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Ownership of Firms and Their Implication for Productivity: An Empirical Investigation in to Indian Mining Industry

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OWNERSHIP OF FIRMS AND THEIR IMPLICATION FOR PRODUCTIVITY: AN EMPIRICAL INVESTIGATION IN TO INDIAN MINING INDUSTRY

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Abstract

This paper examines the difference in productivity existing between the public and private sector of the mining industry in India. The literature on the effect of firm ownership on productive efficiency stands highly divided hence in this context our study adds to the literature by attempting to study the effect of firm ownership on total factor productivity (TFP) in the four sectors of Indian mining industry from 2000 to 2016. Here, we have sought to compare the productivity difference between the public and private mining firms in the four sectors namely- metallic, non-metallic, coal and petroleum. Our paper uses the Levinson and Petrin (LP) method for estimating the TFP of each firm. The results indicate the superiority of private firms in three sectors – metallic, non-metallic, and coal, whereas the petroleum sector reports quite the opposite result. Highest productivity difference was recorded in the non-metallic sector, where in private firms were two times more productive than that of the public firms. Metallic and coal sector followed suit where private firms registered almost more than one times more productivity than the public firms. The above results suggests that although the liberalization process that started around 1990 entailed opening up of the mining industry to private sector participation, with an aim of building healthy competition to improve the productivity of public sector, this very aim has not been materialized as there exists still a large gap between the public and private firms.

Key Words: Firm Ownership, TFP. Productivity difference, Levinson and Petrin method, Mining Industry

Introduction

The basic objective of this paper is to empirically examine the productivity implications of various forms of mineral ownership and ownership of extractive firms. Mineral resources being non-renewable, scarcely endowed and restricted to remote geographical locations, the primary concern here is that their ownership conferment decides to a large extent the welfare of the nation (**Das, 2013**). Further the way the minerals are extracted also assumes importance from the productive efficiency point of view. Thus, a very pertinent question in this context is does different ownership of mining firms have different productivity implications? In other words who extracts minerals more efficiently, private or public firms? The answer to this question has always been subjected to debate. While the relationship between ownership and productivity link has been widely researched, no consensus has been reached regarding the superiority of one over the other. Insights from theoretical literature based on public choice and property rights theory show superiority of private firms over public firms. But several empirical studies produce inconclusive results, some of them showing no significant difference between private and public firms. The inconclusive decision regarding the superiority of public and private firms has made it an empirical issue. Hence in this respect, we intend to gather empirical evidence in the context of Indian mining industry. Towards this end, this study makes an effort to empirically answer the above raised question who is more productive. Private or public sector mining firms?

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This study, with a view to answer the above question estimates the total factor productivity of the mining industry as well as its component sectors such as- metallic, non-metallic, coal and petroleum. Thereafter the paper estimates and compares the TFP[1] levels and growth rates of public and private mining firms in the four sub-sectors of the Indian mining industry. This paper has also attempted to examine the influence of other factors on the TFP levels of mining firms at sub-sectoral level as well as for the whole mining industry. The rationale behind using the TFP is that it reflects the full productivity growth unlike partial productivity which takes in to consideration only a single factor input. The results of this study reveals that private sector firms are more productive than that of the public sector in all the three sub-sectors of mining industry in India namely-coal, metallic and non-metallic industry and public sector is only productive in case of petroleum. The reason for this divergence result in case of petroleum sector could be due to limited competition in this category. This paper clearly brings out the fact that even a decade after the complete openness of Indian Mining industry, the very goal of building healthy competition between the public and private sector mining firms so as to improve the productivity of the industry as a whole has not been materialized as there is glaring productivity difference between the two types of firms.

The rest of the paper is organized as follows. Section 2 presents the theoretical and empirical literature on the effect of firm ownership on productivity. Section 3 discusses the methodology followed by the section 4 that throws light on data sources and construction of variables. Finally, the section 5 discusses the results and analysis and section 6 concludes the paper.

Review of literature

Theoretical literature

The subject of firm ownership and productivity or extraction efficiency is always controversial. Who extracts minerals more productively is always a matter of concern. Several theoretical and empirical literature discuss this extensively. However, the literature stands highly divided on this. While one group of literature argues for the superiority of private firms over the public firms (**Das, 2013; Wolf, 2009; Li and Xia, 2008; Faria *et al*, 2005; Stiglitz, 1988**), the other sections opines differently (**Martin and Parker, 1995; Caves and Christen, 1980**). In this section, we provide a summary of selected literature on the effect of firm ownership on productivity.

The differences in productivity can result from differences in firm ownership. The public choice theory and the property rights theory discuss this extensively. According to public choice theory, ownership difference results in productivity difference due to two kinds of problem – the agency problem and the incentives problem. Due to agency problem, which is otherwise referred to as principal-agent problem, the public sector firms perform inefficiently as compared to private firms. In case of public sector enterprises there is a difference in ownership (Principals) and management (agents). As the agents have more and better information about the resources than the owners, they

[1] Total factor productivity is measured as the ratio of output to weighted sum of all inputs. Since partial productivity uses only a single factor, it does not necessarily provides the true picture of productivity. For example, labour productivity will improve if labour requirement per unit of output declines. But this reduction in labour requirement may be achieved through more use of capital. Hence partial productivity does not reflect the full productivity growth. However this issue can be resolved by using the total factor productivity measure. So in this paper, we have attempted to measure the TFP.

have the clear advantage of using these resources for their own benefits. In the absence of a proper monitoring by the owners, managers misuse their status for personal gain at the expense of the investor's interest (**Li and Xia, 2008**). This information asymmetry enables the managers to undertake wasteful projects in their self-interest.

