Energy Consumption, Emissions and Environmental Certification: Study of Indian Manufacturing

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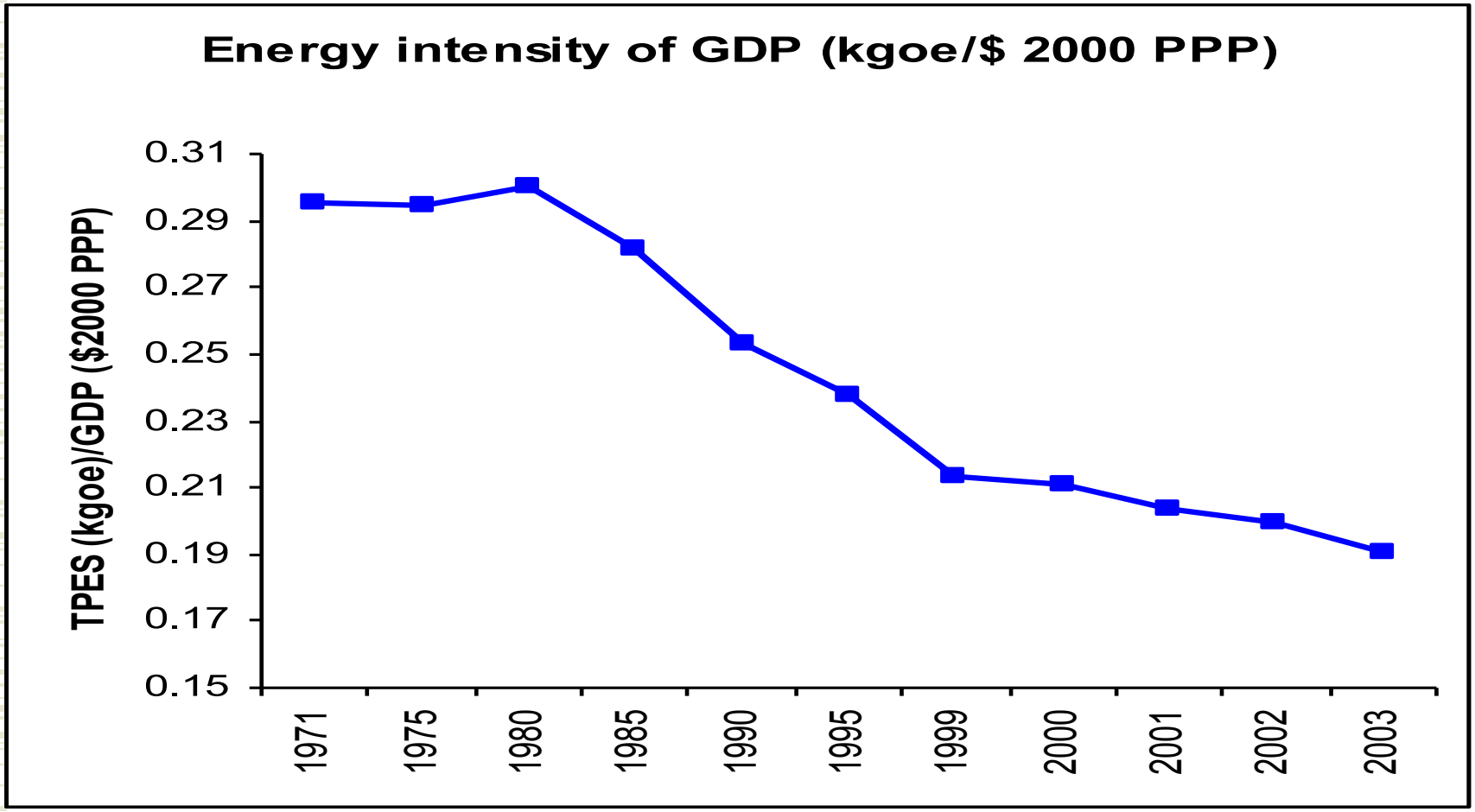
Introduction

