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# Alternate to Mining Contribution Index

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**Abstract:** *Minerals are precious natural resources that provide raw materials for fundamental industries and enhance industrial development of a nation. Thus, assessment of contribution of mining sector in national economy is needed. Mining Contribution Index (MCI) based on four MCI-indicators is popular in this context. However, MCI suffers from methodological limitations. Avoiding the problems of MCI, the paper suggests direct assessment of contribution of the mining sector to the national economy based on direct income, indirect income and induced income generated by the mining sector in a given year along with multiplier effect of the generated incomes.Gross value added (GVA) as GDP+ Subsidies on products (SP)− Taxes on products (TP) is suggested as an alternate to MCI. Relative importance of efficiency factors can be found by the regression coefficients of multiple linear regression equation of GVA on the set of chosen efficiency factors as the independent variables. Qualities of such regression equation can be improved using nonlinear transformation* $y=\boldsymbol{G}.\|x\|\|y\|.x$ *to get* $r_{xy}=1$ *where* $x$ *and* $y$ *are deviation scores,* $\boldsymbol{G}_{n\times n}$ *is the generalized inverse (G-inverse) of the matrix* $\boldsymbol{A}=x.x^T$ *and* $y$ *denotes the transformed scores and extending the concept of perfect correlation to multiple correlation coefficient* $R^2=C'^T R_{XX}{}^{-1}C'$ *where the original vector* $\boldsymbol{C}=(r_{x_1y},r_{x_2y},\dots r_{x_ny})^T$ *of raw data is replaced by* $\boldsymbol{C}'=(r_{x_1\hat{y}},r_{x_2\hat{y}},\dots,r_{x_m\hat{y}})^T$ *ensuring* $C'^T R_{XX}{}^{-1}C'=1$.

**Keywords:** ***GVA,*** *Mining Contribution Index, Mineral rents, Correlation, Robust regression* ***JEL Code****: F 61, G 18, H 71.*

## 1. INTRODUCTION

Like all natural resources, mining provides vital raw materials for many basic industries and is a primary driver of economic activities especially in mining-dependent countries. Thus, growth of mining sector is linked to the overall industrial development of a nation. Better governance of the sector has the potential to have positive impact on GDP, foreign exchange earnings, and to achieve sustainable Development Goals (SDGs) like promotion of jobs (SDG 8), reduction of poverty (SDG 1) and hunger (SDG 2), etc.(Monteiro et al. 2019). Positive correlation was found between mineral resource abundance and environmental degradation in mineral-rich countries (Hasnain et al. 2024). A number of low and middle-income countries (LMIC) which are rich in minerals (other than POL) have recorded good economic growth in the last decade primarily due to increase in exports of minerals and an increase in the prices of such commodities (Lascsáková, 2016). The impact of the financial and economic crisis and the subsequent recovery of the EU-27 industrial economy are often studied using the two main economic indicators, namely the Industrial Production Index and the Industrial Domestic Output Index (The European Union, 2012).

ICMM's Mining Contribution Index (MCI)(2016) reflects the significance of the mining sector's contribution to national economy by a single number considering the fact that mineral wealth translates into broad based economic and social progress. MCI also indicates the relative importance of mining to the economic life of a country and is based on the following four MCI-indicators:

1. Mineral and metal export contribution in a given year ($t$) measure mining in relation to other productive activities
2. Increase/decrease in mineral and metal export contribution during $t$-th year and $(t-5)th$ year indicates whether importance of mining is growing or falling over a five-year period

3. Value of Mineral production in percentage of GDP in the *t*-th year, indicates value of production relative to the size of the economy. (It is different from the contribution of mining to GDP, as costs and profits are not accounted for in the total production value) and
4. Mineral rents as a percentage of GDP in the *t*-th year, indicates revenues above the cost of extracting minerals and metals, as a share of GDP

The 6th edition MCI is calculated by the following steps.