In the same way, the public sector firms also perform inefficiently due to lack of two types of incentives- organizational and individual. There is no organizational incentives for the public sector firms to improve their productivity. Unlike private firms, the managers of public firms are seldom concerned about organizational improvement. They show least concern about the bankruptcy and competitiveness of their companies as they know that the losses of these firms would be taken care of through budgetary support giving the public firm managers least incentive to perform efficiently. Most of the time political interference in the functioning of public sector firms also results in inefficiency. Whereas on the individual front, fixed tenures and determined pay scale do not provide much incentive to increase the efficiency of managers of public sector firms. As the salaries of public sector firms are not linked to profit, they do not put in their best efforts to maximize the profits of public sector firms. Similarly fixed tenure do not provide them any incentives to work hard.

As per property-rights theory also, public firms are inefficient than private firms. Property rights theory proponent **Alchian (1965)** holds the view that property rights are more attenuated in a public firm than in a private firm. This is because ownership in case of public firms is diffused among all members of society, and no members has the right to sell his/her property. Given this aspect of public ownership, there is little incentive for owners to monitor the behaviour of managers. On the contrary, the ownership of private firms is concentrated among fewer individuals and each individual has the right to sell his/her property shares. This gives the owners the incentive to have a watch on the management to ensure better productivity.

Empirical Literature

The literature is abound with vast number of studies concerning the performance of public and private firms. Some studies have shown the superiority of private firms over the public firms (**Das, 2013; Wolf, 2009**; **Li and Xia, 2008**; **Victor, 2007; Faria *et al*, 2005; Dewenter and Mala-testa 2001; Al-Obaidan and Scully, 1991**), whereas other studies show either the superiority or neutral status of public firms over the private firms (**Martin and Parker, 1995; Issac *et al*, 1994**; **Boardman and Vining, 1989; Caves and Christensen, 1980;**). Das (2013) in his study found out that private mining firms are more productive than public firms in three subsectors such as metallic, non-metallic and coal, While for petroleum sector the public firms shows better productivity than the private firms. Wolf (2009) studied world's 50 largest oil and gas companies and found out that private firms are better than public firms in terms of output efficiency and profitability. Based on 90 firms observed in 2004 Victor (2007) used a single variate regression to explore the relative efficiency of National oil companies and private oil companies. Her results revealed that the private companies are one third better than the national companies in terms of converting reserves in to output and generation of revenue per unit of output. Li and Xia, (2008) in a study of Chinese State firms and Non-state firms establish that non-state firms are more efficient than the state firms. Studying the Brazillian private and public companies providing water and sewerage utilities Faria *et al* (2005) showed that the private companies are only marginally more efficient than the public ones. Dewenter and Mala-testa (2001) using the sample of Fortune 500 largest international companies for the year 1975, 1985 and 1995 and controlling for firm size, location, industry and business cycle effects, find private firms more profitable, less labour intensive and show lower financial leverage than state owned enterprises (SOEs). Al-Obaidan and Scully (1991) study efficiency differences between 44 international private and state-owned petroleum companies. Controlling for multi-nationality and operational integration, they find that state-owned enterprises are, on average, only 61–65% as technically efficient as private firms.

One of the studies that show superiority performance of public firms is that of **Caves and Christensen (1980).** In their study of Canadian railroads, they show that there is no significant inferior performance by the public ownership. According to him, public ownership is not inherently inefficient than private ownership, rather the inefficiency arises from the fact that public firms are not subject to healthy competition. **Boardman and Vining (1989)** point out that efficiency difference between public and private firms vary from sectors to sector. He further shows that public firms are more efficient in that sector where there is limited competition or regulations are imposed on private firms such as electricity and water. Private firms are more efficient in the delivery of services where the government sub contracts to the private sector. Greater efficiency of private sector is also observed in health related literature. Board man and Vining argues that the comparison between public and private firms would be in appropriate as most of the comparative studies are undertaken either for natural monopolies or regulated duopolies.

Issac *et al* (1994) views that a comparison between public and private firms would be inappropriate and may lead to inconclusive results depending on the age structure of the firm. Hence age can be a major determinant in deciding the difference in productivity and efficiency between public and private firms. Their study shows that in the long run, private firms show more productivity growth than the state owned enterprises.

From the above review of literature, it can be contended that studies on ownership and productive efficiency presents varied results for different sectors. Hence it would be wrong to spell out the superiority of one ownership over the other. Rather it remains an empirical issue which need further investigation. In this context, our study would be an addition to the existing literature of impact of ownership on productivity.

Mining Reforms in India

Once mining was a monopoly of government and as such it was under the complete control of public sector with minimal private sector participation. Private sector participation were only allowed in captive mine provisions. Lack of healthy competition in this sector resulted in the low growth rate of Indian Mining Industry. Realising this and with the upsurge in demand for mineral products, the government of India invited private sector investment in to this industry by opening up the industry in the year 1994. The testimony to this fact is the national Mineral policy (NMP), 1993 that initiated the process by inviting private investment for thirteen major minerals such as iron ore, manganese ore, chrome ore, sulphur, gold, diamond, copper, lead, zinc, molybdenum, tungsten, nickel, and platinum group of minerals exclusively reserved for the public sector. In order to attract large scale private investment in to the sector, consequently Mines and Minerals (Regulation and Development) (MMDR) Act 1957, was amended in 1994. Mineral Conservation and Development Rules 1958 (MCDR), Mineral Concession Rules 1960 (MCR) were soon after modified to incorporate the changes and simplify the procedures for attracting large private sector participation in to the industry. In the recent past, (During 2014-16), the Indian mining industry has witnessed major policy interventions to promote exploration and enhance private sector participation that has aided in sector's growth. Recently the MMDR act has been further amended in the year 2015 which has brought in a number of changes in the Prospecting License (PLs), Reconnaissance Permit (RP) and Mining Leases(ML) and delegated more powers from central government to State governments (DIPP, GOI, 2016) . With an aim of pumping in private sector investment in to the sector, this sector has been completely opened up to 100 % FDI since 2006.

