ENERGY CONSUMPTION IN THE INDIAN MANUFACTURING SECTOR DURING 2000-01 TO 2021-22: INDEX DECOMPOSITION ANALYSIS IN CONTEXT OF PERFORM ACHIEVE AND TRADE

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1. Overview

Achieving net-zero emissions is a global priority, with India as a key player. India's industrial and manufacturing sectors are critical in achieving this aim, as they are major contributors to energy consumption and CO_2 emissions. The industrial sector is rapidly growing, recording a growth rate of 6.7% in 2022–23, highlighting its increasing significance in the country's energy and emissions landscape. As a developing nation, India faces the challenge of balancing economic growth with sustainable energy use, as economic expansion is essential to address development priorities. In this context, energy efficiency plays a vital role in achieving decoupling by improving energy utilization without compromising output growth, enabling the country to sustain production levels while reducing energy intensity (EI). With the twin imperatives of enhancing industrial productivity and meeting climate commitments, there is a need to understand and optimize energy consumption in the industrial sector. A key initiative driving energy efficiency in India's industrial sector is the Perform, Achieve, and Trade (PAT) scheme. Launched by the Bureau of Energy Efficiency in 2012 under the National Mission on Enhanced Energy Efficiency, PAT uses a cap-and-trade mechanism to set sector-specific EI targets for its Designated Consumers, fostering optimal use of energy. Given this backdrop, our study provides a comprehensive analysis of EI trends in the Indian aggregate manufacturing sector and the seven energy intensive manufacturing sectors under PAT, viz. cement, steel, textiles, pulp and paper, chlor-alkali, aluminium, fertilizers (henceforth collectively referred as 'PAT industries') from 2000-01 to 2021-22. We consider broader industry categories for chlor-alkali, fertiliser and aluminium that are basic chemicals, fertiliser & pesticides and basic precious and other non-ferrous metals, respectively. Next, we analyse the extent to which energy efficiency has contributed to decoupling of industrial activity growth from growth in energy use in the industry for the same period as well as two sub-periods: pre-PAT (2000-01 – 2010-11) and post-PAT (2011-12- 2021-22).

2. Methods

The framework of analysis is based on the calculation of EI for all the industries as the ratio of yearly energy input used and output produced, both measured in monetary units at constant prices. After calculating the trend of EI, the study deploys Index Decomposition Analysis (IDA) to decompose the change in total energy demand or Total Effect (TE) into Activity Effect (AE) and (energy) Intensity Effect (IE) for the PAT industries. For the aggregate manufacturing sector's decomposition, there is an additional factor, the Structural Effect (SE), other than AE and IE since we define the sector's structure as 'energy intensive' (the PAT industries) and 'less energy intensive' sectors. We also apply the CUSUM test to the Year-on-Year IE data to identify potential structural breaks or shifts in energy efficiency trends over time. Annual Survey of Industries published by Central Statistical Organization under the Ministry of Statistics and Programme Implementation, Government of India and the Wholesale Price Indices published by Office of the Economic Adviser, Department for the Promotion of Industry and Internal Trade (DPIIT) are the main data sources.

3. Results

3.1. Results of EI trend and IDA in the aggregate manufacturing:

The aggregate manufacturing sector exhibits a downward trend in EI with a reduction from 0.09 in 2000-01 to 0.04 in 2021-22. However, during the pre-PAT period, EI decreased considerably from 0.09 to 0.05. In contrast, during the post-PAT period, it exhibited a relatively static trend, fluctuating narrowly between 0.04 and 0.06. For the pre-PAT period, AE is 246% which implies that had output growth been the only driver causing a change in energy demand, with no change in energy intensity and structure, then energy demand would have been 246% instead of 100%. However, because of gains in energy efficiency by 129% and structural change towards less energy intensive sectors by 17%, 146% of the increased energy demand has been neutralised. Similarly, for the post-PAT period, 73% of increase in energy demand due to AE has been neutralised by SE and IE by -9% and -64% respectively.

3.2. Results of EI and Index Decomposition Analysis for the PAT industries:

The EI trends of the PAT industries also show a downward trend during the overall study period. The pulp & paper sector exhibited a decline from 0.20 to 0.08, followed by fertiliser & pesticides, which reduced from 0.20 to 0.09, and the basic chemicals, which fell from 0.20 to 0.10. Both the textiles and basic precious metals sectors recorded almost similar reductions, with textiles dropping from 0.13 to 0.08 and basic precious and non-ferrous metals from

0.14 to 0.09. Conversely, the iron and steel sector showed only a slight decline from 0.10 to 0.08. The IDA results for the PAT industries have been discussed under the following industry-specific sub-sections:

3.2.1. **Cement**: During the pre-PAT period, AE contributed to a 141% increase in energy use, while IE offset this by -41%. During post-PAT period, IE neutralized 46% of the energy use driven by AE. The overall magnitude and trends of both driving factors have remained relatively consistent across both the sub-periods. The decoupling of IE from AE is evident from 2003–04 while the structural break is observed around 2011. Therefore, even though decoupling trend could be observed from 2003-04 onwards, the role of IE in offsetting growth in energy demand due to AE was more prominent post 2011.

