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Editorial

50 years of *Resources Policy* – What is next? Key areas of future research

A B S T R A C T

In 2024, *Resources Policy* reaches its 50th anniversary as a journal. Fifty years leading the field of mineral and fossil fuel policies and economic research worldwide. Considering this special milestone, we provide a forward-looking view in this paper, highlighting seven areas we believe are critical for robust research that *Resources Policy* should publish in the future. Leveraging our research expertise and knowledge with the journal, these seven areas of future research include implications of post-mining and energy transitions, the dark side of critical minerals, the increasing substitution of local labour by alternative inputs, the role of the resource curse in resilience considerations, the cleaner production role of mining, macroeconomic frameworks, and the future of mining beyond mines (deep-sea and space mining). We believe more research is needed in these seven research areas, which can enhance our understanding of critical aspects, reduce uncertainty, and provide novel ways to address societal, environmental, economic and policy challenges related to the extraction and use of minerals and fossil fuels.

> Resources Policy *is … devoted to the economics and policy issues related to mineral and fossil fuel extraction, production and use. The journal content … analyses issues of public policy, economics, social science, geography, and finance in the areas of mining, minerals, fossil fuels and metals.*
>
> *(Resources Policy Aims and Scope, 2024)*

1. Introduction

In 2024, we celebrate the 50th Anniversary of *Resources Policy*, a journal that began in 1974 with a vision to shape the landscape of mineral and fossil fuel policy research. From its inaugural issue featuring eight articles, the journal has evolved significantly, reflected by a substantial increase in its readership, impact factor, editorial board, and breadth of extensively covered topics.

Academically, there has been a significant change in the journal's impact in the last couple of decades. Primarily focused on economics and policy issues related to the production and use of minerals and fossil fuels, the journal has filled a crucial niche in the academic landscape. Over time, it has attracted a rapidly expanding stream of papers on crucial topics relating to sustainability and the resources sector, including socio-economic impacts, project evaluation, the resource curse, corruption, regulation, regional development, and the impact of resources on Indigenous communities. Since the early 2000s, the journal has gone from an impact factor of under one to an impact factor of over 10 in 2023, with an increasing number of published papers. Although such trends are not uncommon across some high-impact scientific journals in the last decades, the impact factor growth of the journal has been remarkable for an outlet with a narrow scope focusing on the dynamics and impacts of a few industries (minerals and fossil fuels) instead of generalized journals that cover entire dimensions of research, such as environment or energy.

Given the journal's significant growth in the academic community and its use by industry and policymakers, this paper expands on what we believe are key prospective research directions that could further influence the policy and economics of mineral and fossil fuel extraction. To do so, we highlight seven key research areas within the journal's scope that we believe are extremely important to expand our understanding of.

Commemorating the journal's 50th Anniversary, this paper complements the bibliometric analysis presented by Campbell et al. (2024). While the bibliometric analysis provides a comprehensive summary of key past authors, institutions, papers and topics, this paper provides a 'forward-looking' analysis by highlighting what we believe is crucial research to expand on.

2. Seven areas crucial for future mining and fossil fuel policy and economic research

This section identifies critical topics and outlines significant research gaps that merit further investigation. We anticipate that future editions of *Resources Policy* will publish high-quality articles on these areas, which should not only fill research gaps but also extend scientific influence beyond academia, potentially impacting policy, industry practices, and community outcomes.

2.1. Fossil fuel-dependent economies, mine closure and transitions

Transitioning away from fossil fuels is critical in addressing climate change threats. This shift offers substantial global benefits, but fossil-fuel-dependent countries and regions face disproportionate economic challenges (Raimi et al., 2023), many of which are already being dealt with in coal-producing regions worldwide. For instance, in only five years (2011–2016), US coal mining employment declined by nearly 50 percent, with 20 coal counties experiencing a total wage earnings loss of more than 19 per cent (Weber, 2020). To manage a just and equitable green-energy transition, it is crucial to implement policies that help these communities diversify their economies and find new revenue

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streams to support essential public services. The "Inflation Reduction Act" of 2022 in the US, which includes subsidies and incentives for coal-dependent communities, exemplifies such initiatives. However, there is a pressing need for research to optimise the design and effectiveness of these policies, ascertain their best implementation locales and timings, and optimally restructure public finance in transition economies.

