Use of more advanced technology (including use of IT) helps in improving energy efficiency.

Main findings

- A significant positive relationship is found between the energy intensity of a local firm belonging to a particular industry in a particular state with the energy intensity of foreign firms belonging to that industry in that state.
- This indicates energy efficiency spillover from foreign firms to local firms.



Conclusions

Conclusions

- There was a marked fall in energy intensity of Indian manufacturing (organized) since 1992. The fall seems to have occurred mainly because the energy intensive industries became more efficient in energy use, which in turn may be traced in part to increases in the real price of energy faced by manufacturing.
- The proposal for introducing in energy intensive industries a system of trading in energy efficiency certificates will raise the effective price of energy to energy inefficient firms and thus induce them to reduce energy intensity.

Conclusions

- Technology is found to be an important factor in determining energy intensity. Technological advance helps in improving energy use efficiency.
- Energy efficiency is found to be relatively lower in plants of older vintage, which signifies that to reduce energy intensity and hence CO₂ emission intensity, old plants need to be replaced by new ones. Suitable policies are therefore needed to facilitate such replacement.



Thank You