Considering the increased participation of private sector in the mining industry, it is worth undertaking an empirical investigation to find out the productivity gap between public and private sector mining firms.

Methodology

For comparing the productivity between public and private mining firms, we first estimate the firm level total factor productivity (TFP) and then TFP of each sector by taking the weighted mean of TFP levels using the share of each firm in the specific sector as weights. We follow the same methodology as was used by **Das (2013)** in his study of comparing private and public firm's productivity in case of Indian mining industry.

Productivity is defined as the output per unit of representative units of resources (**Abramovitz, 1956)** and is measured as a ratio of output(s) to input(s). Total factor productivity (TFP), which is defined as the ratio of output to the combination of inputs, is being seen as a measure of technological change that has taken place in the industry. TFP growth is defined as a residual of growth of output minus growth of input(s) or 'the change in output levels controlling for changes in input levels, or alternatively as the change in unit cost controlling for changes in input price' (**Nishimizu and Page, Jr, 1986. pp. 241**).

TFP can be estimated by broadly two methods such as growth accounting method and econometric or production function method. We use the latter approach for our estimation purpose. For our present study, we estimate TFP as a residual in the production function, which can be written as:

$$\ln P_{it} = \ln q_{it} - \ln x_{it}\beta$$

Where, P_{it} is firm specific productivity, $q_{it} = p_{it} x_{it}\beta$, x_{it} is vector of inputs and β is the vector of input coefficients. Therefore, first we need to estimate the input coefficients from a production function which is expressed in Cobb-Douglas form. For *i*th firm in period *t* it can be defined as follows:

$$q_{it} = a_0 + a_c c_{it} + a_l l_{it} + a_e e_{it} + u_{it} \qquad \text{.................... (1)}$$

Productivity is estimated as

$$P_{it} = q_{it} - a_c c_{it} - a_l l_{it} - a_e e_{it}$$

Where q_{it} is the log of gross output in the year t , c_{it} is the log of capital stock, l_{it} is the log of wage bill, e_{it} is the log of energy expenses (comprises of power and fuel) and u_{it} is an error term. P_{it} is the log value of firm specific productivity. We then take the antilog of *Pit* in order to arrive at the estimated productivity. Therefore we are first required to estimate the input coefficients from the production function which is defined in Cobb Douglas form.

The advantages of production function approach (or econometric method) in estimating TFP is it is free from the restrictive assumptions like competitive market, constant return to scale, uniform price and technology (as taken in growth accounting method). On the other hand it is inflicted by other problems such as simultaneity or endogeneity. This can be explained as follows. In equation (1) the error term can be decomposed into productivity component i.e. $\boldsymbol{\omega}_{it}$ and other errors (such as estimation, errors in data etc.) i.e. *it.* Thus, $u_{it} = \boldsymbol{\omega}_{it} +$ it. . Unbiased estimation of equation (1) with OLS method required the stochastic error terms and exogenous inputs. However, very often this condition is not met as the error term $\boldsymbol{\omega}_{it}$ and inputs (mostly variable) are correlated. **Marschack and Andrews (1944)** point out that since inputs are chosen by firm and not known to the econometrician there is endogeneity in the estimation equation, which would make the OLS estimates inconsistent. Thus, the inputs chosen by the firm, subject to some optimality condition, would be affected by the productivity shock. This would imply that the simple OLS estimates of the production function would be biased and inconsistent because the productivity could be both contemporaneously and serially correlated with inputs. Contemporaneous correlation occurs if the firm hires more workers based on its current productivity in anticipation of future profitability. In the case of a single-input production process, serial correlation between productivity and hiring decisions will lead to an upward bias in the coefficient and in a multi-input setting the direction of bias is less obvious **Griliches and Mairesse (1998).**

A number of methodologies have evolved over time to address the simultaneity problem; the first being the within transformation. However, application of within transformation demonstrated that either it was not doing enough, in the sense that there still were potential simultaneity problems, or was doing too much, in the sense that the transformation might be aggravating other pre-existing problems such as errors in variables. **Chamberlain (1982)** suggested for the first differences (or longer differences) of the available panel data, rather than going for within transformation. If the error term gets transmitted to the current period variable inputs, then the difference in the variable input needs to be instrumented. Because the number of available instruments depends on the length of the panel and changes from one cross section to another, the optimal estimation procedures become more complex, calling for the use of general-method of- moments (GMM) estimators (e.g. **Arellano and Bond, 1991). Griliches and Mairesse (1998)** point out that such 'internal' instruments (past levels for current differences and past differences for current levels) are likely to be quite poor and possess little resolving power. They suggest to do better will require bringing in some additional information from somewhere else: 'external' instruments, more theoretical restrictions on the structure, and/or more equations.

Olley and Pakes (1996) [OP] address the simultaneity problem through a proxy for the unobserved transmitted component, $\boldsymbol{\omega}_{it}$, by bringing in a new equation, the investment equation. Griliches and Mairesse point out that use of proxy for $\boldsymbol{\omega}_{it}$ has several advantages over the usual within estimators (or the more general Chamberlin and GMM-type estimators). It does not assume that *it w* reduces to a 'fixed' firm effect; it leaves more identifying variance in variable and fixed inputs and hence is a less costly solution to the omitted-variable and/or simultaneity problems; and it should also be substantively more informative. **Biesebroeck (2007)** points out that if productivity shocks are persistent, OP is the most reliable method. Moreover, if measurement errors affect inputs and investment, OP is as effective as GMM to estimate productivity levels. **Levinsohn and Petrin** (2003) further refine the technique of Olley and Pakes and use intermediate input (raw materials) as proxy to control for the simultaneity problem.

