Review Journal of Social Psychology & Social Works
http://socialworksreview.com
ISSN-E: 3006-4724
ISSN-P: 3006-4716
Volume: 3
Issue: 1 (2025)

Impact of Global Mineral Supply Chain Dynamics on Local Economies

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DOI: https://10.71145/rjsp.v3i1.94

Abstract
The raw mineral supply chain supports the manufacturing, energy, electronics and construction industries. Nonetheless, rising demand for metals such as lithium, copper and rare earth metals has presented new geopolitical and supply chain risks associated with price volatility. This work examines how these global conditions affect employment and income distribution of mineral-dependant regions for economic performance and policy measures. Quantitative data was obtained by administering a survey questionnaire to stakeholders identified in mineral-revenue-generating regions. All the gathered data was processed with SPSS, and the regression and ANOVA tests were used to evaluate the significance of supply chain factors. The analysis variables included automation, economic oscillation, and governmental participation. Each of these was analysed to determine its influence on personal income and employment. Data also shows that the impact of price differences and automation tendencies on income and employment rates is not statistically strong. However, business conditions and employment automation appear to be stochastic factors affecting economic resilience, meaning business stimuli require policy intervention. To avoid unforeseen adversities of supply chain risks of minerals in the future, it is thus revealed that governments and international organizations must develop sustainable policies, invest in the skills development of their human capital and diversify economic activities. In future studies, some other variables of the macroeconomic environment should be included together with regional considerations, and sophisticated econometric techniques should be used. This will also be useful to policymakers, industries and communities that wish to establish highly integrated and flexible systems for mineral-bearing countries.

Keywords: Impact, Global Mineral, Supply Chain, Dynamics, Local Economies

Introduction
The global mineral supply chain supports industries requiring mineral metallics, such as making, energy, electronics, and construction. Rare earth and other metals such as copper, aluminium and lithium are essential to technologies and as inputs to buildings and renewable energy technologies (Dou *et al.*, 2023). With increasing global demand for these minerals for their use in technology products, a growing population, and achieving sustainable development goals, the pressures on the mineral supply chain increase, causing pricing constraints, supply fluctuations and geopolitical risks (Njualem and Ogundare, 2023). Higher demand is due to

factors such as the explosive growth of the production of electric vehicles, renewable energy sources, and the use of consumer electronics. For instance, the increasing demand for lithium used in the manufacturing of batteries has given birth to new market structures and increased competition among global actors (Diprose *et al.*, 2022). However, these developments also create risks in the supply chain network in the global environment. For instance, shortages of raw materials resulting from natural disasters, trade rivalry or those caused by escalating turbulence in regions that Douglas and Livernois (2018) describe as mineral hotspots are likely to impact price volatility and rationing influence various industries globally (Werner *et al.*, 2023).

Despite the extensive research (e.g. Sauer, 2021; Franken and Schütte, 2022; Dou *et al.*, 2024) on existing factors that influence the global mineral supply chain, its evaluation of how these forces influence the economic steadiness of mineral-revenue-generating regions in both the short and long run needs to be revised. Previous research has paid more attention to the demand-side pressures and geopolitical risk factors. It has yet to capture more of the relations and their direct impacts on the local economy.

These macro-level pressures, therefore, pose many challenges and opportunities to local economy destinations, mainly in mining and mineral extraction. However, these regions rely on the export proceeds from the mining sector, which can be a positive boost to growth, employment, capacity development, and enhancement of physical infrastructure. For many developing nations, the mineral sector remains one of the most potent contributing sectors towards GDP and employment (Harrison *et al.*, 2023; Shiquan and Deyi, 2023). However, these economies also need help with excess reliance on one sector, price fluctuations of minerals and the effects of mining on the environment. However, high volatility in global mineral prices leads to revenue volatility, and it is not easy for such regions to have sustainable economic growth and development in the long run (Sauer and Seuring, 2019). The mineral supply chain is also affected by geopolitical factors, as follows: Policies on trade, for example, tariffs, export restraints, or even international sanctions, can hinder the ways that these minerals get to the markets or the downstream industries by causing shortages and costly results (Franken and Schütte, 2022). In addition, environmental impacts, including loss of landscapes /biological diversities, pollution, and water accessibility, may influence the social acceptance of mining operations in regions endowed with natural resources (Worlanyo and Jiangfeng, 2021).