India: Current Scenario

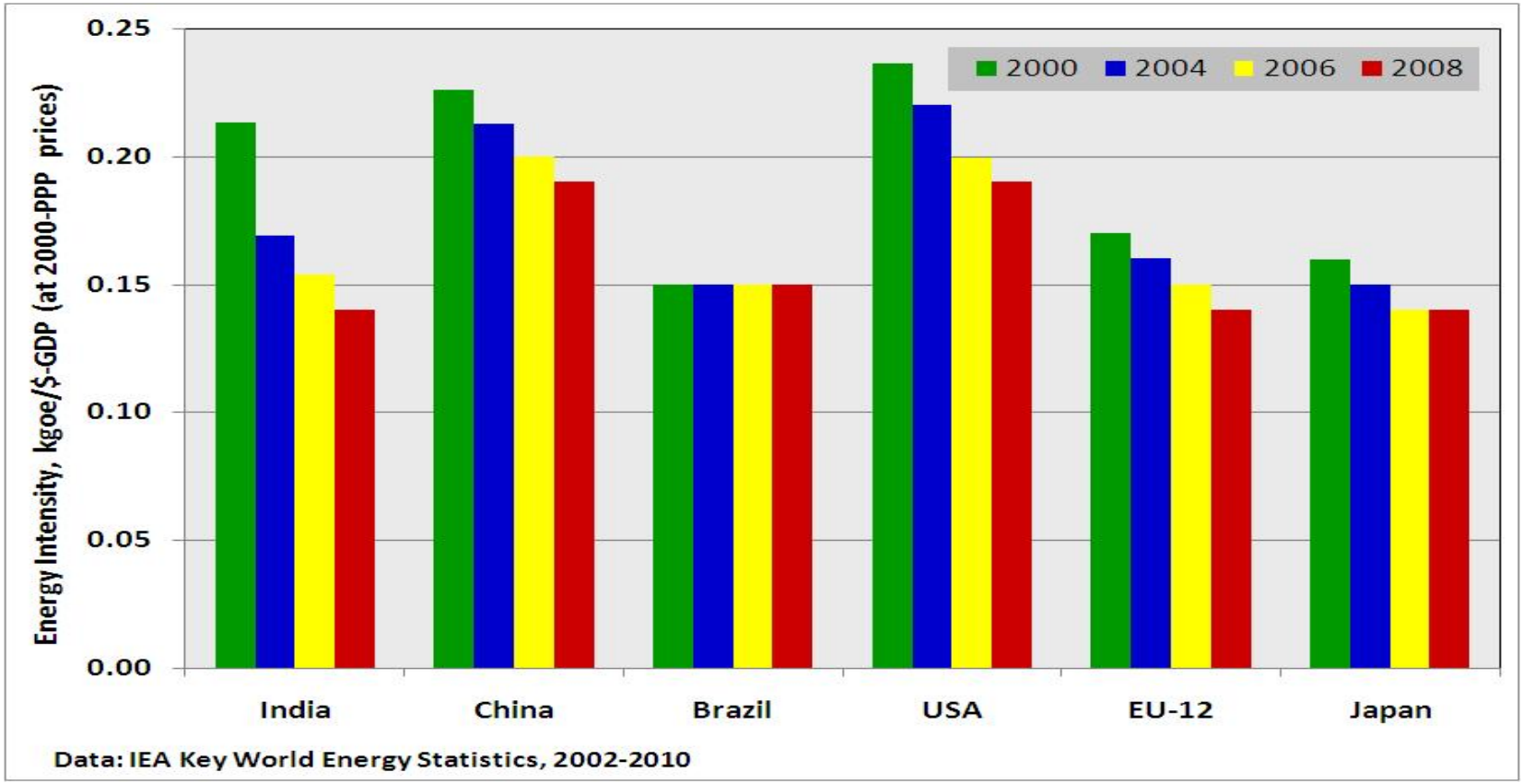
- India is a responsible nation and is committed to growth with environmental responsibility.
- India has delivered a GDP growth rate of 8% with only 3.7% growth in its total primary energy consumption.
- India has achieved energy-GDP decoupling at much earlier stage of its development cycle.
  - GDP growth rate has been higher than projected even though power capacity addition has been lower (only 50%) than planned
  - Industrial growth and profitability has been high even though oil prices have been fluctuating.

