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# Study of efficiency and productivity growth in opencast and underground coal mining in India: a DEA analysis

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## Abstract

This paper attempts to study efficiency and productivity of coal mining in the Indian coal sector using detailed input and output data for underground and opencast coal mining for the period between 1985 and 1997. The non-parametric approach of data envelopment analysis (DEA) is adopted for performance analysis of different coal mining regions. Total factor productivity growth was analysed using the Malmquist index by decomposing productivity change into efficiency and technical change. Results of the analysis do not conform to the prevailing notion of opencast (OC) mining having shown more productivity growth than underground mining in India. An increasing percentage of OC mining regions showed a decline in efficiency over the period of analysis. Approximately 58%, 59% and 67% of the mining regions showed decline in productivity between 1985 and 1990, 1990 and 1995 and 1995 and 1997, respectively. Technical progress seems to have been the major driving factor behind productivity growth in opencast mining, while efficiency growth has been the most important factor in growth of underground mine productivity. Underground mines seem to have adopted a more efficient practice of operation to compensate for the lag in technical change. On the other hand, operational efficiency of opencast mines seems to have been overlooked in the process of increasing production through technological improvement in OC mining. © 2002 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

Productivity measures of Indian coal mining activity in underground and open-cast mining have shown a steady increase (especially from the 1980s onwards), when measured in output per manshift (OMS). However, this cannot be fully attributed to improvement in actual productivity of any of the inputs of production. In response to the rising targets of production in the coal sector during the 1980s, the policy decisions emphasised primarily on capital accumulation as the prime driving force to growth in production (BICP, 1988). Massive investments have been made towards mechanisation of both opencast (OC) and underground (UG) mining operations and import of foreign technology (Chari, 1988). Hence, productivity analysis needs to be done on usage of all inputs, both labour and machineries. This study attempts performance analyses of mining activity by both opencast and underground processes in the various coal producing districts across the country. Performance of the different regions depends on the state of technology and economic efficiency of the regions. The technology is depicted by the best practice frontier of production and economic inefficiency is related to misallocation of resources relative to the frontier (Lovell, 1993). Two kinds of analyses would be of interest. Firstly to study the levels of economic efficiency and productivity and second to analyse growth in factor productivity.

Farrell (1957) proposed that productive efficiency has two components. The purely technical or physical component refers to the ability to avoid waste through output augmentation with a given set of inputs and/or input conservation for a given amount of output. Koopmans (1951) defines technical efficiency as a feasible input output vector where it is technologically impossible to increase any output (or reduce any input) without simultaneously reducing another output (or increasing another input). The other is the allocative efficiency which refers to the ability to combine inputs and outputs in optimal proportions at their prevailing prices, under a behavioural assumption for the decision making units (DMUs), for example, cost minimisation, revenue maximisation, etc.

This study is primarily concerned with technical efficiency without assuming any behavioural goal dictating the input and output decisions of the mining activity. The coal sector being a public sector unit has administered prices of output and also input accumulation is not based on profit maximisation considerations that usually guide private sector units. Hence, operational efficiency in usage of various inputs in coal mining is studied. The objective is to derive performance measures for the different mining regions and also to isolate the effects of efficiency and productivity growth from the production environment and identify the sources of efficiency and productivity differentials. Identification of the sources of productivity is essential in adopting a right approach to policy decisions to improve performance. Hence, a measurement which quantifies the differentials that are predicted qualitatively by theory is required (Lovell, 1993).

Input based indices of technical efficiency were developed by Farrell (1957) who measured the maximum equiproportionate reduction in all inputs consistent with equivalent production of observed output. A non-parametric approach to frontier

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