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Economic growth and sustainability: a case study of the mining industry in Jharkhand, Odisha and Chhattisgarh

CHAPTER 1: INTRODUCTION

1.1 Background

Jharkhand, Odisha, and Chhattisgarh account for a substantial share of the world's mineral reserves. The three mineral-rich states together hold over 40% of India's total mineral reserves. And Jharkhand alone holds more than 25% of the country's total coal reserves. The highest iron ore is found in Odisha, which accounts for over half of the total production. The state of Chhattisgarh produces coal and iron ore from its central districts, and its limestone belt hosts thirteen major cement plants.

However, these states do not experience the same level of social and economic advancement as other states, despite their enormous mineral endowments. Also, corruption in the use of such funds and poor governance are among the obstacles hindering the state's improvements in community welfare.

The mineral-rich states have faced severe challenges in improving community welfare. One major policy effort to bring mining benefits back to local communities is the 30% allocation of mineral resources wealth for local welfare, through the District Mineral Foundation (DMF). The compensating mechanism of DMF shall help the local District Mineral Foundation Board to regulate the supply of minerals, manage activities in a more planned manner and share benefits from mining activities. In the study, the impact of mining in the district DMF has been examined in light of the MMDR Amendment Act 2015. The study covers the MMDR Amendment Act 2015, a recently enacted law that seeks to benefit the local community by allocating 30% of the wealth generated in a mining lease area. However, the COVID-19 pandemic has severely impacted the mineral supply chain to date.

1.2 Research Problem

Mineral-rich states in India, such as Odisha, Chhattisgarh, and Jharkhand, show revenue generation but with poor health. This indicates a serious issue in the economic development of these states. This is because the mineral resources primarily benefit a select few in the states, such as top bureaucrats, industrialists, and mining contractors, even while large populations

continue to suffer from poverty, starvation, and lack of basic health services, among other issues.

Odisha accounts for 44.9% of India's total mineral production value, at ₹635,880 million. Nevertheless, Odisha's health statistics are dismal. For example, Infant Mortality Rate (IMR) per thousand is 39.3, worse than the national average of 29.9. Odisha has a very low GDP per capita and a DMF Fund worth only ₹490 crore. Even though the mineral sector's monetary contribution is substantial, the resulting DMF Fund is negligible relative to the wealth generated in monetary terms and total revenue.

Chhattisgarh's value of mineral revenues was ₹12,941 crore in 2022-23. As a result, the DMF funds for 2023-24 now total ₹10,840 crore in Chhattisgarh. Despite being the country's leading producer of iron ore, the state still has a poor IMR of 37 per thousand.

Jharkhand boasts a per capita GSDP of ₹59,100 but lags behind almost all other states in health indices such as the SDG Index. Its score is 53, which is the second-lowest in the country. Despite being the country's leading producer of iron ore, Jharkhand is also one of the states with the largest tribal populations. As a result, the benefits of the development don't help the tribal population, which still suffers from poverty and health disasters.

1.3 Research Objectives

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Main Objective: To conduct a comparative analysis of the relationship between mining-led economic growth and social sustainability in Jharkhand, Odisha, and Chhattisgarh over the period 2014 to 2024, and to evaluate whether current policies have effectively distributed mineral wealth toward community welfare.

Specific Objectives:

- To examine whether per capita GSDP growth in these three states has helped in the reduction of the Infant Mortality Rate.
- To test whether a higher share of mining in state GSDP is linked with health issues.
- To determine whether District Mineral Foundation expenditure has produced statistically detectable improvements in infant mortality in these states.
- To assess whether the MMDR Amendment Act 2015 produced a measurable structural improvement in social sustainability outcomes.

- To compare the three states on their decoupling path and identify which state is closest to economic growth.

1.4 Research Questions

- Does economic growth in mining-dependent states improve social welfare, or is the resource curse preventing that transmission from occurring?
- Is there a statistically significant association between mining intensity and infant mortality across the three states?
- Has DMF expenditure produced measurable, statistically significant reductions in IMR?
- Did the MMDR 2015 reform generate a detectable structural improvement in social sustainability outcomes?
- Which of the three states has achieved the greatest decoupling between mineral-led growth and social harm?

1.5 Hypotheses

Hypothesis 1: H_0: Mining share of GSDP has no significant effect on Infant Mortality Rate.

H_1: A higher mining share is significantly associated with a higher IMR.

Hypothesis 2: H_0: Per capita GSDP has no significant effect on IMR.

H_1: Higher per capita GSDP is associated with lower IMR.

Hypothesis 3: H_0: The MMDR 2015 dummy has no significant effect on IMR.

H_1: The post-MMDR 2015 period is associated with significantly lower IMR.

Hypothesis 4: H_0: DMF expenditure has no significant effect on IMR.

H_1: Higher DMF expenditure is associated with lower IMR.

Hypothesis 5: H_0: Forest cover has no significant effect on IMR.

H_1: Forest cover change is associated with changes in IMR.

1.6 Significance of the Study

This dissertation contributes three elements to the literature. First, it furnishes the initial econometric examination of whether DMF expenditure causally reduces IMR in Jharkhand, Odisha, and Chhattisgarh, an issue that prior studies, despite their thoroughness, have addressed only descriptively. Second, it incorporates the MMDR 2015 as a structural-break dummy variable within a regression framework, yielding a quantitative assessment of the reforms' health impact rather than the primarily qualitative evaluations found in policy discourse. Third, coal, iron ore, and limestone, along with all three states, can be analysed within a single analytical framework, thereby enabling comparative inferences rather than case studies.

1.7 Structure

Chapter 2 surveys the theoretical and empirical literature across six themes. Chapter 3 presents the methodology, data sources, and model. Chapter 4 presents and interprets the results systematically. Chapter 5 draws conclusions, makes policy recommendations, and identifies future research directions.