Our study uses Levinsohn and Petrin (2003) method to estimate the TFP as this is considered as the most appropriate method for estimating productivity that takes care of simultaneity. Following levinson and petrin our study uses intermediate input namely energy consumed as a proxy to deal with the simultaneity problem. Our choice to use energy as a proxy is justified by the primary nature of mining industry and minimal use of raw materials.

We can rewrite our equation (1) as

$q_{it} = a_0 + a_c c_{it} + a_l l_{it} + a_e e_{it} + \boldsymbol{\omega}_{it} + \quad it$ .... (2)

In the semi-parametric estimation firm's energy demand function $eit = et$ (□t, cit) is assumed to be monotonically increasing in productivity, conditional on its capital stock. Inverse of the energy demand function □t = □t (et, cit) depends only on the observable variables cit and eit. Substituting this value into (2) we can derive a partial linear model as follows:

$q_{it} = a_l l_{it} + \text{ø}(e_{it}, c_{it}) + \quad it$ .... (3)

Where, $\text{ø}_t(e_{it}, c_{it}) = a_0 + a_c c_{it} + a_e e_{it} +$ □t (et, cit)

The estimation of equation (3) is carried out in two stages. In the first stage, as the error term in equation (3) *it* is not correlated with the input, we estimate the coefficient for labour (a_l) by including □t (.) in the estimation routine. In this □t (.) is approximated by a third order polynomial with full set of interactions. Since capital and energy enters □t (.) in two ways, a complete model is used to identify the a_c and a_e .

In the second stage, □t is assumed to follow first order Markov process. w □□E [□$_{it}$ / □$_{it-1}$] +ξ_{it}

Where ξ_{it} is the innovation in productivity over last period's expectation. Two moment conditions are used to identify a_c and a_e . The first moment condition to identify a_c , which assumes that capital does not respond to ξ_{it}, is

E[(ξ_{it}□□ *it) cit]= E [*ξ_{it} *cit] =0* .... (4)

The second moment condition to identify a_e , assumes that the last period's energy choice is uncorrelated with ξ_{it} is

E [(ξ_{it}□□ *it*)e_{it-1}] = E [ξ_{it} m_{it-1}] =0 .... (5)

The residuals used in the moment conditions in (4) and (5) are given by

$\xi_{it} +$ *it* (a*) = $q_{it} - a_l l_{it} - a_{e*} e_{it} - a_{c*} c_{it} -$ E[□$_{it}$ □$_{it-1}$] .... (6)

Where, the residuals are expressed as a function of the two parameters $a^* = a_c^* a_e^*$. $E[\omega_{it} | \omega_{it-1}]$ is estimated by regressing ω_{it} hat on fourth order polynomial ω_{it-1} hat. ω_{it} hat and ω_{it-1} hat are obtained from the following two equations using the estimates from the first stage (labour coefficient) and candidate values for ($a_c * a_e *$). The candidate values are the OLS estimates of production function (1).

$$\omega_{it} + \xi_{it} = y_{it} - a_l l_{it} - a_{c*} c_{it} - a_{e*} e_{it} \qquad \text{.................... (7)}$$

$$\omega_{it-1} = \phi_{t-1}(.) - a_{c*} c_{it-1} - a_{e*} e_{it-1}. \qquad \text{.................... (8)}$$

We also use the following three additional moment restrictions to test the unbiasedness of the estimated coefficients of the choice variables of the firm, namely *c, l, and, e*

$$E[\xi_{it}\, l_{it-1}]=0,\ E[\xi_{it}\, c_{it-1}]=0,\ E[\xi_{it}\, e_{it-1}] =0$$

These over-identifying moment restrictions are valid under the null-hypothesis that the coefficient estimates are unbiased. Thus, we have total five population moment conditions given by the vector of expectations:

$$E[(\xi_{it} + \eta_{it})\, Z_{it}] = 0$$

Where, Z_{it} is the vector given by

$$Z_{it} = \{c_{it}, e_{it-1}, c_{it-1}, e_{it-2}, l_{it-1}\}$$

Finally, we obtain estimates ($\hat{a}_c$, $\hat{a}_e$) by minimizing the GMM criterion function.

$$Q\, a^* = \min_{a^*} \sum_{h=1}^{5} \left(\sum_i \sum_{t=T_{i0}}^{T_{i1}} (\xi_{i,t} + \eta_{i,t}(a^*))\, Z_{i,h,t} \right)^2$$

Where, *i* and *h* index the firms and five instruments respectively; T_{i0} and T_{i1} index the second and last period firms *i* is observed.

Using the estimated production function coefficients, TFP (*Pit*) levels for each firm is estimated as follows: $\boldsymbol{P_{it} = \exp(\ln q_{it} - \ln c\, \hat{a}_c - \ln l\, \hat{a}_l - \ln e\, \hat{a}_e)}$

Industry level TFP has been estimated as the weighted mean of firm level TFP estimates where each firms' output share in the industry is used as weights. Similar exercise has been carried out to compute TFP levels for four sectors of mining industry namely metallic, non-metallic, coal and petroleum. Further, by dividing each sector into two ownership groups (public and private) TFP has been estimated for eight sub-sectors. For grouping the firms under four sectors we have followed the National Industrial Classification (NIC) codes at five-digit level. Similarly, for ownership classification we have enlisted all the government –Central as well as State –enterprises under public sector and rest under private sector.