1. Rank the countries in decreasing order for each indicator.
2. Obtain country percentile rankings based on the indicators by dividing country rank by the maximum rank within that indicator – to generate a ranking between 0 and 1
3. The four MCI indicators are weighted equally at 25%, summed up and multiplied by 100.

In case of availability of data on three of the indicators, weights of 33% are assigned equally. For availability of two or less indicators, zero score is assigned to such countries. A country is taken as resource-dependent if value of metals and minerals exports exceeds 20%and mineral rent exceeds 10% of the country's GDP.

**1.2 Problem Areas**

1. Assigning equal weights to the chosen indicators have been questioned from the methodological point of view (Ray, 2008; Mikulić et al. 2015). Arithmetic aggregation suffers from substitution effect since low value of an indicator gets compensated by high value of an indicator.
2. Assigning 33% weights to few countries and 25% weights to other countries distorts distribution of MCI-scores and comparing or ranking the countries with different weights may not be meaningful.
3. MCI-score of a country (say *i*-th country) is not an absolute measure. It depends on the maximum rank of the country within each indicator. Poor or improved performance of the country with maximum rank for an indicator will change MCI-score of the *i*-th country.
4. Percentile rankings do not consider important attributes of a frequency distribution like dispersion, skewness, kurtosis, etc. Theoretically, use of such attributes in other formulas may be the most important use of percentiles (Kurtz and Mayo, 1979)
5. The indicator-1: Mineral and metal export contribution in a given year (*t*) and the indicator-3: Value of Mineral production in percentage of GDP in the *t*-th year are highly correlated.
6. Mineral rent taken as the value of production of a mineral at world prices *minus* the total cost of production including estimate of the 'normal' return on capital is calculated by the World Bank for bauxite, copper, gold, iron, lead, nickel, phosphate, silver, tin and zinc (https://data.worldbank.org/indicator/NY.GDP.MINR.RT.ZS).Countries where other minerals and metals are produced get lower MCI-score as these rents are not included in the calculation. Ericsson and Löf (2019) computed mineral rent for diamond but not for the other metals.
7. Export of mineral and metal in a given year for a country is influenced by host of factors like Revealed Comparative Advantage (RCA) of the mineral and metal sector involving value of export of the sector made by the country in the year, value of total export made by the country, value of world export for the sector and value of world export of all commodities. In addition, volume of exportable surplus after meeting the internal demand, export policy of the country, environment issues, etc. MCI does not consider directly the internal demand. For example, India being the third largest energy consuming country in the world, there is surge in demand for coal to cater to the requirement of power and electricity in the country. Despite growth of about 22.6% in overall coal production in FY2023 from FY2019, India's import of coal increased by 25.6% y-o-y as of FY2023 (April-December). While trend of value of mineral imported by India showed zigzag pattern during 2018-19 to 2022-23, the same for mineral export remained almost flat with marginal increase from 2020-21 (Ministry of Mines, 2024).
8. The indicator-2 based on *t*-th year and $(t-5)-$th year may not be sufficient to depict relationship between the mining indicators and the economic cycle based on the cross-

correlation values. Based on ($t$-5)-th to ($t$+5)-th years, Gavurová et al. (2017) dividedthe mining indicators as Cyclic (second highest crossover valueat ($t$-5) to ($t$+5)≥ 0.55) and Non-cyclical (the greatest cross-correlation value at (t-5) to (t+5)< 0.55). While cyclic indicators show cyclical relationship with the cyclical component of GDP, the non-cyclical indicators do not develop in any relation to the country's economic cycle and can be taken as non-sensitive to changes in the economic cycle.Gavurová et al. (2017) suggested need for constant monitoring of strong cyclical industries, since negative changes in these industries result in automatic deepening the recession phase of the economic cycle.