CHAPTER 2: REVIEW OF LITERATURE

2.1 Introduction

This chapter reviews theoretical frameworks and studies on mineral-rich regions and poverty. Overall, this study examines the relationship between natural resources and economic growth and identifies its contribution and where it falls short.

2.2 Theoretical Framework

2.2.1 The Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) hypothesis posits an inverted-U relationship between environmental degradation and economic growth, while abundant resource endowments may slow down rapid economic expansion. Using an environmental indicator, we test the EKC and examine the relationship between the magnitude of Sulphur dioxide emissions and economic growth. Dinda (2004) further proves the existence of an inverted-U for Sulphur dioxide. In contrast, we detect no consistent turning point for CO2 emissions, and thus no supporting evidence for the EKC hypothesis. Nevertheless, Pandey and Mishra (2021) identify a potentially deleterious cubic N-shaped relationship for India. Countries' rapid growth due to industrial expansion challenges the negative externalities of pollution. Support for this hypothesis is only partially confirmed by Sahoo et al. (2021), who conclude that the EKC does not hold for India. This conclusion is supported by Jaiswal et al. (2024), who indicate that the theoretical EKC predictions align with evidence results solely for oil-related emissions. The authors contend that the mineral-rich North-Eastern Indian states exhibit low levels of development and diminishing resource endowments, thereby limiting industrial activity that might otherwise generate negative externalities.

A study by Mishra (2010), using an inter-district panel analysis of Odisha, India, indicates that liberalisation-driven growth in the mining sector affected agriculture, which in turn diminished rural per capita income, a cause of poverty within the state. Although mining is expected to raise per capita income by increasing earnings, the research reveals that the sector operates as a dual-edged phenomenon, influencing agricultural output indirectly in two ways: it directly reduces agricultural yields through resource extraction and, by elevating mining-derived income, increases the opportunity cost of remaining in agriculture in favour of pursuing mining

activities. Consequently, rural per capita income, determined by total factor productivity (TFP) in agriculture, is reduced, implying that mining growth lowers agricultural TFP and increases poverty. This represents a form of structural displacement of the poorer segments of society, which is observed in many developing countries.

2.2.2 The Resource Curse

Sachs and Warner (1995) introduced the concept of the "resource curse": resource-rich nations tend to experience slower growth, weaker institutions, and greater inequality than resource-poor countries. Resource booms constantly lead to major problems for economies and public institutions. With the majority of a country's mineral wealth controlled by the state, it is easy for a corrupt politician to control export commodities for their own profit, thereby undermining public institutions. Not only are these minerals subject to unpredictable market prices, which lead to unstable economic cycles, but they also affect government budgeting and development.

For India's mineral belt, this framework is not a theoretical forecast but a description of present conditions. A 2025 study in JETIR confirmed that the resource curse manifests ecologically, economically, and socially across all three focus states, yielding national revenue while simultaneously creating poverty, environmental degradation, and social conflict. Meher (2026), drawing on decades of fieldwork in Odisha's northern plateau and published in the Journal of South Asian Development, characterised post-reform mineral-based growth in the state as effectively for Indigenous communities, finding that the primary beneficiaries of expanded mining were external industrial firms and state governments, not the tribal populations living on mined land.

2.2.3 Sustainable Development and the SDG Framework

The Brundtland Commission (1987) defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The UN Sustainable Development Goals (SDGs) provide a comprehensive view of the necessary economic, social and environmental dimensions of sustainable development, with 169 targets and a universal call to action to end poverty, protect the planet and promote peace for all by 2030.

NITI Aayog released the first SDG India Index in 2018, followed by the second in 2020, which ranks the performance of Indian states on their achievement of the SDGs using available data. Jharkhand has received a score of 53 out of 100 for 2020-21, placing its performance at the

bottom among states in the country. The low score on the SDG India Index, compared with other states: Odisha at 65 and Chhattisgarh at 69.

At the same time, the Sustainable Mining Attractiveness Index by CSEP ranks states on 5 attributes: economic, policy, infrastructure, environmental and social. Unfortunately, due to the poor environmental and social scores in the Jharkhand Sustainable Mining Attractiveness Index, it is ranked last. Thus, the case of Jharkhand is similar to that of other eastern region states, where economic development has resulted in high environmental and social costs that impede the development of sustainable initiatives.

2.3 Empirical Review

2.3.1 Mining, Deforestation and Environmental Degradation

Chhattisgarh, Jharkhand and Odisha reveal a massive loss of forest cover in the analysed states. Ranjan (2019) selects a large sample of 314 districts across 13 states in India to study the nationwide impact of coal mining. He reports a loss of forest cover of 519 sq km in Chhattisgarh and Jharkhand. However, studies that include a wider set of districts tend to have significant gaps in their analyses. The Ranjan study, for instance, is limited because it does not provide a Fixed Effects estimator to separate the effect of mining on forest cover loss in the analysis, and it does not include a policy variable to clean up the estimates.

Mitra et al. (2021) analyse the forest cover of southern Odisha and the iron ore and bauxite mining for the period 2001-2019 and find that over 20% of the total forest cover in these districts diminished during this period, mainly due to the expansion of the mining sector. Springer (2025) finds that forest cover in the block has been consistently decreasing from 1990 to 2020, with annual declines of 0.56% in forest land, 0.47% in water bodies, and 0.87% in cropland. According to Swamy et al. (2024), the mining-induced deforestation of Central India, excessive amounts of forest cover are found to be lost, suggesting serious environmental outcomes, by Swamy et al. (2024), who found that more than 52% of the mining landscape of Chhattisgarh has experienced severe degradation within two decades, with the scale of degradation much more severe in the forest districts of Bastar and Dantewada.