Data and Variables

The study uses firm level data from prowess database of Centre for Monitoring Indian Economy (CMIE). Prowess is an online database provided by the Centre for Monitoring Indian Economy (CMIE) which covers financial data for over 23000 companies operating in India. Most of the companies covered in the database are listed on stock exchanges, and the financial data includes all those information that operating companies are required to disclose in their annual reports. The accepted disclosure norms under the Indian Companies Act, 1956, makes compulsory for companies to report all heads of income and expenditure, which account for more than 1per cent of their turnover. The prowess database provides quantitative information on variables such as output, sales, raw materials and energy. The presence of firms in the database is entirely subject to their voluntary reporting and does not reflect the true entry and exit of the firms from the industry. Therefore, the dataset does not suffer from the selectivity bias (which arises due to the selection of firms existing in the industry due to their competitive edge).Our dataset contains yearly information on Indian mining firms from 2000 to 2016. The reason for taking 2000 as the initial year is that the Indian economy witnessed structural reforms in the early 1990s, which have subsequently brought in vast changes in the mining sector policy and the results of this sectoral reform process was realized in the late 1990's. Another reason is in the fact that data on all variables, price indices and deflators for all variables are systematically available from this year onwards. Our sample includes firms mainly from four important subsectors: coal, metallic, non-metallic and petroleum. We have selected firms primarily on the basis of availability of data. Firms having data for at least of four years in sequence have been included in the analysis. Thus, we have a sample of firms consisting of total 976 observations on 69 firms. Out of total 69 firms, 18 are in non-metallic mining,10 in metallic, 33 in coal mining, and 8 in petroleum mining. In the year 2000, the data represents 84% of the total value of mining output and a subsequently a higher percentage in the subsequent years. In 2004-05, the data set represents around 92% of the total value of output of mining industry (Table-1). The dataset used for this analysis is an unbalanced panel.

Table 1: Representation of Prowess Output as a % Share of Total Output in the Mining Industry

Years	Total Value of Output In Mining Industry RS in Crores	Total Value represented by CMIE data Rs Crores	% Representation by Prowess
2000-01	60931	51305	84.2
2001-02	66878	53253	79.63
2002-03	71382	64768	90.73
2003-04	75018	67840	90.43
2004-05	98934	91563	92.55
2005-06	113354	102085	90.06
2006-07	131023	115220	87.94
2007-08	154622	121385	78.5
2008-09	174133	143077	82.17
2009-10	192108	165523	86.16
2010-11	266623	221689	83.15
2011-12	284149	226792	79.81
2012-13	280006	210471	75.17
2013-14	277413	232918	83.96
2014-15	290588	221416	76.2
2015-16	282966	245188	86.65
2016-17	371100	316093	85.18

Note: The data used in this table are taken from various issues of the Indian Bureau of Mines' (IBM) Publication "Indian Mineral Industry at a Glance". The data published by Central Statistical Organisation (CSO) in its Annual Survey of Industries provides only a part of the total value of mineral production.

Construction of Variables

The first step in estimating the production function is to convert all the values in to real terms as the prowess database provides the values in nominal terms. This can be done by deflating the nominal values with the appropriate price indices. For this, we have collected the values of price indices from the "Index numbers of wholesale prices in India, base 2004-05=100" published by the Economic advisor, Ministry of commerce and Industry, Government of India. We, by using the available time series data, have constructed all the variables for our analysis purpose. The time series variables are measured at 2004-05 prices. The detailed procedure is explained below.

Output: The value of output series for each firm is obtained by deflating the current year values. As the mining industry is divided in to four sub sectors, and the price deflators of each subsector is different, therefore disaggregated price deflators have been used for the four sectors – coal, metallic, non- metallic and petroleum. For the mining industry as a whole, the WPI of minerals have been used to deflate the current year values to convert it in to the real output.

Labour: The labour input is measured in terms of wages and salaries. Nominal values of wage bill has been converted to real value by deflating the total wage bill (Salary and wages) with consumer price index for industrial workers taking the 2001=100 as base. The data for the latter is obtained from the labour bureau, Ministry of labour and employment, Government of India.

Energy: The energy variable is constructed by deflating the energy cost (power and fuel) by the composite price index of fuel, power, light and lubricants.

Capital: The capital variable is estimated using the perpetual inventory method. The detailed procedure is provided in the Appendix A.1.

The summary statistics of the variables used in the estimation of TFP of mining industry is provided in the below table 2.

Table 2: Summary Statistics of the Variables Used in the Estimation of TFP of Mining Industry

Years	Real Output value in Crore		Labour		Fuel & Energy in Crores		Capital Stock Crores	
	Average	SD	Average	SD	Average	SD	Average	SD
2000-01	393.9	2993.4	37.9	220.7	11.3	53.2	1044.6	10754.7
2001-02	431.1	3387.6	44.6	250.1	11.1	49.9	1015.5	10182.2
2002-03	409.2	3209.5	37.5	222.1	10.5	51.8	1028.4	10185.4
2003-04	555.3	4700.3	41.7	236.8	10.7	48.0	992.8	10129.0
2004-05	557.3	4354.1	41.4	231.9	9.8	43.0	996.8	9846.9
2005-06	354.6	2899.2	42.5	236.7	9.0	39.4	915.5	8676.1
2006-07	339.0	2691.3	43.0	243.1	9.1	41.6	1070.4	11218.0
2007-08	325.2	2691.7	43.6	248.4	47.9	273.2	973.0	9886.5
2008-09	338.4	2534.4	48.5	285.5	10.2	46.5	982.1	9914.8
2009-10	304.3	2236.5	50.8	282.8	10.5	51.6	1026.4	10289.4
2010-11	290.7	1966.0	50.7	273.6	12.0	55.4	1280.4	13726.2
2011-12	273.3	1789.5	52.5	282.7	9.8	47.0	1124.7	11382.4
2012-13	250.8	1619.9	60.5	319.6	11.6	54.6	1117.7	11382.3
2013-14	259.5	1635.8	56.3	290.5	13.4	64.7	1170.0	11492.6
2014-15	268.4	1671.8	58.4	308.4	16.1	76.8	1194.1	12288.5
2015-16	303.1	1861.9	58.0	306.5	20.0	96.5	1214.3	11559.6
2016-17	413.1	2582.5	140.5	780.3	14.2	71.4	298.0	1488.5