Moreover, the anticipated closure of at least 400 mines globally by 2034—including many coal mines due to reduced demand for thermal coal—presents another set of challenges and opportunities (Measham et al., 2024). The trajectory of coal mining varies significantly across different regions, with marked differences between the uses and long-term needs of thermal and metallurgical coal. New coal power plants are still being commissioned in countries like China, India, and Indonesia (Kong and Gallagher, 2021; Cui et al., 2021). In contrast, the closure of 166 coal-fired power plants in the US between 2009 and 2017, alongside planned closures in Europe and South Africa, highlights the diverse nature of coal mining's future (Haggerty et al., 2018; Burke et al., 2019; Cole et al., 2023; Śniegocki et al., 2022). Understanding these varied pathways is vital for crafting informed policies and research initiatives.

It is not uncommon to find mine closures not happening properly or at all, leaving surrounding communities to face enduring environmental and health hazards. In places where operators have set aside financial assurances for closure, governments have leverage and resources to prevent or address improper abandonment of mines (Gerard, 2000). Yet, how effective or adequate are existing financial assurances? What policy approaches best ensure that post-mining communities are not handicapped as they seek to chart a new economic course? Similar challenges exist for oil and gas wells, which operators can improperly abandon, particularly during times of low prices that force companies into bankruptcy (Weber et al., 2021).

The shift towards closure and post-mining transitions necessitates a broader integration of diverse disciplinary perspectives, moving from localised site-specific studies to broader regional analyses. This includes addressing the biophysical, social, and economic dimensions of mine closures and engaging with various stakeholder values (Arratia-Solar et al., 2022). Frameworks and empirical studies focusing on how these closures are managed (across regions and countries) are crucial. However, too much of the research on mine closure and transition tends to be siloed, so more and better integration among different disciplines, including robust empirical assessments and transitions, is needed (Measham et al., 2024). In addition, it is arguable that the best time to ensure proper mine closure is before the mine is permitted and developed. Thus, lessons learned from coal mine transitions are likely relevant for getting governance of new "critical minerals" mining right from the beginning.

2.2. The dark side of "critical minerals"

"Critical minerals" such as copper, lithium, cobalt, and rare-earth elements are fundamental for various modern technologies and renewable energy solutions, including electronic devices, electric vehicles, wind turbines, and solar panels (Hayes and McCullough, 2018; Sturman et al., 2022).[1] Due to their unique properties, these minerals are considered irreplaceable in today's advanced and eco-friendly technologies (Islam et al., 2022; Hund et al., 2023). As global efforts to transition toward a low-carbon economy intensify, the demand for these essential energy transition minerals is projected to rise sharply, emphasising the important need for the mining industry to expand sustainably and innovatively (Calderon et al., 2024; Sovacool et al., 2020).

However, the sustainability of extracting and exploiting such critical minerals presents a complex challenge (Lèbre et al., 2020). The processes involved are often associated with high environmental and social costs, including large-scale environmental damage and serious human rights violations, such as child labour in mining operations (Sovacool, 2019). These issues highlight a global governance gap concerning the supply of these materials and cast a shadow over their pivotal role in green technologies and just transitions.

Addressing the sustainability of critical minerals requires a nuanced understanding of the interplay between technological advancement, environmental protection, mining areas, economic prosperity, and social equity. Researchers are key to enriching this debate by providing valuable data, insights and strategies that promote a more sustainable and equitable approach to mineral exploitation (Arratia-Solar and Fleming-Muñoz, 2024). Critical areas for research include analysing the complete value chain of these minerals from extraction to processing, exploring the political economy of their supply and demand, providing more and better data and frameworks for regulation and monitoring of mining expansions, and understanding how geopolitical considerations influence global alliances and conflicts (Sovacool, 2019).