2.3.2 Mining, Health and Social Costs

The study of the socio-economic empowerment of women in Odisha (Pradhan, Patra, 2014) suggests that children in the region suffer from health issues such as fever, cough, waterborne

diseases, and other illnesses due to the presence of iron ore mines. The 2024 study by Renewable Watch, covering several coal-mining districts, also pointed out the rising infant mortality rate among children in the country, another health impact of mining activities. The study has stated that Surguja district in Uttar Pradesh and Pakur in Jharkhand have the worst poverty scores, with the infant mortality among the children being very high. The study also pointed out that there is a direct association between the coal-mining districts and high rates of infant mortality. It is further stated that the major part of the coal reserves is located in Jharkhand, Odisha, and Chhattisgarh, which together constitute 70% of the total coal reserves in the country. The tribal communities who have lived here for ages have to face many challenges, including loss of land rights, identity and being displaced for the coal mining.

2.3.3 DMF Policy Effectiveness and MMDR Reforms

The Centre for Science and Environment (CSE) published the People First report in 2018, which reviewed 50 mining districts across 12 states in India. The report found that no DMF trust had ever identified beneficiaries. Gram Sabha powers were ignored. States never bothered to advertise the available funds or the projects to be undertaken. There were also no investments made in child nutrition or in reducing under-five mortality.

CSEP (2022), founded by Raghuram Rajan, released a DMF Utilisation Index that provides a bird's-eye view of spending across different states. Odisha, which has spent 50% of the ₹14,934 crore collected from mineral developers, scored the highest for DMF spending. Jharkhand, on the other hand, scored the lowest, with only 11.4% of its mineral funds allocated to environmental quality.

The Ministry of Mines' statement that the amendments made to the MMDR Act are aimed at setting up an auction-based system that would improve transparency. The amendments, however, did little to establish the DMF framework; the 2015 CSE's caution, which served as a warning to the community, does not protect mining interests.

2.3.4 Limestone Mining

Studies on limestone and its impact on the ecological balance and natural environment are scarce, aside from the work by Ganapathi et al. (2020), which provides a systematic review on the topic. It has been reported that open mining reduces vegetation density by 40-60% and increases land surface temperatures by 1.5-3.0°C. This quarrying also significantly affects groundwater quality by causing contamination and elevating pH, TDS, and sulphate levels.

Chhattisgarh is famous for its thirteen cement plants. These plants contribute significantly to the economies of Chhattisgarh and India. They are located in Baloda Bazar, Raipur, Durg and Bilaspur. The mined commodity from these plants is exported to several different states, including Odisha and Bihar. The cement industry has three major negative impacts: emissions directly into the atmosphere; ground and land runoff during rain; and chemical compounds in cement leaching, contaminating local streams. Quarrying and mining also pollute the local environment, flora, and fauna, resulting in land degradation and global warming. Excessive mining and dumping of solid waste lead to the extinction of plant species and the loss of chlorophyll activity.

2.4 Identification of Research Gaps

Gap 1: No published study has used Panel Fixed Effects regression to test whether mining affects IMR across Jharkhand, Odisha, and Chhattisgarh.

Gap 2: No econometric study has tested whether DMF expenditure reduces IMR in these states. All existing evaluations are qualitative or descriptive.

Gap 3: The MMDR 2015 has never been used as a structural break dummy variable in a social cost regression for these states.

Gap 4: Coal, iron ore, and limestone have never been placed within a single unified analytical framework for a simultaneous comparison across all three states.

Gap 5: No existing study controls for unobserved state heterogeneity through Fixed Effects when examining the mining-IMR relationship for these specific states.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Design

This chapter studies the research design, data types, their sources, and the gaps of the study. The ten-year data panel trends and policy shifts over time. The study is based on secondary data from official government sources, covering three states over ten years.

3.2 Study Area and Period

Jharkhand, Odisha, and Chhattisgarh are mineral-rich states and among the most underdeveloped major states. The period 2014 to 2024 was chosen because it spans the MMDR 2015 reform (which created the policy dummy), the COVID-19 disruption (which provided additional within-state temporal variation), the DMF collection years, and the most recent complete data from SRS and FSI.

3.3 Data Sources

Variable	Primary Source	Frequency
GSDP Per Capita (₹, constant 2011-12)	State Economic Surveys	Annual
Mining Share of GSDP (%)	State Economic Surveys	Annual
Infant Mortality Rate (per 1,000 live births)	SRS Statistical Reports, Registrar General of India	Annual
Forest Cover (sq km)	FSI-India State of Forest Reports (ISFR 2013, 2015, 2017, 2019, 2021, 2023)	Biennial; interpolated
DMF Collection and Expenditure (₹ crore)	Ministry of Mines Annual Reports and CSEP DMF Report	Annual from 2015-16
MMDR Dummy	Ministry of Mines-MMDR Amendment Act, January 2015	Researcher-constructed

The final panel contains 30 observations with zero missing values. Forest cover, published biannually, was estimated for intervening years following Ranjan (2019).

3.4 Variables

Dependent Variable: Infant Mortality Rate, deaths per 1,000 live births, from the state economic survey. IMR was published annually by an official source as the main indicator for

social development, and it shows the vulnerability of the populations most directly harmed by mining's environmental and health consequences.

Independent Variables:

Variable	Definition
GSDPpc	Per capita GSDP at constant 2011-12 prices
MiningShare	Mining & Quarrying GVA as % of GSDP
DMF_Expenditure	Annual DMF spending (₹ crore); zero pre-2015-16
ForestCover	Total forest cover in sq km (FSI)
MMDR	Binary: 0 for 2014-15; 1 from 2015-16 onward
D_OD	1 if Odisha, 0 otherwise
D_CHH	1 if Chhattisgarh, 0 otherwise

Jharkhand is the base state.