Source: Author's estimation

Results and Analysis

Our results are presented in this section. First of all we have shown the production function estimates from two different methodologies namely OLS and LP (Levinson and Petrin) method. Thereafter, we have presented an intra-sector comparison between TFP levels of public and private sector firms. We have refrained ourselves from comparing the TFP levels of public and private sector mining firms across sectors, as any such attempt may lead to misleading results. This is because the four sectors of mining industry exhibits different pricing mechanism. For instance, in case of coal and petroleum, the administered price mechanism is followed where in the price of coal and crude petrol is determined by the central government and not the market forces. Therefore, it does not reflect the true market price. On the other hand, in case of metallic and non-metallic sector, the price is by and large determined by the market forces. Thus, productivity estimates for the sectors where administered price mechanism is followed would definitely show a downward bias as against the sectors where price is market determined. In this kind of a scenario, it would be misleading to compare the productivity estimates across sectors. However, comparison of productivity estimates within the sectors (Intra-sector) would not cause any such bias, as all the firms within the sector would be facing the same pricing mechanism. Hence, given this kind of possibility, we have attempted to provide an intra-sector comparison of TFP levels and across sectors, we have compared only the growth rates. At the end, we have tested the productivity gap between the public and private firms through a multivariate regression model controlling for initial productivity levels and age of the firms.

The production function estimates from two different methodologies namely OLS and LP method are presented in the table 3.

Table 3: Production Function Estimates

Inputs	OLS	LP
Labour	0.463* (0.027)	0.512* (0.098)
Capital	0.398* (0.024)	0.406* (0.078)
Energy	0.231*(0.023)	0.221* (0.069)
P (Q)		0.624
No of Observations	976	976

Notes: For LP method the bootstrap standard errors are provided in the parentheses. Number of replication is 500. For OLS ordinary standard errors are given. P (Q) is the P value of over identification test.

* indicates the significance of variables at 1% level of confidence.

The results shows that the OLS estimates for labour and capital are biased downward and that of energy is biased upward as against the estimates of LP. The value of P (Q) for the LP method shows the P value of over identification test under the null hypothesis that over identification restrictions are valid. A valid null hypothesis indicates that the proxy is conditioning out all the changes in the inputs correlated with unobserved productivity. The above table demonstrates that the null is accepted at a reasonable level of significance. The results of the estimates from these two different methodologies reveals that LP method is a better method over OLS for this particular study.

Having discussed that the LP method estimates are better than that of OLS estimates, we then proceed forward to show the results of comparison of TFP levels between public and private sector.

Comparison of TFP between Public and Private Mining firms:

Here, we intend to compare the TFP levels of public and private mining firms in the four sectors of Indian mining industry. In order to make the comparison a feasible and smooth process, we have converted the absolute TFP levels in index form for public and private mining firms in the four sectors. The TFP indices have been constructed by assuming the initial year TFP value of public sector as 100. This serves as the reference point and with respect to this, the TFP values of subsequent years and private sector are estimated. Thereafter, under each sector TFP indices of private firms are compared with those of firms in the public sector.

Table 4 shows the TFP levels in index form for public and private firms in the four sectors of mining industry in India. It reveals that over the entire period of analysis, the TFP levels of private firms were higher than that of their public counterparts in three sectors such as metallic, non-metallic and coal. However, for the Petroleum mining, the situation was quite different. For this sector the TFP levels of public sector exceeded that of private sector. In the initial years, from 2000-01 to 2008-09, the productivity levels of private firms were dominant over the public firms. While in the rest of the years, from 2009-10 to 2016-17, productivity levels of public firms outweighed that of their private counterparts except for the years – 2010-11, 2011-12, 2014-15, and 2016-17.

Table 4: Comparison of TFP between Public and Private Mining Firms Over 2000 to 2016 in Four Sectors of Mining Industry

Year	Metallic		Non-metallic		Coal		Petroleum	
	Public	Private	Public	Private	Public	Private	Public	Private
2000-01	100.00	173.00	100.00	201.00	100.00	138.00	100.00	312.00
2001-02	106.60	176.96	126.30	257.65	108.10	156.75	152.10	463.91
2002-03	110.80	157.34	139.80	248.84	105.40	159.15	147.10	425.12
2003-04	108.90	145.93	147.50	302.38	105.80	217.95	143.70	421.04
2004-05	118.10	171.25	162.40	280.95	111.20	280.22	157.80	312.44
2005-06	111.30	158.05	165.30	274.40	109.30	181.44	170.90	300.78
2006-07	120.60	165.22	171.10	236.12	108.30	148.37	205.10	299.45
2007-08	112.40	134.88	178.30	317.37	114.10	151.75	180.90	198.99
2008-09	121.70	143.61	168.40	308.17	112.10	143.49	190.30	213.14
2009-10	138.90	183.35	156.90	283.99	107.50	150.50	195.50	187.68
2010-11	147.20	197.25	164.80	306.53	110.10	173.96	218.40	268.63
2011-12	137.40	169.00	170.90	281.99	112.00	153.44	176.30	195.69
2012-13	152.70	187.82	173.10	283.88	107.40	155.73	196.50	192.57
2013-14	158.80	235.02	168.70	251.36	106.90	157.14	224.30	186.17
2014-15	167.40	232.69	159.40	250.26	109.80	164.70	189.50	191.40
2015-16	169.90	265.04	178.20	313.63	115.80	167.91	180.20	180.20
2016-17	160.80	250.85	181.20	337.03	118.90	170.03	233.20	237.86

In order to know to what extent private mining firms are more productive than the public mining firms, we have taken the ratios of productivity levels of private firms to that of public mining firms. Table 5 shows the ratios of private firms to that of public firms. A value larger than 1 indicates the multiples by which private firms are more productive than the public firms. A value less than one signifies the multiples by which private firms are less productive than the public firms and a value equals to one exhibits no difference in productivity between the public and private mining firms.