Additionally, there is a pressing need to increase transparency and record current mining practices in relation to environmental and labour standards to characterise and quantify the environmental costs versus the benefits provided by these minerals, such as employment and carbon emissions reduction from traditional fossil fuels. Also, developing forecasting models for these minerals' future demand and supply is crucial, incorporating economic dynamics, technological changes, and market uncertainties.

Finally, examining and improving the governance of mineral resources is essential (Sturman et al., 2022). This involves exploring strategies that resource-rich economies can employ to maximise local value addition and avoid the pitfalls of the resource curse, thereby ensuring that these minerals contribute positively to resilience and sustainable development (see also section 2.6).

2.3. The increasing decoupling of the local labour force with mining activity

Despite the increasing capital intensity of the mining industry, labour continues to be a pivotal element for economic development in mining regions, facilitating employment, wage distribution, and knowledge transfer. However, the organisation of the labour force in the mining industry has undergone significant changes due to pressures to cut costs, navigate price cycles, and enhance productivity, alongside adapting to digital and energy transitions.

Technological modernisation initiated in the 1980s and 1990s, propelled by persistently low mineral prices, led to increased subcontracting and transformed the industry into a global production network (Humphreys, 2015; Morris et al., 2012; Bridge, 2008). This evolution was further amplified by the mining commodities price supercycle between 2002 and 2011 and later by what Baldwin (2019) described as the third wave of globalisation through automation and remote work, a shift accelerated during the COVID-19 pandemic (Storey, 2023). These transformations underscore several research gaps in understanding how outsourcing and automation impact mining productivity, safety, and health (Humphreys, 2020; Onifade et al., 2023), the required skill shifts, the inclusion of women in the industry (Lööw et al., 2019; Campero et al., 2023), and the broader implications of digitalisation on job security and the capital-labour relationship (Ellem, 2016).

Additionally, the increasing trend of long-distance commuting (LDC) has progressively distanced mining workers from their traditional communities, altering the socio-economic dynamics of mining regions (Manky, 2017; Atienza et al., 2020; Palomino and Sarrias, 2019; Paredes

[1] The quotation marks highlight the overuse of the term 'critical minerals' in current mining trends. Using this term in urgent discussions about sustainability and net-zero goals can increase risks for ecosystems and populations near mine sites, as the 'criticality' of supply can be used to greenwash and fast-track costly mining projects (Arratia-Solar and Fleming-Muñoz, 2024).

et al., 2018; Aroca and Atienza, 2011; Prada-Trigo et al., 2021; Rehner and Rodríguez, 2021; Storey, 2016). Future research needs to explore the efficiency of LDC and its effects on how the mining industry is perceived and legitimised in local communities, as well as the effectiveness of local content policies in mitigating the negative impacts of these labour changes. It also highlights the need for research to better understand better the mismatch between local workforce development and industrial labour demand trends.

The rapid advance of digitalisation, including remote work and increased automation, is also reshaping labour organisations in the mining industry. While the full implications of this shift are yet to be determined, digitalisation is expected to increase LDC, impact local employment opportunities, and possibly create spatial inequalities (Paredes and Fleming-Muñoz, 2021). Future studies should investigate optimal labour arrangements that balance the interests of mining companies, workers, and communities, assess how automation influences both mining and non-mining regions, and explore how the value generated in mining areas is distributed and what redistribution policies might be needed to compensate the regions hosting mining operations fairly (Wang, 2020).

2.4. National, regional and local resource curse and economic resilience

The resource curse has been a topic widely studied and explored (Auty and Furlonge, 2019). Many studies attempt to evaluate whether it exists across countries (for a comprehensive review, see van der Ploeg, 2011), while much less studies have focused on evaluating it within countries (e.g., James and Aadland, 2011; Aragón and Rud, 2013; Fleming et al., 2015). Although cross-country studies are abundant (given the easy access to country-level data) and can provide hints on macroeconomic policy effectiveness, within-country models are much more useful in identifying the channels through which resources can jeopardise the economic prosperity of extractive regions (Lufin and Soto-Diaz, 2022). Empirically, regional data also provide avenues to conduct robust analyses of the causes and consequences of resource dependency on economic outcomes, avoiding endogeneity flaws that cross-country models have (van der Ploeg, 2011).