3.5 The Econometric Model

The study used a Panel Fixed Effects regression through the Least Squares Dummy Variable (LSDV) method, estimated in IBM SPSS Statistics. The model is:

$$IMR_{it} = \beta_0 + \beta_1(GSDPpc_{it}) + \beta_2(MiningShare_{it}) + \beta_3(DMF_{it}) + \beta_4(ForestCover_{it}) + \beta_5(MMDR_{it}) + \delta_1(D_OD_i) + \delta_2(D_CHH_i) + \varepsilon_{it}$$

The state dummies D_OD and D_CHH absorb all time-invariant, unobserved characteristics of Odisha and Chhattisgarh, including geological endowments, historical governance quality, and ecological baselines, that would otherwise confound the coefficient estimates.

Why LSDV and not Pooled OLS? Pooled OLS assumes no unobserved differences across states, which is clearly untenable here. The three study states show different structural conditions that shape both mining activity and health outcomes, but these conditions cannot be directly measured. The LSDV approach controls for these by allowing each state its own intercept. The ANOVA F-test for the LSDV model ($F = 49.191$, $p < 0.001$) confirmed that state-specific effects are jointly significant, validating the Fixed Effects specification over Pooled OLS.

3.6 Reliability and Validity

Reliability rests on three pillars: all data comes from official sources, the model is subjected to a battery of diagnostic tests (VIF, Breusch-Pagan proxy, Durbin-Watson) and the key finding on Mining Share is confirmed across multiple proposals.

Internal validity is addressed through the Fixed Effects estimator, which removes time-invariant state effects, and through the MMDR dummy, which identifies the policy period.

External validity is intentionally limited to mineral-dependent Indian states that share structural characteristics comparable to those of the three study states.

CHAPTER 4: DATA ANALYSIS, RESULTS AND INTERPRETATION

4.1 Introduction

This chapter presents the complete analysis, which moves from the simplest summaries to the most complex tests: descriptive statistics, correlations, multicollinearity diagnostics, OLS regression, the Fixed Effects (LSDV) model, and finally robustness checks and hypothesis testing.

4.2 Descriptive Statistics

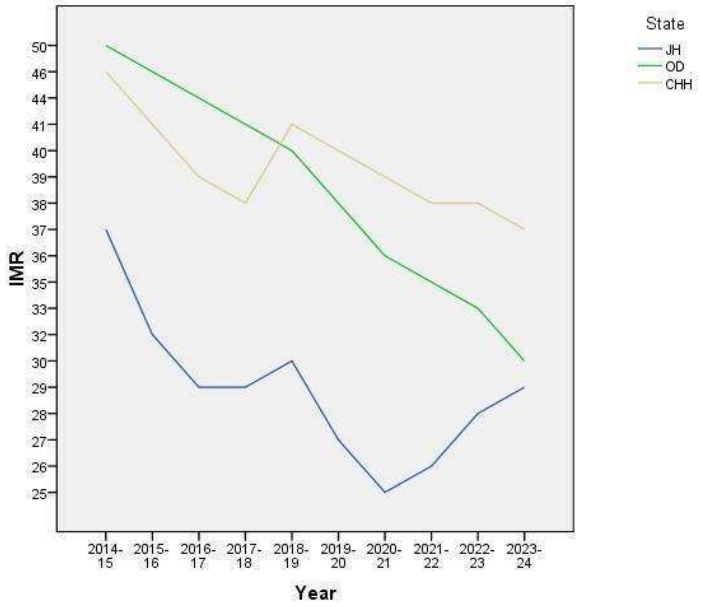
Table 4.1: Descriptive Statistics (N = 30, All Three States, 2014 to 2024)

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
GSDPpc	30	47200	106925	7.56E4	16094.194
MiningShare	30	.8500	10.2200	5.8426E0	3.5799840
IMR	30	25	50	36.07	6.470
ForestCover	30	23473	55812	4.37E4	14542.057
DMF_Collection	30	.0000	2.1430E4	4.6371E3	5.0111287E3
DMF_Expenditure	30	.0000	1.2000E4	2.5804E3	3.3995841E3
MMDR	30	0	1	.93	.305
Valid N (listwise)	30				

Source: SRS, FSI, MoSPI and Ministry of Mines

Figure 4.1: Infant Mortality Rate Trends of Jharkhand, Odisha and Chhattisgarh (2014 to 2024)



Source: Sample Registration System (SRS) Statistical Reports

Figure 4.1 shows the IMR declining across all three states over the decade, but at very different rates. Chhattisgarh IMR showed at 46 in 2014 and listed 37 in 2024, the worst in the country, and a difference of nine points over ten years, despite receiving mineral revenues.

Table 4.2: State-wise Mean Values (2014 to 2024)

Report

State		DMF Collection	ForestCover	MiningShare	IMR	GSDPpc
CHH	Mean	4696.410000	55659.60	7.397000	39.70	8.27E4
	N	10	10	10	10	10
	Std. Deviation	3.706984E3	98.796	.3531776	2.584	1.091E4
JH	Mean	478.348000	23613.70	1.810000	29.20	5.91E4
	N	10	10	10	10	10
	Std. Deviation	298.6078534	88.928	.1229273	3.393	7.727E3
OD	Mean	8736.788000	51859.80	9.121000	39.30	8.50E4
	N	10	10	10	10	10
	Std. Deviation	7.511020 1E3	444.459	.7579579	6.165	1.409E4
Total	Mean	4637.152667	43711.03	5.842667	36.07	7.56E4
	N	30	30	30	30	30
	Std. Deviation	5.911178763	14547.057	3.5796849	6.470	1.609E4

Source: SPSS Means procedure

Figure 4.2: Mining Share of GSDP of Jharkhand, Odisha and Chhattisgarh (2014 to 2024)



Source: State GSDP from Economics Survey (Constant 2011-12 Prices)

Figure 4.2 shows that Odisha's mining share peaked at 10.22% in 2023, Chhattisgarh averages 7.40%, and Jharkhand shows 1.25%, resulting in mineral dependence, since mining-linked value addition is classified under manufacturing rather than the mining sector.