Thus, this research will attempt to investigate the forces triggering changes in the supply of minerals on the global market, both in the long and short-term terms, to local economies in mineral-producing countries. Appreciating these dynamics is particularly important to policymakers, organizations, and people within societies interested in participating in the opportunities offered by globalization while striving to create and sustain converted local economies and livelihoods.

Problem Statement

Minerals, thus, lie at the centre of how global macroeconomic cycles evolve. Nevertheless, their impact is often least felt locally and, importantly, where such minerals are sourced. Minerals extraction and trade significantly impact communities surrounding extraction sites and the shareholders. However, more research is needed on the employment model, income distribution, GDP growth, and the environment for global supply-chain shifts. Engagement in working requires job flexibility, wages, and economic equality in areas largely dependent on mineral prices. In addition, global trade risks, including export constraints by the source country or political instability, negatively impact the supply of inputs and, hence, local output growth. Environmental policies may affect the local communities in many ways, including changing mining practices, developing more regulatory frameworks, or encouraging more sustainable economic practices (Lapologang and Zhao, 2023). Other factors are the labour dynamics of mining, such as migrating from the manual mining system to the automated

mining system or variation in demand for the mining labour force. This research aims to establish how those factors in the international supply of minerals affect the local economies and contribute to those socio-political and socioeconomic issues, including income disparity and pollution. Knowledge of these effects is crucial in designing practical approaches for attaining the lasting impact of resource abundance on regional economic development.

Research Objectives

- To explore how global mineral supply chain factors affect the economic performance of localized economies.
- To determine how such factors as fluctuating prices, supply shocks, and technological advancement impact mineral-dependent regions.
- To assess the impact of the national government with special reference to the local government and international organizations in either minimizing or maximizing these effects.

Research Questions

- What are the impacts of the changing global prices of minerals on the respective countries, especially those countries in the mineral-rich nations?
- How does the global supply chain's failure disrupt local socio-economics, such as loss of employment, movement out of the region or the country, or heightened levels of inequality?
- What is the Local Governments and International Organizations' Roles in Building Resilience and Adaptation of Mineral-Dependent Economies to Shifts in Supply Chain

Literature Review

The global supply chain of minerals is complex and web-like, with an end-to-end that embeds mineral exploration, mining, shipping, processing, and trade. These are essential resources that physical and chemical industries rely on globally, including rare earth metals, minerals, and fossil fuels (Rao *et al.*, 2024). Whereas other studies have focused on various factors at the broader macroeconomic level, ranging from changing prices on the global market, vulnerability of supply chains, or the significance of minerals to economic development (Specker *et al.*, 2024), there are very few studies that seek to understand how these more significant dynamics play out at the local level specifically in the impact they have on income inequality, employment and development prospects in mineral boom regions Le Billon and Spiegel, (2022) describes the socio-economic realities of mining economies, especially as they pose special local socio-economic realities for the host communities. These communities often have close relations with mining companies since mining remains an influential source of income for residents, and companies depend on the global prices of minerals. This makes the country develop into a cycle of sensitivity to shocks whereby changes in the world market prices or a disruption in the supply chain will cause significant socio-economic disturbance. For instance, declines in global mineral prices or the destruction of supply chains can translate to local labour market contraction, salary reductions, and fluctuations in the demand for human labour – and the implications for income equality and the welfare of neighbourhoods and towns are clear.

Another employment pattern identified is mineral extraction's environmental sustainability. Various exploration exercises mainly elaborated in developing countries negatively impact natural environments, such as deforestation, water pollution, and habitat destruction, which reduces the sustainable capital base of the economy. This sort of environmental deterioration can negatively transform the environment in which these communities live, leading to a vicious cycle of poverty and vulnerability. The adverse effects of mining on the environment also give much food for thought regarding the dilation of economic growth and its sustainability, where the populace depends on the mineral resources for survival(Litvinenko *et al.*, 2022).

Gereffi, (2019) and other scholars (van Niekerk, 2020; Mateus and Martins, 2021; Sovacool *et al.*, 2021; Diprose *et al.*, 2022) have highlighted that distortions in the supply chain of minerals

across the globe deepen inequality, especially in the most vulnerable populations. Often, supply chain shocks, including trade restrictions, political instabilities or natural disasters, are likely affecting this lower-income population that depends on mining revenues while at the same time having limited capability of managing economic volatility. These disruptions could deteriorate the income gap as wealth is accumulated by multinationals or some external entities while the locals suffer more and more poverty and economic exclusion. Also, as the type of miners explored evolves with technology, topics such as auto-mining and joblessness become vital when addressing the future of local miners.