Trend in Energy Intensity



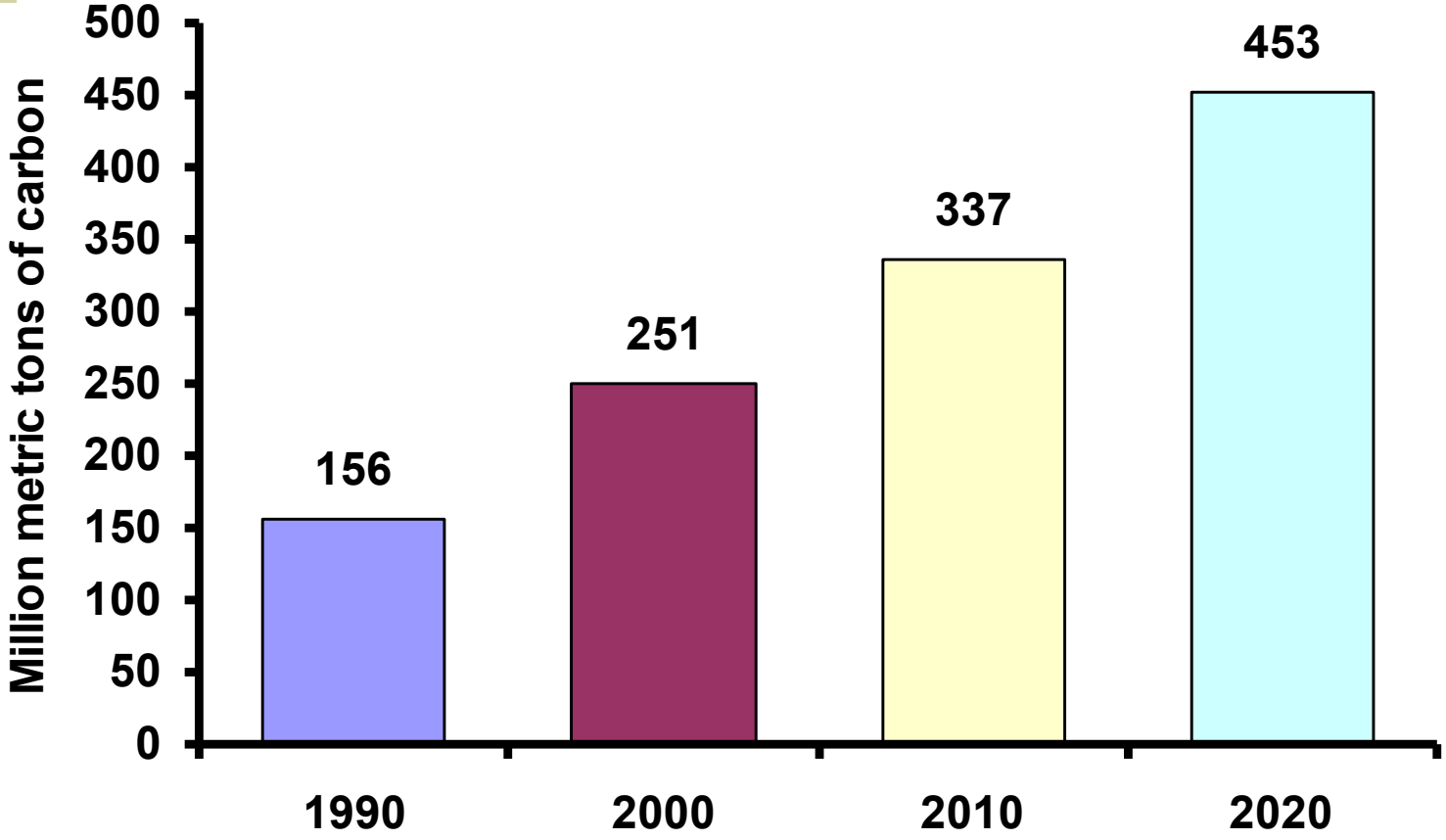
Source: Sahu and Narayanan (2012)

Energy Intensity: A Comparison



Source: Sahu and Narayanan (2013)

India's Carbon Emissions



Source: EIA International Energy Outlook 2003 (base case)

Review and Methods

- Murthi and Parikh (1997) investigates the linkages between economic growth, energy consumption and carbon dioxide (CO2) emissions in India by analyzing the structure of production and consumption in the Indian economy. According to their study, CO2 emissions are projected to increase from 0.18 tonnes of carbon (tC) per capita in 1990 to about 0.62 tC per capita in 2020 under the reference scenario which corresponds to a GDP growth rate of 5.5 percent per annum.
- Reddy and Ray (2010) argue that much of the reduction in energy intensity in Indian manufacturing has been due to "structural effect rather than actual improvement in energy efficiency.
- Goldar (2013) has used a different database and points to the extensive variation across industry groups as also states in terms of energy intensity reduction achieved. He also suggests new investments and scale economies have made a substantive difference in such efforts.