Table 5: Ratio of TFP Levels of Private to that of Public Mining Firms in the Four Sectors of Indian Mining Industry

Years	Metallic	Non-metallic	Coal	Petroleum
2000-01	1.73	2.01	1.38	3.12
2001-02	1.66	2.04	1.45	3.05
2002-03	1.42	1.78	1.51	2.89
2003-04	1.34	2.05	2.06	2.93
2004-05	1.45	1.73	2.52	1.98
2005-06	1.42	1.66	1.66	1.76
2006-07	1.37	1.38	1.37	1.46
2007-08	1.2	1.78	1.33	1.1
2008-09	1.18	1.83	1.28	1.12
2009-10	1.32	1.81	1.4	0.96
2010-11	1.34	1.86	1.58	1.23
2011-12	1.23	1.65	1.37	1.11
2012-13	1.23	1.64	1.45	0.98
2013-14	1.48	1.49	1.47	0.83
2014-15	1.39	1.57	1.5	1.01
2015-16	1.56	1.76	1.45	1
2016-17	1.56	1.86	1.43	0.93

Source: Author's estimation

It can be seen from the above table that non -metallic mining sector records highest productivity gap between public and private firms. The private firms in this sector were approximately two times more productive than the public firms. For metallic and coal sector the private firms are more productive than the public firms by approximately one and half times. However, so far as petroleum sector is concerned, the productivity of public firms are close to or exceeds that of the private firms for years from 2007 to 2016. This is partly due to sharp decrease in productivity levels of private firms. The public firms in petroleum sector experienced a steady rise, while sharp decline in productivity levels was observed by the private firms.

Since liberalization, the Indian mining industry is opened up to private sector participation. This has created a sort of competition between the public and private firms in order to enhance their productivity growth so as to survive in the competitive market. In this context, it is imperative to provide a comparative picture of difference in productivity growth rates of public and private firms. The table 6 shows the average annual TFP growth rates of private and public firms in the four sectors of Indian mining industry for the period from 2000 to 2016.

Table 6: Average Annual TFP Growth Rates (%)

Time Period	Metallic		Non-metallic		Coal		Petroleum	
	Public	Private	Public	Private	Public	Private	Public	Private
2000-05	-0.31	0.63	3.68	7.02	1.38	1.46	6.11	3.23
2006-11	-0.28	0.76	3.47	6.36	1.45	1.53	6.5	2.57
2012-16	2.03	2.35	4.01	7.09	1.02	1.37	5.85	3.11

Source: Author's estimation

The above results shows that over the entire period of analysis, the TFP growth of private firms were higher than that of public firms except the case of petroleum sector. The entire period is divided in to three sub periods with a duration of five years each. The first period 2000 to 2005-06 is considered as the second phase of liberalization, the first phase being 1992-93 to 2000. The second phase is the period during which the mining boom happened due to rising commodity prices and also this period has significance as the World witnessed the financial crisis of 2008. The last phase indicates the phase of recovery. Over the entire period of analysis, the TFP growth of private firms in the metallic, non-metallic and coal sectors were higher than that of the public firms. However, for the petroleum sector the situation was quite contradictory. During this phase, the public mining firms TFP growth was higher than the private mining firms. It shows that in the petroleum sector, the public firms have consistently shown a higher productivity than the private firms. On the other hand, as far as the coal sector is concerned, the public firms showed poor productivity growth. One of the possible reasons why the public firms have performed well in terms of productivity growth than the private firms in petroleum sector could be due to persistence of limited competition and high regulation of private firms.

The above discussion clearly points out towards the existence of productivity gap between public and private firms. However, this productivity gap may arise due to factors such as differences in age and initial productivity level of firms. The age of the firms might cause differences in the productivity of public and private firms (**Issac *et al*, 1994**). To confirm this, we have estimated a multivariate regression model where TFP levels are expressed as dependent variable and lagged values of TFP level, age and ownership of firm as independent variables. The regression model is shown in the equation below

$$\mathbf{P_{it} = \alpha_p P_{i,t-1} + \alpha_A A_{it} + \alpha_O O_i + \eta_i + v_{i,t}}$$

For i= 1,…,N and t= 2,…..,T

Where P_{it} is the log value of TFP levels of firm i in period t, O is the dummy variable for ownership of firms. The dummy variable takes the value 1 for private sector firms and zero otherwise. Hence a positive and significant value for 0 implies that private sector firms are more productive than their private counterparts. A_{it} is the log value of age of the firm i in period t, $\mathbf{\eta_i + v_{i,t} = U_{it}}$ is the usual fixed effects decomposition of the error term. The above model is an autoregressive model as the lagged dependent variable has been included as one of the independent variables on the right hand side of the equation. As we are well aware of the fact that in an autoregressive model the endogeneity problem is the major problem. In order to address this, we adopt the Blundell and Bond (1998) method, a GMM estimation, which uses lagged differences of P_{it} as instruments for equations in levels along with lagged levels of P_{it} (from second to fifth) for equations in differences. The above equation is estimated for the whole mining industry as well as for the four sectors of the industry separately. The results of this dynamic panel regression is shown in Table- 7.