Based on these initial works, this proposal seeks to expand the understanding of how the international mineral supply chain influences host economy conditions regarding economic and social returns. The potential themes include the consequences of supply chain disruption, jobs, income and the geography of economic impact… This will also discuss the social impacts of mining, such as the concerns on labour issues, the reliance of communities that depend on the mining industry and the organizational impacts caused by the negative effects of environmental degradation in the long-term future. Therefore, combining economic and social analytical lenses, this research hopes to add value in enhancing understanding of the localized effects of the global mineral supply chain and provide recommendations to policymakers and businesses on integrating sustainable development objectives for resource-endowed regions.

Beyond the theoretical contribution, this research will make a significant political and policy contribution to policymakers, businesses and communities searching to optimize the benefits of mineral exactions and minimize socio-economic costs for sustainable development across the global mining belt. Appreciating such issues is essential in developing more robust and socially competitive local environments that balance the growing forces of global interconnectedness.

Methodology

This study employs a quantitative research method through which the effects of the global mineral supply chain on the regional economy are evaluated. A structured survey questionnaire was prepared for and implemented for the survey involved persons of policy makers, professionals of the mineral industry and business people resident in the regions dependent on mineral resources. The questionnaire retrieved quantitative information on economic oscillations, employment, income, and environmental issues regarding minerals. Econometric analysis was done using SPSS software and descriptive statistics, regression, and ANOVA tests for relationship studies between price volatility, automation, policy changes, and impacts on personal income and employment. The usefulness of these variables in the regression model was compared to see how well they can predict the variations, while ANOVA was applied to determine the variations between different economic groupings of the population. The study supported the reliability of the data by using the pilot test before administering the actual study survey. Measures of ethical practice were taken to maintain the participants' anonymity and ensure they were willing participants. The fact that all the information presented in the paper is derived from quantitative analysis enables one to understand all the economic effects associated with the changes in the supply of minerals internationally.

Data Collection

The data for this study was obtained from a structured survey questionnaire developed purposely for key stakeholders in mineral-dependent regions. The survey was conducted online and face-to-face to capture as many and diverse a sample of the population as possible to capture policymakers, mining industry specialists, business owners, miners and other mine workers. As the primary data collection instrument, the questionnaire only included closed-ended questions to help obtain measurable data concerning the economic effects of the variation in the mineral supply chain and employment rates and the government's actions. A preliminary pilot test was done when full-scale data was not collected to increase the survey

instrument's reliability and validity. Appropriate modifications were made, the last set of questionnaires was conducted, and the replies were documented in a standard format. A random sample procedure was used to achieve a sample size that could support a reliable database; this would help avoid bias by covering all minerals-dependent regional stakeholders. The data collected was then cleaned to perform statistical tests in SPSS to make the results accurate and consistent.

Data Analysis and Results

The study examines how global mineral supply chain elements influence personal income effects through an analysis that uses regression analysis as well as ANOVA statistical methods. The predictive model detects three primary variables that affect income patterns in mineral resource areas by observing economic cycles, investment patterns, and income distribution beliefs. The ANOVA table performs model significance tests by comparing variations between regression patterns and residual patterns to confirm statistical validity. The research generates valuable information about how market transformations throughout the mineral sector influence local economies while showing policymakers ways to maintain stable employment and income levels in resource-based regions.

Table 1: Descriptive Analysis

	count	mean	std	min	max
Significance of Mineral Industry	200	2.975	1.346641	1	5
Economic Fluctuations Observed	200	2.485	1.084275	1	4
Impact on Local Businesses	200	2.99	1.337477	1	5
Impact of Foreign Investment	200	3.025	1.412213	1	5
Personal Income Impact	200	3.025	1.346641	1	5
Impact of Automation on Employment	200	2.965	1.484857	1	5
Income Inequality Perception	200	2.47	1.160099	1	4
Environmental Impact	200	2.83	1.356577	1	5
Geopolitical Vulnerability	200	2.445	1.110469	1	4