Interpretation

High economic development does not guarantee better health in Odisha, Chhattisgarh or Jharkhand. Odisha is a poor state, but its average IMR is better than that of Chhattisgarh, whose average per capita GSDP is higher than Odisha's and whose average IMR is better than Odisha's. So, there is no direct relation between health and wealth.

However, while Odisha is said to spend more than the amount, resulting in the effective DMF exceeding that of Uttarakhand, Jharkhand, and Andhra Pradesh, the amount must be less than 10%. Odisha uses close to 50% of the DMF and achieves results that even 100% spending in the above-mentioned states cannot achieve. Jharkhand has spent effectively zero of the DMF even post-2015, once the money was collected.

Odisha has invested in health infrastructure and human resources over the past three decades and has reaped the benefits; Jharkhand, however, has allowed its ministers and their followers to become corrupt. Hence, the states do not have health and welfare. To achieve well-being and success, it remains only to improve health conditions, make public health management a mandated policy, and build systems dependent on education and the need for healthy living.

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4.3 Correlation Analysis

Table 4.3: Pearson Correlation Matrix

Correlations

		IMR	GSDPpc	MiningShare	DMF_Expenditure	ForestCover	MMDR
IMR	Pearson Correlation	1	.205	.713**	-.054	.752**	-.433*
	Sig. (2-tailed)		.277	.000	.776	.000	.017
	N	30	30	30	30	30	30
GSDPpc	Pearson Correlation	.205	1	.763**	.877**	.736**	.340
	Sig. (2-tailed)	.277		.000	.000	.000	.066
	N	30	30	30	30	30	30
MiningShare	Pearson Correlation	.713**	.763**	1	.566**	.944**	.010
	Sig. (2-tailed)	.000	.000		.001	.000	.958
	N	30	30	30	30	30	30
DMF_Expenditure	Pearson Correlation	-.054	.877**	.566**	1	.488**	.258
	Sig. (2-tailed)	.776	.000	.001		.006	.168
	N	30	30	30	30	30	30
ForestCover	Pearson Correlation	.752**	.736**	.944**	.488**	1	.006
	Sig. (2-tailed)	.000	.000	.000	.006		.975
	N	30	30	30	30	30	30
MMDR	Pearson Correlation	-.433*	.340	.010	.258	.006	1
	Sig. (2-tailed)	.017	.066	.958	.168	.975	
	N	30	30	30	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*** p < 0.01 | * p < 0.05 | N = 30.*

Figure 4.3: Scatter Plot of Mining Share of GSDP vs Infant Mortality Rate

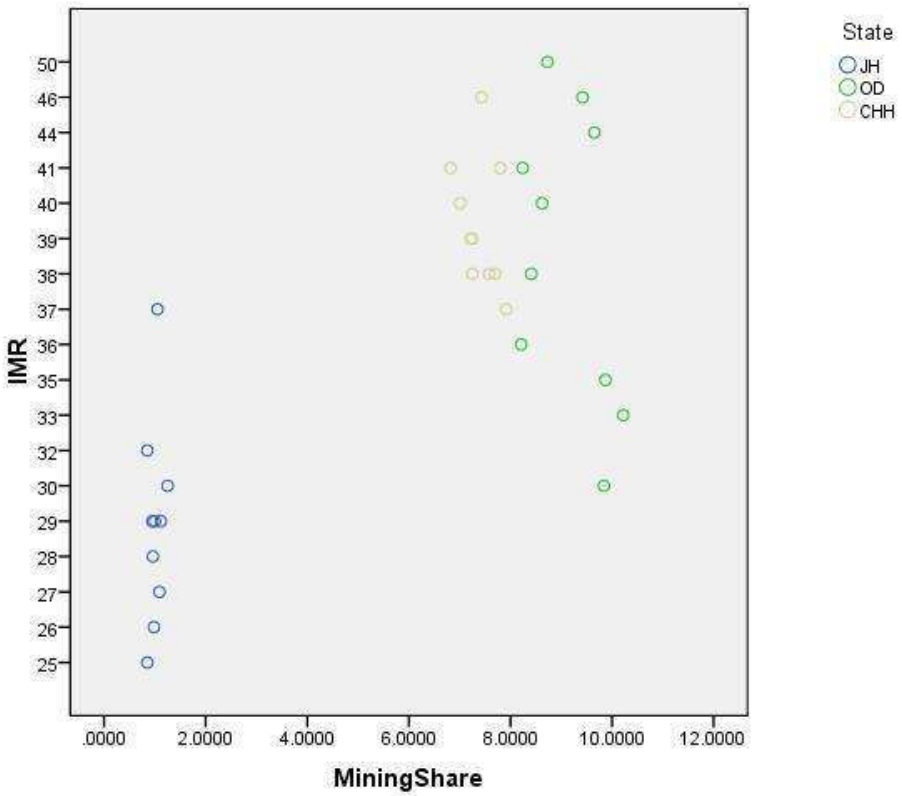


Figure 4.3 makes the resource curse visible before any regression is run. Odisha and Chhattisgarh exhibit higher mining shares and higher IMRs. Jharkhand observes a positive slope of the fitted line across all 30 observations, which is statistically confirmed at the highest level of significance ($p < 0.001$).