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- Barrows and Olliviery (2014) investigates the impact of exporting on the CO2 emission intensity of manufacturing firms in India. They found that that prices systematically bias estimates when emission intensity is measured in value; that firms adjust emission intensity in quantity through changing output shares across products, but that firms do not lower emission intensity within products over time (technology).
  - The results imply that the productivity benefits from market integration alone are not enough to induce clean technology adoption.
- Methodology
  - Index Decomposition: General Parametric Divisia Index
  - Computation of CO2 Emission Coefficient: IPCC Referral Approach
  - Econometric Analysis: Panel Econometrics such as Fixed and Random Effects
  - Estimation of Technical Efficiency: Stochastic Frontier Approach (Four factors of production)

Decomposition of CO2 Emission

Decomposition of CO2 emission intensity

Year	$\overset{*}{AC}$	$\overset{str}{AC}$	$\overset{int}{AC}$	$\overset{res}{AC}$
1991	0.97	0.99	0.99	1.00
1992	0.74	1.44	0.73	0.71
1993	1.35	0.72	1.41	1.32
1994	1.03	0.94	1.04	1.04
1995	0.89	1.09	0.90	0.91
1996	0.94	1.03	0.94	0.96
1997	1.03	0.93	1.05	1.05
1998	1.04	0.94	1.04	1.06
1999	0.93	1.00	0.98	0.95
2000	0.97	1.02	0.96	0.99
2001	0.95	1.01	0.96	0.98
2002	0.93	1.04	0.94	0.95
2003	0.99	0.99	0.98	1.01
2004	0.99	0.99	0.98	1.02
2005	0.84	1.17	0.84	0.87
2006	0.96	1.01	0.97	0.99
2007	0.91	1.08	0.91	0.93