3.2.2. **Basic Chemicals**: During the pre-PAT period, AE increases energy use to 481%, IE offsets -381% of increase in energy use. During the post-PAT period, out of 158% growth in AE, -58% of growth in activity was neutralised by IE. From 2002-03 onwards, IE diverges from AE, indicating a decoupling trend. The structural break in the sector is observed around 2008 implying a stronger role of IE in delinking from AE was attained post 2008.

3.2.3. **Fertiliser & Pesticides**: For the pre-PAT period, AE was 417% and IE was -517%. This indicates a significant contribution of IE, which could offset the growth in AE by over 100%, effectively neutralizing the impact of AE and achieving a net reduction in energy demand. However, in the post-PAT period, both AE and IE experienced declines, recorded at 225% and -125%, respectively with IE neutralizing 125% of the growth in output driven by AE. The decoupling trend between AE and IE, emerging from 2003-04 and becoming more pronounced from 2006–07 onwards that somewhat coincides with the structural break in IE that is around 2007.

3.2.4. **Pulp & Paper**: For the pre-PAT period, AE contributed 900% to the increase in energy demand, while IE offsets 800% of this growth. During the post-PAT period, AE contributed to 229% of increase in energy demand, of which 199% could be neutralised by IE. IE begins to diverge from AE in 2002-03, with further decoupling observed from 2007-08 onwards. The structural break in IE is also evident around 2009.

3.2.5. **Iron & Steel**: During the pre-PAT period, 21% of the increase in energy demand due to activity growth was offset by IE. In the subsequent sub-period, activity grew by 110%, with -10% of this growth neutralized by IE. While IE exhibits a downward trend, its contribution to decoupling energy demand from activity growth remains limited, reflecting the sector's challenges in achieving significant energy efficiency improvements. Though the structural break in IE can be observed around the year 2008, IE has not been very effective in terms of achieving absolute decoupling.

3.2.6. **Textiles**: In the pre-PAT period, AE contributed 304% to energy demand growth, while IE could offset AE by -204%. In the post-PAT period, AE was 198%, and IE neutralised it by -98%. The IE trend delinks from AE in 2004-05, showing strong decoupling until 2010–11. However, post 2010-11, the IE trend flattens and remains closer to the horizontal axis, indicating reduced decoupling in the later years. The structural break appears around 2008.

3.2.7. **Basic precious & other non-ferrous metals**: In the pre-PAT period, AE was 171%, while IE could offset -71% of growth in activity. In the post-PAT period, AE's contribution to energy demand was 128%, with IE neutralizing -28% of the growth. Decoupling of IE from AE is noticeable from 2002–03 onwards. However, this decoupling remains weak, with IE fluctuating around the horizontal axis and showing limited divergence from AE. Structural break in IE can be observed from 2010 onwards.

3.3. Trend in value of output of aggregate manufacturing and PAT industries

The aggregate manufacturing sector, iron & steel and basic precious & other non-ferrous metals experienced a decline in output growth during the study period. Only the cement and textile sectors demonstrated somewhat constant output growth. Meanwhile, the basic chemicals, fertiliser & pesticides and pulp & paper sectors experienced slight increase in output growth.

4. Conclusions

While improvements in EI can be observed over the study period, the energy efficiency gains have been slower. The decomposition results reveal that a portion of energy demand growth in both PAT industries and aggregate manufacturing were offset by energy efficiency gains. However, the extent of this neutralization in the post-PAT period has been relatively modest in case of most of the industries. Thus, while EI improvements contributed to mitigating energy demand, their impact was neither strong nor significant enough to drive substantial reductions. The structural breaks observed in the IE across all the sectors occurred before 2011, predating the introduction of the PAT scheme, suggesting the influence of other factors and policies as well. These factors collectively highlight the proactive nature of industrial sectors in reducing energy intensity even before targeted programs like PAT were implemented. The implementation of a policy like PAT aimed to ensure that India, as a developing nation, could achieve energy efficiency without compromising output growth. However, in the pursuit of meeting the required EI targets, a noticeable decline in output is observed across manufacturing sectors. This prompts reflection on the outcomes of such a policy, which may have subtly resulted in absolute reductions in output, resembling trends seen in developed nations but again, contrary to India's developmental objectives.