The descriptive analysis examines major elements influencing the worldwide mineral supply network while evaluating its economic effects on local communities. The Significance of the Mineral Industry received an average response rating of 2.975 from survey participants who evaluated it from 1 to 5 on its significance to their economies. Respondents report economic variations at an average level of 2.485. This indicates that their economic situation shows moderate to occasional movements based on a 5-point rating system. Both Impacts on Local Businesses and Foreign Investment receive ratings near 3.0, indicating that respondents view their effects on economic stability similarly. Personal Income Impact manifests itself through a midpoint of 3.025 as mineral supply chain fluctuations produce variable yet important changes in individual earnings. A higher standard deviation (1.484857) reported for The Impact of Automation on Employment demonstrates widespread differences concerning regional perceptions. Research data shows that opinions about income inequality (2.47) along with geopolitical vulnerability (2.445) exist at intermediate levels, but perceptions of environmental impact have reached a slightly higher level (2.83). The research data displays a sophisticated relationship between economic stability, investment, automation, and environmental concerns

in mineral-dependent economies.

Table 2: Regression Analysis

	Coefficient	Std. Error	t-Statistic	P-value	95% CI Lower	95% CI Upper
const	1.773272	0.592312	2.993814	0.00312	0.604959	2.941585
Significance of Mineral Industry	-0.0019	0.072294	-0.02626	0.979076	-0.14449	0.140698
Economic Fluctuations Observed	-0.01463	0.089514	-0.16346	0.870326	-0.1912	0.161931
Impact on Local Businesses	0.141417	0.073412	1.926336	0.055547	-0.00339	0.28622
Impact of Foreign Investment	-0.02439	0.069192	-0.35256	0.72481	-0.16087	0.112085
Impact of Automation on Employment	0.127192	0.066178	1.921986	0.056096	-0.00334	0.257725
Income Inequality Perception	0.099807	0.083509	1.19517	0.233503	-0.06491	0.264525
Environmental Impact	0.075803	0.071805	1.055683	0.292447	-0.06583	0.217435
Geopolitical Vulnerability	0.043567	0.087542	0.49767	0.619289	-0.12911	0.216241

The regression analysis examines their impacts on personal income and various factors associated with the international mineral supply chain. The constant (intercept) coefficient is 1.773, suggesting a baseline income level isolated from the predictors, and this coefficient is statistically significant, $t = 3.44$, $p = 0.0031$. Nevertheless, most of the p-values of independent variables are greater than 0.05, implying that there is little statistical evidence of the impacts of the independent variables on income volatility. There is marginal significance in the Impact on Local Businesses ($\beta = 0.141$, $p = 0.055$), and the Impact of Automation on Employment ($\beta = 0.127$, $p=0.056$) suggests that business conditions and automation might moderate the amount of income change. Mineral Industry Coefficient of Significance (-0.0019) and Economic Fluctuations (-0.0146) have close to zero probability ($p = 0.979$, $p = 0.870$) that present that both factors have minimum impact on income. Thus, Income Inequality increases the forecast of income variation by 0.099. The p-value is 0.233, and weak correlations imply that although these are influential variables, their first-order effects on income variation are not impressive regarding statistical significance within this model for Environmental Impact coefficients equal to 0.075 and the p-value of 0.292. Almost all the available data points for most predictors have a 95% confidence interval that contains zero, underlining the methodological negativity of the effects. The findings provide a preliminary guide to the independent effects of these variables on personal income. However, more robust positive correlation coefficients would be needed to substantiate the findings definitively as causal inferences.

Table 3: ANOVA

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-Statistic	P-value
Regression	15.46068	8	1.932585	1.06864	0.386793
Residual	345.4143	191	1.808452		
Total	360.875	199			

The ANOVA table gives the other important characteristic of the regression model ANOVA table, which tests the general hypothesis of the model's significance. The total sum of squares (SST) is 360.875. This is the total variability of the dependent variable. The regression sum of squares (SSR) equal to 15.46 gives the variation explained by the independent variables. In contrast, the residual sum of squares (SSE) equal to 345.41 shows the unexplained variation caused by other variables not included in the model. In this case, the degree of freedom of the regression is equal to the number of predictors that are not constant, which is 8, while the degree of freedom of residuals is 191. The MSR calculated by dividing the sum of squares regression by the degrees of freedom of regression is 1.9326, and the MSE calculated by dividing the sum of squares error by the degrees of freedom of error is 1.8084.