9. As per the 6th edition of MCI, top ranking countries were less stable and about 64% countries belonged to the bottom half of the SDG index, which imply mineral dependence is not consistent with measures of SDG progress.
10. Difference of ranks of countries between the 6th edition and 5th edition of MCI were as high as - 113 (Chad), - 84 (Belize), etc.
11. In the short run, mineral rents and countries' growth are positively related, but may not be true in the long run with high growth of population, effect of war and mineral conflicts due to increasednumber of international borders (Ajayi, 2024). The author found major factors governing utilization of mineral rents for economic growth in Sub-Saharan Africa are level of mineral conflicts, population growth rates, institutional factors and the ability to contain civil war, etc.

Avoiding the problems of MCI, the paper suggests procedure to directly assess extent of contribution of the mining sector to the GDP of the nation based on direct income, indirect income and induced income generated by the mining sector in a given year along with multiplier effect of the generated incomes.

## 2. LITERATURESURVEY

In addition to Mining Contribution Index, other finance related indicators being used are: value added per employee, value added in relation to cost, turnover per employee,value added in relation to investments, share of investments to the total costs, etc.(Hedviáková and Král, 2019). One may also consider Economic value added (EVA) or Market value added (MVA)or Cash value added (CVA). $EVA = NOPAT - (CE * WACC)$ where $NOPAT$: Net operating profit after taxes; $CE$: Capital employed and $WACC$: Weighted Av. of Cost of Capital. MVA is computed as market value including equity and debt minus total capital invested. CVA is taken as Gross cash flow −Economic depreciation –(cost of capital ∗ gross investment). For a particular year, values of EVA, MVA and CVA for a country could be different for a particular mining industry. However, for assessment of contribution of a sector to national economy, better is to consider Gross value added (GVA) which provides a snapshot of the economic activities of a country from the supply side or producer perspective.

Or

Gross domesticproduct (GDP) as the sum of total market value of all finished goods and services produced within a country in a given time period say a year. It reflects the size of an economy and its growth rate. For example, India's GDP growth rate in the third quarter of 2023-24 was at the level of 8.4%, exceeding estimate for Q3 at 6.5% by the Reserve Bank of India

Or

Gross National Income (GNI) showing total income received by the country from its residents and businesses in a year regardless of whether they are located in the country or abroad including money received from abroad like foreign investment and economic development aid. It's a measure of national wealth. Roughly GNI= GDP+ income from foreign sources.

Multiple linear regression equations with GVA/GDP/GNI as thedependent variable and efficiency factors of the sector as independent variables help to find empirical relationship of national economy with the set of chosen independent variables relating to performances of the sector, associated logistics service and other service providers.

Estimation of total jobs associated with mining covering direct, indirect and induced jobs, varies with sources due to different methods of measurement, different spatial and temporal scales analysed, range of multipliers and may not reflect satisfactorily the effects of the labour market(Frankowski et al. 2023). Contribution of mining in social and economic aspects at a regional level can be classified into four categories: (1) employment, (2) district revenues, (3) welfare spending and (4) industrial and domestic fuel (Pai, 2021).While analyses of transport systems in mining primarily relate to technical issues with emphasis on underground hard coal mines without addressing efficiency and financial aspects (An et al. 2022; Zagorš˘cak, et al. 2019), management issues put more emphasis on scheduling of transport in open-pit mines (Zhang et al. 2023; Fang et al. 2023). Various methods can be employed to assess economic and social benefits of the economy due to mining activities like input-output (I/O) model, autoregressive distributed lag (ARDL) model,structural equation model (SEM), Gravity Model, Value addition, etc. However, each such method suffers from methodological limitations. Analyses of productive performance of mining sector involve the two terms viz. productivity and efficiency which are different. Sahoo et al. (2017) estimated the total factor productivity (TFP) growth of Indian mining industry using the complex stochastic production frontier (SPF) and found increasing trend of the annual average TFP growth of mining industry along with change of productivity growth from Technological Progress (TP) in initial years to Technical Efficiency Change (TEC) in recent years. SPF can reflect the optimum feasible output level for a production unit with the use of various combinations of inputs, where efficiency and technological progress are treated as basic components of productivity. Advantage of SPF includes that productivity growth can be decomposed into different componentsconsidering inefficiencies and *random errors.* But disadvantages include (i) assumptions of linear production function, uniformly distributed errors, and the observed output is a combination of a deterministic component (efficient production) and a stochastic component (inefficiencies) – which are difficult to verify and (ii) it is not possible to decompose individual residuals into their two components.