Table 7: Results of Dynamic Panel Regression Analysis

	Dependent Variables				
Independent variables	**Model- 1**	**Model -2**	**Model-3**	**Model-4**	**Model-5**
	Total Industry	**Metallic**	**Non-Metallic**	**Coal**	**Petroleum**
$P_{i, t-1}$	0.521* (0.011)	0.281* (0.015)	0.374* (0.03)	0.25* (0.02)	-0.06 (0.27)
A_{it}	0.007 (0.03)	0.32* (0.010)	0.38* (0.07)	0.30* (0.012)	0.36* (0.05)
O_i	0.14** (0.06)	0.18* (0.04)	0.24* (0.05)	0.17* (0.05)	-0.59 (0.31)
Constant	0.91* (0.16)	0.108* (0.001)	0.47* (0.13)	0.15* (0.01)	0.29* (0.11)
Sargan	64.56 (0.85)	0.000 (1.000)	0.000 (1.000)	0.000 (1.000)	0.000 (1.000)
AR(2)	-1.114 (0.259)	0.92 (0.341)	-1.056 (0.276)	-1.043 (0.28)	-0.8 9 (0.381)
Number of observations	906	120	350	330	106

Source: Author's estimation

Notes: standard errors of the two step GMM estimators are presented in the parentheses. Sargan test P-values are in parentheses.

*, ** indicate significance at 1% and 5% level

From this table, it can be visualized that the sargan test statistics implies that the over identification restrictions are valid, which in turn validates the instruments used. Similarly, the statistics for AR (2) indicates the absence of serial correlation of order two. This satisfies the pre requisite for instrument validity when the second lag has been included in the instrument set. The results reveals that at industry level, the private mining firms TFP levels are significantly higher than that of the public firms, as the coefficient of Ownership variable (O_i) is positive and significant. A sector wise analysis also confirms such a difference in the metallic, non-metallic and coal sector. However, for petroleum sector TFP levels of public sector are more than that of the private sector. The results also shows that at the industry level, the age of the firm does not significantly affect the TFP levels. But at sectoral level, the age of the firm positively and significantly affects the TFP levels. As far as lagged TFP levels are concerned, these have a positive and significant influence on the TFP levels of mining industry as a whole, whereas at sectoral level, this is true for coal, metallic and non-metallic mining.

Conclusion

This paper has attempted to examine the productivity gap existing in the public and private sector of mining firms over the period 2000 to 2016. The results shows that private firms were more productive than that of the public firms in the three sectors of mining industry- metallic, non -metallic and coal. Whereas for the petroleum sector the public firms showed superior productivity. Highest productivity difference was recorded in the non-metallic sector, where in private firms were two times more productive than that of the public firms. Metallic and coal sector followed suit where private firms registered almost more than one times more productivity than the public firms. The above results suggests that although the liberalization process that started around 1990 entailed opening up of the mining industry to private sector participation, with an aim of building healthy competition to improve the productivity of public sector, this very aim has not been materialized as there exists still a large gap between the public and private firms. The probable reasons for this wide difference in productivity could be many such as lack of incentivization, inadequate and unskilled manpower, absence of upgraded technology, inadequate infrastructural facilities and so on. The reasons may vary from firm to firm and sector to sector. However, all these pertinent causes provides us enough impetus to call for the attention of policy makers to take necessary steps in the form providing incentives to the public firms, improving infrastructural facilities, upgrading manpower by providing them training and learning opportunities, facilitating them with better and improved technologies so that they can improve their productivity levels and thereby can stand up to the private firms in the competitive field.

Appendix

A.1: Measurement of Capital

The database provides firm's Gross Fixed Asset (GFA) at historical cost. In many of our studies, especially in productivity related studies, we use capital as a variable. But, it is a herculean task to estimate the capital accurately. Generally capital stock is valued at historic cost which is known as book value of capital. But we actually need the present value of capital stock at constant prices for analysis. One of the methods to obtain this present value is through applying perpetual Inventory Method (PIM). Thus, in this study, data on capital stock have been estimated using the perpetual inventory method. As a first step to this, first of all given GFA values are re-valued at the replacement cost with 2009-10 as the benchmark year. For estimating revaluation factor we have followed the method of Srivastava (1996). This study uses the gross fixed asset rather than net fixed asset because depreciation charges in the Indian industry is highly arbitrary, fixed by income tax authorities hardly representing actual consumption. The detailed methodology of capital stock estimation (GFA) is presented below.

Estimation of Capital Stock Using PIM

To estimate the capital stock from GFA, we have assumed the following

1. **Selection of Base year**
   For our data, the base year is 2009 (our study period is 2000 to 2016). This is due to the availability of a greater number of observations in this year. We assume that the earliest vintage in the capital occurs from 1984, or the year of incorporation if it is after 1984.This specific year 1984 was chosen because the life of machinery and tools is assumed to be 25 years for mining industry.
2. We assume that the price of capital changes at a constant rate $\Pi = Pt/Pt\text{-}1$ from the 1984 or the year of incorporation up to 2009. The values of Π are arrived from a series of price deflators constructed from CSO's data on Gross Fixed Capital Formation (GFCF) published in various issues of National Accounts of Statistics.
3. Similar to the price of capital we also assume that the price of investment changes at a constant rate $g=It/It\text{-}1$. The growth rate of fixed capital formation at 2004-05 constant prices, taken from various issues of NAS is applied to the case of all the firms.
4. Based on the value of Π and g, we estimate the "Re-valuation factor", R^G, defined by Srivastava (1996) as

   $$R^G = [(1+g)^{t+1} -1](1+\Pi)[(1+g)(1+\Pi) - 1]/ g\{[(1+g)(1+\Pi)]^{t=1}-1\}$$
5. After the re-valuation factor is estimated. We multiply the capital stock in the base year (2009) by this factor in order to convert the base year capital in to capital stock at replacement cost at current prices.
6. The value of capital stock in the benchmark year is then converted to constant prices using the WPI for machinery with the year 2004-05 as the base.
7. Capital stock in the subsequent year is then estimated by adding subsequent year's investment, $GFA_t - GFA_{t-1,}$ (at constant prices) to the existing stock of capital stock at each point of time using perpetual inventory method.

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