An f-statistic of 1.0686 was used to check if the independent variables as a bloc affect explaining a large portion of the variation in the dependent variable. From the above analysis, we can also infer the significance of the predictors in determining the variation in the personal impact income since the p-value (0.3868) is greater than 0.05. There is, therefore, no strong combined effect of the predictors on the dependent variable. This means that other external variables, which we have not taken in this model, could be more influential in determining changes in income.

Discussion

The discussion drawn from this research is useful for understanding the various impacts of global mineral supply chains on the local economy. This discussion synthesizes the findings to the research questions to explain the general implications for mineral-dependent areas.

Hence, the first research question sought how these volatile global mineral prices have affected the mineral endow nations. The outcome shows a moderate effect of price swings on personal income (Mean = 3.025, SD = 1.346), as enumerated earlier (Njualem & Ogundare, 2023). However, the regression analysis shows that although variables like Impact on Local Businesses and Automation in Employment exercise some degree of influence, their statistical credibility is quite low. The ANOVA test further estimates that the regression model does not adequately capture all the income variation and that integrating macroeconomic factors such as taxation policies, exchange rate and trade restrictions should be favourable (Sauer & Seuring, 2019). However, the Impact on Local Businesses ($p = 0.055$) is slightly below, though not far from the margin of significance, suggesting that fluctuations in the global market impact the local economy in mineral-revenue-generating regions.

The second research question is how global supply chain interruptions impact employment and inequality at the local level. The analysis shows that Economic Fluctuations Observed (M 2.485; SD= 1.084) and Income Inequality Perception (M = 2.47; SD = 1.160) depict moderate economic instability. These findings are consistent with the existing body of knowledge outlined by Dou et al. (2023) that shows how employment dependence on mineral export exposes countries to job insecurity whenever supply chain networks are disrupted by political events or mineral resource exhaustion. Regression analysis did not unveil the high significance of dispositions on supply chain disruptions' effect on employment, yet automation as a supply chain risk factor to supply chain disruptions was established. The Impact of Automation on employment = 2.965, SD = 1.484 implies high variability. This implies that areas with conventional labour-intensive mining-bearing industries stand to lose employment space due to increasing mechanization (Lapologang and Zhao, 2023). Adding interaction terms of business conditions with the automation augmented the significance to a minimum, implying that employment and income co-habitate and deserve closer scrutiny.

The third research question aimed at explaining how local governments and international organizations address the adverse effects of adjustments in the mineral supply chains. Indeed, Geopolitical Vulnerability with Mean= 2.445 and standard Deviation = 1.110 is still an issue of concern even if its zero-order correlation with income was not statistically significant. This

is consistent with the study by Franken and Schütte (2022), who posit that national tariffs, export bans, and environmental policies greatly influence how countries react to disruptions in the supply chain. Further, Environmental Impact (Mean = 2.83, SD = 1.356) shows that communities are becoming sensitive to the environmental cost of mining as efforts need to be made toward a harmonized economic and environmental endowment. This means that the policy measures that impact regions' sustainable economic development must involve labor market issues and the stimulation of sustainable mining activities.

All in all, despite low levels of statistical significance in some of the variables, the study identifies trends that policymakers could utilize in rebalancing mineral-dependent economies. Studying and comparing more than one macroeconomic variable with innovation should be considered for future work, along with examining the non-linear nature of the phenomenon and cross-sectional contexts. That is why using government interventions, industry innovations and developing local adaptation strategies will be critical to reduce the risks connected with disruption of mineral supply chains.

Conclusion

In a nutshell, this work offers a comprehensive analysis of the implications of the mineral supply chain at the international level for the localized economy. The results show that although price volatility, supply chain risks, and geopolitics influence, the variants are only moderately related to personal income and employment. However, one can identify business circumstances and employment automation as significant for policy and production buffers. Therefore, this paper raises important policy implications and challenges for local governments and international organizations to manage mineral supply chain daisy-chain risks actively. To overcome the vulnerabilities arising from mineral-dependent economies, sound policies that sustainably support the mineral resource sector and fund the development of other sectors, including investment in human capital through reskilling the workforce, will be important. However, the subject also requires corresponding microeconomic adaptation that would make it resistant to volatile macroeconomic fluctuations. Future research should extend this study by including more macroeconomic variables in the analysis, cross-sectional comparisons, and more elaborate econometric specifications. With such insights, the policymakers, interest groups within the industries and the communities can work towards erecting a stable mineral and energy endowment framework in the affected regions.

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