Percent changes in emission intensity due to structural [sectoral] change

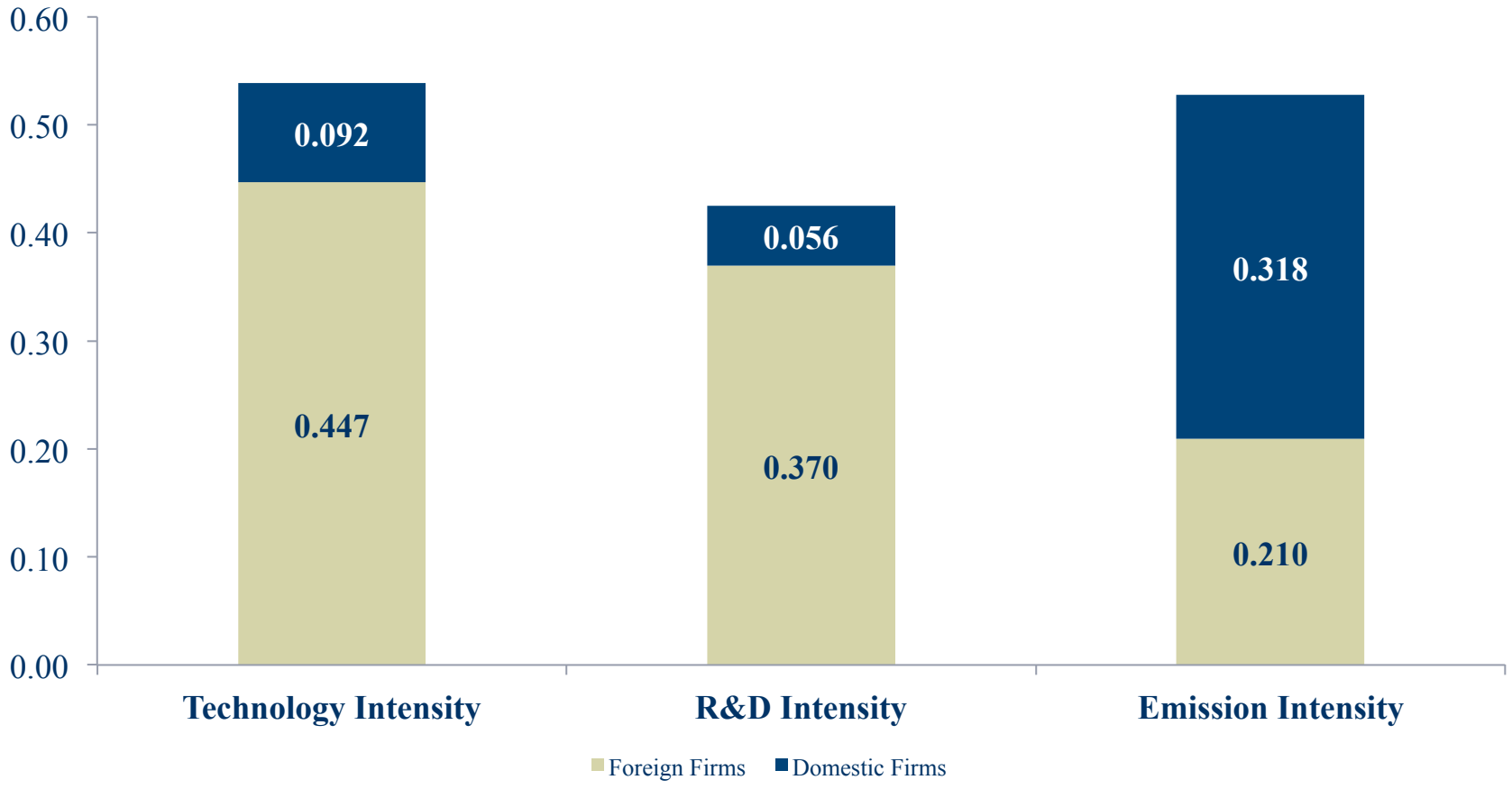
Year	% change in $\overset{*}{AC}$	% Change in $\overset{str}{AC}$	% Change in $\overset{int}{AC}$
1991-1992	25.97	-44.11	27.21
1992-1993	-35.12	27.86	-41.19
1993-1994	-2.59	5.96	-4.39
1994-1995	11.06	-9.08	10.45
1995-1996	6.00	-3.49	5.66
1996-1997	-3.01	6.88	-5.04
1997-1998	-4.11	5.79	-3.65
1998-1999	7.02	-0.10	1.67
1999-2000	3.12	-1.90	4.16
2000-2001	4.52	-1.42	3.73
2001-2002	6.94	-4.08	6.20
2002-2003	1.20	0.69	1.59
2003-2004	0.78	0.58	1.73
2004-2005	15.72	-16.69	16.35
2005-2006	3.75	-1.07	3.34
2006-2007	9.00	-7.83	9.40