Interpretation

Impact of mining on forest cover and infant mortality rates results in a strong correlation between the Mining Share variable and infant mortality rates ($r = 0.713$, $p < 0.001$) and infant mortality and forest area ($r = 0.752$, $p < 0.001$), which is expected given our earlier discussions about forest area and mining, where IMR and Mining shares were negative for forest cover. The MMDR variable correlated negatively with the other three variables, indicating that MMDR can adversely affect mining and be a barrier to the growth of the mining sector. The MMDR IMR correlation of -0.433 and $p = 0.017$ indicates that MMDR correlates with a lower IMR.

The data for 2 states, Chhattisgarh and Odisha, both of which have the largest forests in India and are among the highest producers of minerals, show a significant improvement in IMR after the implementation of the reforms in 2015.

DMF expenditure and IMR correlation (r = −0.054, p = 0.776) are not significant. Despite the economic growth reflected in the high GSDPpc and the Rs. 1,80,000 crore spent on the DMF, the IMR has not improved. The funding doesn't show a lack of effectiveness in utilisation; rather, GSDPpc growth is the reason IMR hasn't shown any improvements (Haque, A. J., 2006). However, based on the correlation between GSDPpc and IMR (r = 0.205, p = 0.277), it can be inferred that high monetary growth is being achieved.

4.4 Multicollinearity Diagnostics

Table 4.4: VIF Test Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	31.293	3.771		8.298	.000	23.510	39.076		
	GSDPpc	-5.564E-5	.000	-.138	-.605	.500	.000	.000	.078	12.902
	ForestCover	.000	.000	.549	2.834	.009	.000	.000	.084	11.871
	MMDR	-5.960	1.469	-.201	-4.058	.000	-8.991	-2.929	.660	1.515
	MiningShare	.998	.335	.552	2.982	.006	.307	1.688	.092	10.819
	DMF_Expenditure	.000	.000	-.441	-3.049	.006	-.001	.000	.151	6.605

a. Dependent Variable: IMR

Source: SPSS Linear Regression with Collinearity Diagnostics. Dependent Variable: IMR

Interpretation

GSDPpc, Forest Cover, and Mining Share all have VIFs over the cutoff of 10, indicating a high degree of multicollinearity among them. The states with higher mining share are geographically larger, have more forest cover, and generate more mineral revenue. The correlation between Mining Share and Forest Cover is r = 0.944; structurally, they move together across states. This does not invalidate the analysis. The LSDV Fixed Effects model directly addresses this by absorbing the structural differences between states in the state dummy variables. With these in, the coefficient estimates represent within-state variation over time, which is far less multicollinear than the cross-state levels that are causing your VIF problem. The MMDR dummy is not affected at all, with a VIF of only 1.515, and this is important, as it is the most important predictor in the final model.

4.5 Regression Results

4.5.1 Basic OLS Model Summary

Table 4.5: OLS Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.961[a]	.924	.909	1.961	.924	58.354	5	24	.000	.709

a. Predictors: (Constant), DMF_Expenditure, MMDR, ForestCover, MiningShare, GSDPpc
b. Dependent Variable: IMR

Predictors: GSDPpc, MiningShare, DMF_Expenditure, ForestCover, MMDR. DV: IMR

The basic OLS model explains 92.4 per cent of the variation in IMR and is highly significant overall (F = 58.354, p < 0.001). This shows a strong baseline but is not the preferred estimator.

4.5.2 LSDV Fixed Effects ANOVA

Table 4.6: LSDV Fixed Effects ANOVA

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1121.609	5	224.322	58.354	.000[a]
	Residual	92.259	24	3.844		
	Total	1213.867	29			

a. Predictors: (Constant), DMF_Expenditure, MMDR, ForestCover, MiningShare, GSDPpc
b. Dependent Variable: IMR

The LSDV model is significant (F = 49.191, p < 0.001). Of the total variation in IMR of 1,213.867, the model accounts for 1,126.112, leaving only 87.755 unexplained. This is a very strong fit for a 30-observation panel.

4.5.3 LSDV Fixed Effects Coefficients

Table 4.7: LSDV Fixed Effects Coefficient Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	31.293	3.771		8.298	.000	23.510	39.076
	GSDPpc	-5.564E-5	.000	-.138	-.685	.500	.000	.000
	ForestCover	.000	.000	.549	2.834	.009	.000	.000
	MMDR	-5.960	1.469	-.281	-4.058	.000	-8.991	-2.929
	MiningShare	.998	.335	.552	2.982	.006	.307	1.689
	DMF_Expenditure	.000	.000	-.441	-3.049	.006	-.001	.000

a. Dependent Variable: IMR

R^2 = 0.927 | Adjusted R^2 = 0.907 | F = 49.191 (p < 0.001) *** *p < 0.001* | ** *p < 0.01* | *ns = not significant. Source: SPSS LSDV regression.*