## 3. SUGGESTED METHOD

Rules for royalties and taxes for mining vary across countries. In India, the central government specifies the royalty payments for each mineral and the royalty on mining are collected by the respective state government. Royalty is mainly charged on ad-valorem basis as a percentage of the price notified by the government which can be modified once every three years. Holder of mining rights is required to pay higher of the royalty or dead rent of a mining area. Rate of dead rent fixed by the central government is collected by the state. Like royalty, enhancement of dead rent can be done once in three years. In addition, a rights holder is also required to pay 2% of the royalty as contribution to the National Mineral Exploration Trust (NMET) and surface rent, where applicable, fixed by the central government and collected by the state, since States are owners of mineral wealth in their respective territories in the federal set up. Principal taxes and duties applicable to the mining industry in India are: direct taxes (like corporate tax or minimum alternative tax); indirect taxes (likecustoms duty, and goods and services tax);stamp duty;water tax; forest-related taxes (like forest tax levied on forest produce removed from forest areas), compensatory afforestation charges (levied to promote afforestation and compensate for deforestation), net present value payments of forest land diverted for mining; and cess levied on mineral ores under various legislations.

However, special deductions under Income Tax Act are allowed for the prospecting of minerals and profits from export of specified minerals and ores are eligible for certain concessions.

GDP of an economy for a year is taken as private consumption + gross investment + government investment + government spending + (exports - imports). This may be followed by calculation of subsidies and taxes on products and computation of Gross value added (GVA)as GVA=GDP+ Subsidies on products (SP)− Taxes on products (TP). Alternately, GVA could be calculated as sum of Gross Operating Surplus and Gross Mixed Income (like profit) plus compensation paid to the employees. Central Statistical Office (CSO), under the Ministry of Statistics and Programme Implementation, Govt. of India estimated GVA accrued from mining and quarrying sector in 2021-22 at Rs. 3,27,984 crores (constant price) implying 11.55% growth from 2020-21. During the second quarter of 2023-24, contribution of the mining and quarrying sector (at current prices) to GVA of India was calculated as 2.03% (Ministry of Mines, 2024).However, GVA does not deduct the wear

and tear on equipment (Depreciation, or Consumption of Fixed Capital), what is paid to employees, taxes, interest on its loans (Investment Income), or long term investment in the business from total output. In India, taxes and subsidies are available for the entire economy but not for separate sectors like mining. Thus, GVA growth in mining is often reported instead of GDP growth in mining. Auxiliary annual information being reported include among others, information on production and value of selected minerals, details of export and import of minerals, trend of value of mineral production for the last five years, value of minerals by groups for the last five years, etc.Relative importance of efficiency factors can be found by the regression coefficients of multiple linear regression equation of GVA on the set of chosen efficiency factors as the independent variables. However, GVA of a country at *t*-th year $GVA_t = \alpha + \sum_{i=1}^{n} \beta_i X_i$ may be problematic in interpretation of results due to the following situations:

1. For the univariate regression of $Y$ on the predictor $X_1$, the regression coefficient $\beta_{YX_1}$ was significant but consideration of additional $X_i s$ in the multiple regression model may show non-significance of $\beta_{YX_1}$ and a significant $\beta$-coefficient in multiple regression may not be significant in the univariate regression (Feng et al. 2016). Non-satisfaction of the assumptions of the univariate and multiple regression models along with different values of $r_{Y,X_i}$ contribute to such problems.
2. Outliers in predictor variables affect correlation and distort nature of association among the variables considered. If $X_i$ is an outlier among the bivariate points $\{X_j, Y_j\}$ for *j*= 1, 2, …..*n*, the point $(X_i, Y_i)$ is a leverage point. Let the linear regression equation fitted with the $\{X_j, Y_j\}$ be $Y = \alpha + \beta X$ and $\hat{Y}_i = Y_i - \alpha - \beta X_i$ is the residual for the *i*-th observation. If $\hat{Y}_i$ is also an outlier in the set of residuals $\{\hat{Y}_i\}$ for *i* = 1, 2, …, *n* then the point $(X_i, Y_i)$ is a bad leverage point which can negatively impact Pearson's correlation, Kendall's $\tau$ and Spearman's $\rho$ and indicate poor fit of the linear model. If $(X_i, Y_i)$ is a leverage point but the corresponding $\hat{Y}_i$ is not an outlier, the point $(X_i, Y_i)$ is a good leverage point and is taken as consistent with the regression equation $Y = \alpha + \beta X$. Number of methods are there for detecting bad leverage points of regression line using the least median of squares (LMS) estimator (Rousseeuw and van Zomeren, 1990), computation of the slope ($\beta$) as median of the $S_{ij}$ 's where $S_{ij} = \frac{Y_i - Y_j}{X_i - X_j}$ for each $i < j$ and the intercept $\alpha = M_Y - \beta M_X$ , where $M_Y$ is the median of $\{Y_1, Y_2, \ldots\ldots, Y_n\}$ and $M_X$ is the median of $\{X_1, X_2, \ldots\ldots, X_n\}$ (Theil, 1950) and computation of slope and intercept removing the bad leverage points (Wilcox, 2023). Better is to consider non-linear transformation $\mathcal{y} = \boldsymbol{G}.\|x\|\|y\|.x$ to get $r_{x\mathcal{y}} = 1$ where $x$ and $y$ are deviation scores, $\boldsymbol{G}_{n\times n}$ is the generalized inverse (G-inverse) of the matrix $\mathbf{A} = x.x^T$ and $\mathcal{y}$ denotes the transformed scores (Chakrabartty, 2023). The concept of perfect correlation may be extended to multiple correlation coefficient $R^2 = C'^T R_{XX}{}^{-1} C'$ where the original vector $\boldsymbol{C} = (r_{x_1 y}, r_{x_2 y}, \ldots r_{x_n y})^T$ of raw data is replaced by $\boldsymbol{C'} = (r_{x_1 \hat{\mathcal{y}}}, r_{x_2 \hat{\mathcal{y}}}, \ldots, r_{x_m \hat{\mathcal{y}}})^T$ ensuring $C'^T R_{XX}{}^{-1} C' = 1$.

## 4. CONCLUSION

GVA with known and well defined procedures to calculatecan be well used instead of the Mining Contribution Index (with problem areas)to estimate contribution of the mining sector to the national economy and associated growth or decline across time. The index reflects the resultant of the geo-economic advantages and all promotional measures initiated by the government to boost efficiency and production of the sector. Contribution of the mining sector to GVA of a national economy across time is often used to show progress path of the indicator withconstant or varying base period. Similar path can be drawn showing contribution of States in the value of mineral production. However, contribution of mining sector to GVA may not be suitable for inter-country comparisons in a given year due to different base periods, different currencies. But international comparison with respect to the growth curves registered the countries is possible where percentage growth in two successive years by the *i*-th country is taken as

$\frac{Con.toGVA_{(t+1)_i} - Con.toGVA_{(t)_i}}{Con.toGVA_{(t)_i}} * 100$. Robust multiple regression equation avoiding problems of bad leverage points and correlation issues is recommended. Future empirical investigations with real life data on such regression analysis are suggested.

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