Discussion

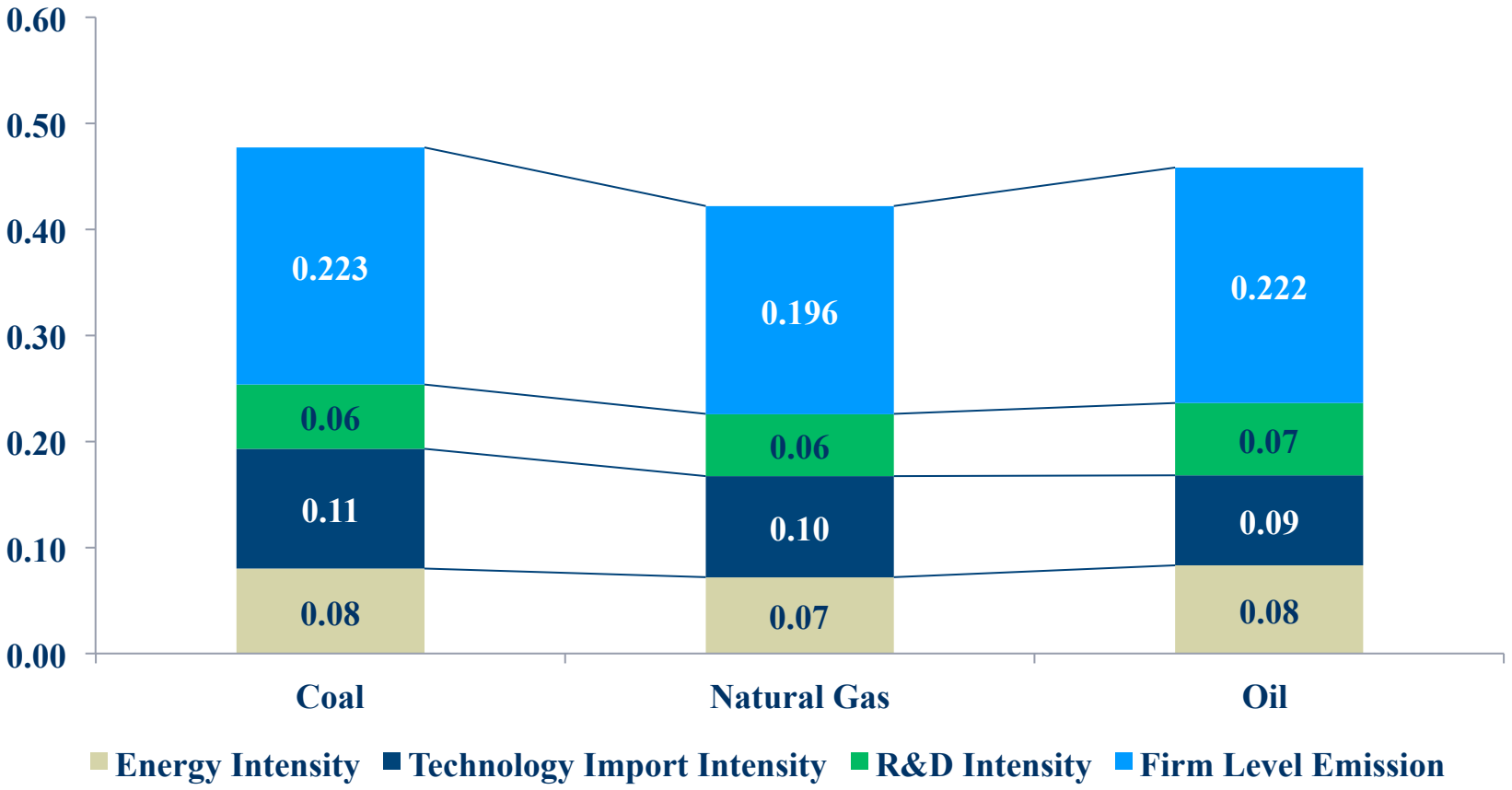
- In case of Indian economy empirical estimates based on a decomposition analysis found that the structural changes in the economy are more important to reduce emission.
- However, the output changes are surely increasing the CO_2 emission largely due to use of fossil fuel.
- Hence, improving energy efficiency, reforms of inefficient energy pricing, imposition of carbon emission taxes, promoting investment in renewable energy and creating public environmental awareness are some of the mitigation strategies suggested for the Indian economy.

Determinants of CO2 Emission

CO2 Emission, technology and R&D intensity of domestic and foreign firms



CO2 emission, energy, technology and R&D intensity between three fuel sources



Comparison of energy intensity and CO2 emission intensity across industries

NIC	Industry Type	Energy Intensity	CO2 Emission Intensity
18	Printing and reproduction	0.116	4.195
11	Beverages	14.381	6.443
10	Food	19.059	1.586
16	Wood products	29.519	21.002
90	Computer and electronic	32.557	6.754
12	Tobacco	44.398	8.051
15	Leather	46.320	33.301
60	Manufacture of basic metals	48.742	7.490
22	Rubber and plastics	56.561	40.630
20	Chemicals	60.122	4.399
50	Non-metallic mineral products	61.970	10.320
40	Pharmaceuticals, medicinal chemical	69.943	14.709
80	Fabricated metal products	86.847	9.532
14	Wearing apparel	109.536	8.174
13	Textiles	159.866	28.508
17	Paper	165.525	22.240
30	Coke and refined petroleum	252.124	55.362