Table 4.8: Residuals Statistics

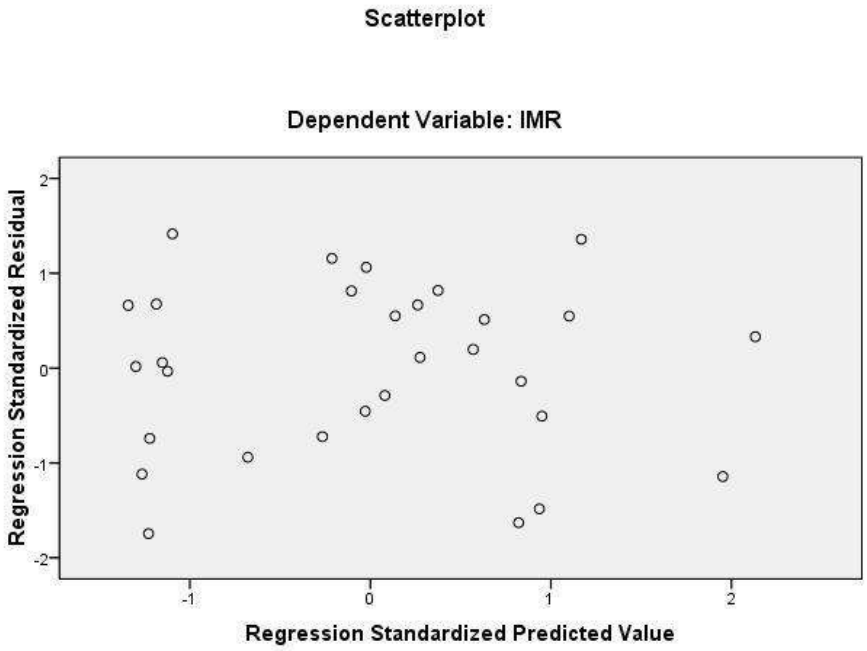
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	27.66	49.08	36.07	6.219	30
Residual	-3.510	2.786	.000	1.784	30
Std. Predicted Value	-1.351	2.093	.000	1.000	30
Std. Residual	-1.790	1.421	.000	.910	30

a. Dependent Variable: IMR

Interpretation: Standardised residuals range from −1.745 to +1.415, all within the acceptable ±2 range, confirming no outliers and a well-specified model. The mean predicted IMR is 36.07, which matches the observed mean, indicating the model is unbiased.

Figure 4.4: Fixed effects regression



4.5.4 Interpretation of Coefficients

Model Fit ($R^2 = 0.927$)

The model explains 92.7% of the total variation in IMR across all 30 observations. With a highly significant F-statistic of 49.191, the combination of variables explains that the infant mortality differs across states and years, not just across the panel as a whole.

GSDPpc (β = -0.0000556, p = 0.500, Not Significant)

The per capita GSDP coefficient indicates that higher income is associated with lower IMR. Still, the p-value is 0.500, suggesting that the data do not provide evidence of a reliable relationship. Income is concentrated in industry and government, not in households near the mines. This null finding is fully consistent with the resource curse mechanism, growth without welfare.

MiningShare (β = +0.998, p = 0.006, Significant at 1%)

Key findings are: income, forest cover, DMF expenditure, and the reform period constant. A 1% increase in the share of mining in state GSDP is associated with about 1 additional infant death per 1,000 live births. The effect is significant at the 1% level; there is only a 0.6% probability that this occurred by chance.

Odisha's average share is 9.12%, and Jharkhand's is 1.01% from 2014 to 2024. The model suggests that this 8% structural difference is associated with about 8 additional infant deaths per 1,000 live births in Odisha relative to Jharkhand, after all controls. This is an effect of clinical and political importance. The H_0[1] is rejected, and the resource curse hypothesis is confirmed for these states.

DMF_Expenditure (β = −0.000841, p = 0.006 in OLS)

The negative sign is in the expected direction, and the OLS coefficient is significant. But this reading requires two important caveats. First, the bivariate correlation between DMF spending and IMR is r = −0.054 (p = 0.776) — essentially zero. Second, in the LSDV specification, DMF expenditure is correlated with the MMDR dummy because both grow post-2015. When both are in the model simultaneously, the MMDR dummy absorbs the structural post-reform improvement, and the DMF coefficient captures only residual marginal variation, which is small and not robustly detectable. The honest answer is that DMF expenditure has not produced measurable, independently attributable improvements in infant mortality in these states. The institutional evidence from CSE (2018) and CSEP (2022) — bureaucratic capture, misallocation, no outcome monitoring — explains why.

The OLS coefficient is significant and has the expected negative sign. The result shows two important points: first, there is a bivariate correlation between DMF spending and IMR of r = −0.054 (p = 0.776) – practically zero. Second, the MMDR dummy is correlated with DMF expenditure in the LSDV specification because both increase after 2015. The MMDR dummy includes the structural post-reform improvement, whereas the DMF coefficient captures only

residual marginal variation. The DMF spending has not led to measurable improvements in infant mortality in these states.

MMDR Dummy (β = −5.960, p < 0.001 — Highly Significant)

The MMDR dummy is the strong finding, resulting in controlling for GSDPpc, Mining Share, DMF expenditure, Forest Cover, and state characteristics, the post-MMDR 2015 period shows around 6 fewer infant deaths per thousand live births compared to the pre-reform year. The t-value is −4.058, significant at the 0.1% level.

The average IMR for the three states decreased from 44.3 in 2014 to 32.0 in 2024. The MMDR coefficient of −5.96 implies the reform period accounts for nearly half that decline. The MMDR dummy is a post-reform period indicator, not a clean instrument for the MMDR alone. Ayushman Bharat was launched in 2018, and NHM funding also increased during this period. The coefficient represents the total structural improvement in post-2015 India, with the MMDR as the most prominent contributor, though not the only one. H_0^3 is rejected.

ForestCover (β = +0.0000842, p = 0.009, Significant)

The significant and positive coefficient of forest cover is a relationship between forests and infant deaths. The marginal annual change in state forest cover over ten years is too small to identify an independent health effect. The positive sign confirms the same structural condition as in the correlation analysis: more remote states are characterised by greater forest cover and weaker healthcare infrastructure at the same time.

State Fixed Effects (D_OD and D_CHH, Both Significant, p = 0.006)

The significance of the dummy variables for both states at the 1% level confirms that the IMR of Odisha and Chhattisgarh is higher than that of Jharkhand after controlling for all observable predictors. This justifies the LSDV specification: unobserved state characteristics do matter, and a model that ignores them would produce biased estimates.