Determinants of CO2 emission

Independent Variables	Coefficient	Standard Error	t value
Capital Intensity	-0.003	0.001	-2.200**
Labour Intensity	-0.005	0.003	-2.520***
Energy Intensity	1.293	0.164	4.870***
Size of the firm	0.043	0.154	2.280***
Square of Size of the firm	-0.132	0.048	-2.730***
Age of the firm	0.013	0.004	3.280***
Square of age of the firm	0.004	0.003	-2.010***
Technology Import Intensity	-0.539	0.274	-1.970**
R&D Intensity	-0.016	0.104	-2.160**
MNE	-0.042	0.168	-0.250
Constant	-1.305	0.141	-9.290
R^2 (overall)	0.289		
F(7,621)	20.65***		
Number of observations	2275		

Discussion

- The results indicate that there are significant differences in firm-level emission intensity and they, in turn, are systematically related to identifiable firm specific characteristics.
- This study found size, age, energy intensity and technology intensity as the major determinants of CO2 emission intensity of Indian manufacturing firms.
- In addition capital and labour intensity of the firms are also related to the firms' emission intensity.

Environmental Participation and Technical Efficiency

Time varying technical efficiency for ISO certified and Non-ISO certified firms

Year	Non-ISO			ISO		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
2007	0.781	0.749	0.813	0.832	0.566	0.925
2008	0.836	0.823	0.849	0.834	0.504	0.944
2009	0.830	0.813	0.846	0.823	0.603	0.918
2010	0.834	0.830	0.838	0.826	0.631	0.924
2011	0.787	0.756	0.818	0.823	0.670	0.921
2012	0.757	0.731	0.782	0.826	0.599	0.908

Determinants of technical efficiency

Independent variables	Coefficient	t
Share of debt capital	-0.002	-2.846***
Export intensity	0.017	1.871**
R&D intensity	0.134	1.917***
Profit margin	0.002	1.237
Firm size	0.155	5.660***
Firm size^2	-0.026	-3.340***
Firm age	-0.004	-2.300***
MNE dummy	-0.006	-2.369***
ISO certification dummy	0.023	2.667***
Interaction between ISO and firm doing R&D	0.011	1.989**
Constant	0.895	1.139
R^2 overall	0.259	
Number of observations	271	
Firm and year effect	Yes	

Discussion

- We conclude from the study that there are inter-firm differences in technical efficiency and they are systematically different based on firm age, firm size, debt capital, MNE affiliation, and ISO certification.
- Specifically, meeting the requirements of ISO certification has helped firms to achieve higher technical efficiency. Therefore, ISO certification has become an important factor in making the firms improve their technical efficiency.
- In addition, the result of this study also confirms that firms that are ISO certified and doing R&D are better off in technical efficiency when compared to others.
- Hence, ISO certification, especially because of the conditionaliities attached to maintain the standards, appears to positively enhance the efficiency of firms in the manufacturing sector of India which is also confirmed by the propensity score matching results.

Technical Efficiency and Participation in CDM

Average of indicators related to CDM from 2007 to 2012

Year/ Observations	Vintage Time	Total Vintage Quantity	Verified Carbon Units	Verified Carbon Units Differences	Income from Carbon Credits
2007 (N=64)	17.187 (34.146)	1959829 (8485309)	261939.6 (828217.5)	1697889 (8076972)	1.427 (7.424)
2008 (N=64)	14.925 (30.013)	1864675 (8471366)	229239.8 (791671.7)	1635436 (8074365)	5.738 (18.466)
2009 (N=64)	14.856 (30.043)	1860491 (8472220)	227805.2 (791958.7)	1632686 (8074900)	9.884 (52.628)
2010 (N=62)	15.004 (30.530)	1934101 (8601055)	233783.5 (804106.9)	1700318 (8198565)	9.308 (49.691)
2011 (N=48)	17.544 (34.240)	2460031 (9734324)	284400.5 (909234.6)	2175631 (9285082)	9.735 (57.468)
2012 (N=42)	18.814 (36.291)	2791692 (10400000)	317984.0 (968634.1)	2473708 (9904310)	10.960 (61.421)
Full Sample (N=344)	16.187 (32.115)	2090368 (8871998)	254407.4 (835277.4)	1835961 (8456618)	7.546 (43.993)

Determinants of Export Intensity in Indian Manufacturing Industries

Independent Variables	Linear regression, correlated panels corrected standard errors (PCSEs)	
	Coefficient	z value
Firm Size	6.614	8.190***
Age of the Firm	-4.489	-6.830***
Profitability	1.036	2.160**
R&D Intensity	0.346	2.087**
Embodied Technology Intensity	4.052	4.660***
Disembodied Technology Intensity	-0.371	-2.030***
MNE Affiliation [dummy]	6.268	2.070**
Medium High Tech [dummy]	1.127	1.016
High Tech [dummy]	-0.572	-2.509***
Log VCU	0.836	2.089**
CDM in Energy Technologies[dummy]	0.654	2.819***
Constant	10.966	8.910***
Industries Dummy	Yes	
	Estimated covariances: 966	

Discussion

- The results of this study suggest the following conclusions.
- Bigger and smaller firms in size are exporting more
- Profitable firms are the highest exporters.
- Higher Research and Development intensity leads firm to become export more.
- Multinational affiliation helps firms in achieving higher export propensity.
- VCU is positively related to export propensity hence, firms those are having higher VCU are exporting more.
- Firms those are improvising technology directly related to energy front are exporting higher compared to others.

Policy Implications

Regulatory Framework

- **Energy Conservation Act, 2001**
  - Created Bureau of Energy Efficiency
  - Appliance standards and labeling
  - Energy consumption norms, and energy-use reporting requirements for energy-intensive industrial units
  - Energy Conservation Building Code for commercial buildings
  - Certified Energy Managers and auditors
- **National Action Plan for Climate Change, 2008**
  - National Mission on Enhanced Energy Efficiency provides mandate for market-based mechanisms to promote energy efficiency
  - National Mission on Sustainable Habitat seeks to incorporate energy-efficiency requirements in building byelaws

Technological Change

- **Installation of energy-efficient infrastructure, equipment and appliances is essential for**
  - Meeting energy demand
  - Managing energy security, and
  - Meeting climate goals
- **Technological transitions – both deployment and development - are important in**
  - Power generation
  - Buildings, especially commercial buildings
  - Equipment and appliances
  - Industry
  - Mobility

Research and Development

- Enhance science and engineering capabilities and create long-term opportunities for research and development relevant from climate change stand point
- Collaborative R&D on promising projects/concept should be undertaken on public-private partnership mode
  - IPR should be shared appropriately among various countries
- R&D on advanced industrial technologies, alternative energy technologies would be of prime importance
- A dedicated fund required to finance climate-friendly technologies

Strategies

- Moderate Energy Demand by Increasing Energy Efficiency
- Improve Vehicle Fuel Efficiency
- Implement Building Energy Codes
- Enlarge the Scope of Appliance and Equipment Standards
- Increase Industrial Sector Energy Efficiency
- Accelerate Deployment of Renewable Energy Technologies
- Further exploitation of renewable energy
- Switch Towards Cleaner Conventional Energy Technologies
- Strengthen and rely upon free and open market, wherever possible, to produce efficient solutions

Mitigation

Industry

- Wide-scale upgrading and innovation
- Replacement and deployment of best available technologies
- Information programmes to promote energy efficiency
- Efficiency in material use, recycling and waste reduction
- Collaborative approaches across firms and sectors

Transport

- Technical and behavioral mitigation measures (energy efficiency and vehicle performance improvements)
- Infrastructure and urban redevelopment investments (more compact urban form that supports cycling and walking, high-speed rail systems)

Buildings

- Adoption of very low building codes for new buildings
- Retrofits for existing buildings
- Lifestyle, culture and behavior influence energy consumption in buildings

Collaborations

Government

- Collection/collation of targeted information
- Develop understanding of climate change impacts on India and response options
- Focus on Adaptation
- Supporting and Leveraging private actions
- Create Climate-friendly technologies fund
- Policy and regulation

Industry

- Adoption of Best Practices
- Focus on Small-Scale Industries
- Leverage Climate-friendly technologies fund
- Partner R&D efforts to develop low/no carbon technologies
- Measure carbon footprint, and develop reporting systems

Civil Society

- Promote awareness about impacts of climate change
- Campaign to effect behavioral change
- Work with Government and other role players as partners in sustainable development

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Thank You