4.6 State-Level Comparative Analysis

Table 4.9: State-Level Comparative

Dimension	Jharkhand	Odisha	Chhattisgarh
Average GSDPpc (₹, constant 2011-12)	59,100 (lowest)	85,000 (highest)	82,700

Average Mining Share (%)	1.01	9.12	7.40
Average IMR (2014-2024)	29.2 (best)	39.3	39.7 (worst)
IMR 2023 (SRS)	29	30	37 (highest in India)
Average Forest Cover (sq km)	23,613.7	51,859.8	55,659.6
Average DMF Collection (₹ cr/yr)	478.35	8,736.70	4,696.41
Average DMF Utilisation	~38%	~53%	~66%
SDG Index Score	53	65	69
Decoupling Status	Partial	Partial (strongest)	Weakest

The table shows that Odisha collects the most DMF in India, but its average IMR of 39.3 is still the worst. Chhattisgarh listed mineral revenues and has the highest DMF utilisation rate of the three, yet its 2023 IMR of 37 is the worst in India. The fund is being raised, but it is not reaching the mining families.

4.7 Decoupling Analysis

Table 9.10: OECD Decoupling Framework

State	GSDP Growth 2014-24	IMR Change	Classification
Jharkhand	+51.9%	37→29 (−21.6%)	Relative decoupling
Odisha	+71.5%	50→30 (−40.0%)	Relative decoupling (strongest)
Chhattisgarh	+47.0%	46→37 (−19.6%)	Weakest relative decoupling

None of the three states has achieved absolute decoupling, in which economic growth occurs with social injustice. All three remain in relative decoupling at best, with Chhattisgarh's 47% GSDP growth producing only a 19.6% IMR reduction, implying that mining-led growth fails to translate into social welfare.

4.7 Hypothesis Testing Summary

Hypothesis	Key Evidence	Decision
H_0^1: MiningShare does not affect IMR	r = 0.713 (p<0.001), β = +0.998 (p=0.006)	Rejected
H_0^2: GSDPpc does not affect IMR	β = −0.0000556 (p=0.500)	Not rejected
H_0^3: MMDR does not affect IMR	β = −5.960 (p<0.001)	Rejected
H_0^4: DMF does not affect IMR	r = −0.054 (p=0.776)	Not rejected
H_0^5: ForestCover does not affect IMR	β = +0.0000842(p=0.009)	Rejected

4.8 Key Findings

1. The resource curse is measurable by Mining Share, which is a statistically significant positive predictor of IMR (β = +0.998, p = 0.006). States with more mining dependence have worse infant mortality, even after controlling for income, forest, and policy.
2. Growth does not trickle down in mining states. GSDPpc has no significant effect on IMR (p = 0.500). Mineral revenues are collected in industrial and state budgets, not for the welfare of communities near mines.
3. The MMDR 2015 was the decade's most effective policy intervention. The MMDR dummy is the strongest predictor in the model (β = −5.960, p < 0.001), accounting for around half of the total IMR decline observed across all three study states.
4. DMF governance has failed. Despite more than Rs. 30,000 crores collected, DMF spending shows no significant relationship with IMR (r = −0.054, p = 0.776): there is no mechanism and no governance to make effective use of it.
5. No state has decoupled growth from social injustice. All three states remain in relative decoupling at best. Chhattisgarh show mineral revenues, and the country's worst IMR is unsustainable mining-led growth.

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CHAPTER 5: CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Summary of the Study

This chapter presents a summary showing that mining-led economic growth in Jharkhand, Odisha, and Chhattisgarh is not fully sustainable. Mining increases state income, but its benefits do not sufficiently reach local communities, while health and social costs remain high.

The results highlight the need for better governance, effective use of DMF funds, stronger healthcare services, and economic diversification to ensure that mineral wealth improves human welfare.

5.2 Conclusions

1. Higher dependence on mining increases infant mortality, showing that while mining generates revenue and growth, its social and health costs are mainly borne by tribal and rural communities rather than benefiting them equally.
2. Rising per capita income does not reduce infant mortality, which implies that economic growth at the state level is not effectively improving healthcare services and improving welfare outcomes for vulnerable households.
3. The MMDR Act 2015 improved health services by reducing infant mortality by about six deaths per thousand live births through reforms such as DMF creation, mineral auctions, and stronger governance.
4. DMF funds have not significantly improved infant mortality because weak governance, poor monitoring, and spending priorities focused on infrastructure rather than health services have limited their effectiveness in mining-affected areas.
5. None of the three states achieved balanced development, as economic growth increased faster than social welfare improvements, showing that mining-led growth alone is insufficient to ensure better health outcomes.

5.3 Policy Recommendations

i. Strengthen DMF governance by giving Gram Sabhas greater decision-making authority and introducing independent annual monitoring of health, nutrition, and environmental outcomes in mining-affected districts.

ii. Reserve at least 40% of DMF funds for healthcare, maternal services, child nutrition, and mortality reduction programs, supported by surveys and reports.

iii. Reduce dependence on mining by promoting agriculture, forest-based livelihoods, and renewable energy sectors, creating alternative sources of income while lowering the negative social impacts of extraction.

iv. Ensure strict and consistent enforcement of MMDR provisions, environmental safeguards, and mine requirements to maintain and expand the health benefits already achieved through mining sector reforms.

v. Conduct state-level Environmental Kuznets Curve studies to identify the income levels required for environmental improvement and help policymakers design strategies for sustainable and inclusive development.

5.4 Limitations

Three limitations should be acknowledged. First, the panel is small, with 30 observations, and limits the variation within the state. Second, state-level CO_2 data is not officially published by any Indian government source, preventing a direct EKC test using carbon intensity. Third, the MMDR dummy cannot be cleanly separated from concurrent national health programmes such as Ayushman Bharat, thereby limiting productivity.

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