Considering all this, we should move beyond merely cross-country analysis to evaluate whether the resource curse exists and instead better identify the occurrence of its potential channels. In other words, it does not matter whether the resource curse exists in cross-country evidence; what matters is why and how some regions or countries have experienced a curse, and others were able to leverage resource wealth to further wellbeing broadly. Hence, placing more research emphasis on investigating the drivers/channels of the resource curse (as comprehensively reviewed by van der Ploeg, 2011) can yield more insightful learnings. Along these lines, more robust insights will be gained if researchers are careful to understand the implications of different measurements of resources, for example, resource dependence (e.g. share of earnings from mining), resource extraction (e.g. mining production), or resource abundance (e.g. economic value of undeveloped deposits) (Marchand and Weber, 2018).

On the other hand, resilience is a concept that has been widely studied. However, scholars have not yet paid much attention to its relation to mineral resource management. Economic resilience is a set of factors that support jurisdictions in coping with and adapting to shocks (Shahbaz et al., 2020). Thus, the concept can also support analysing the causes of the resource curse for regional economies and policies aimed at transforming curses into blessings. Thus, future research should also explore ways to measure regional and community economic dependency on—and vulnerability to—mining activity so governments can better design and prioritise policies to enhance economic resilience and support communities when mining activity declines. Analysis of regional resilience and its factors and related metrics (indicators) is essential to prepare regions for potential mining disruptions. This will aid in formulating strategies to enhance regional resilience, including preparedness and adaptive capacity to mining disruptions.

2.5. Mining as an input supplier of cleaner production processes

Traditionally viewed as a major polluter, the mining industry is increasingly recognised as crucial in combating climate change. This shift highlights a paradox where a sector known for its adverse environmental impact transforms into a force for sustainability. Addressing this paradox requires substantial changes in the industry's identity, driven by solution-oriented policies and the collaborative efforts of researchers, policymakers, and corporations.

Central to transforming the mining industry is a dynamic concept of sustainability, which demands continuous adaptation to include environmental compliance, social equity, transparency, and the protection of cultural heritage (Endl et al., 2021; Osei et al., 2023). Applying systems thinking and complexity theory is essential to integrate these considerations effectively.

Furthermore, the industry's sustainability goals must evolve from merely reducing carbon footprints to achieving carbon-negative operations through innovative technologies and practices. This advancement necessitates transformative innovation and substantial scientific progress. Recent efforts to establish voluntary sustainability standards raise questions about their adequacy and the potential need for diverse standards tailored to different mining contexts. Integrating blockchain technologies could offer new ways to assess sustainability accurately (Aznar-Sánchez et al., 2019).

Regulatory and financial incentives, such as carbon tax and cap-and-trade systems inspired by the Porter hypothesis, are proposed to stimulate innovation within the industry. Investigating the effectiveness of these systems in promoting mining innovation is crucial, as is exploring the potential of green financing to provide the necessary funds for transformative projects in the industry's supply chain (Carl and Fedor, 2016). Evaluating the sustainability of mining projects also requires a shift from traditional methods like discounted cash flow, which do not fully capture operations' social, environmental, and cultural impacts. Developing new evaluation techniques incorporating the externalities is vital for robustly assessing mining projects' long-term value and impact.

Besides all this, the future social acceptance of the mining industry depends critically on its long-standing ability to meet rigorous sustainability standards. This transition nowadays, as in the past, poses significant challenges for both the industry and academia, necessitating a concerted effort to redefine the values and metrics by which mining operations are assessed and managed.

2.6. Rents, taxes and the role of mining as a macroeconomic development engine

In mining policy research and societal debate, a topic of ongoing analysis (without reaching a consensus yet) concerns the disposition of mining rents, particularly those Ricardian and Hotelling rents generated from mineral extraction—what Auty and Furlonge (2019) named the regulatory rents. For example, three institutional frameworks have been trialed in Chile—one of the world's largest mining countries. The oldest corresponds to the exploitation of minerals by a state-owned enterprise (CODELCO) that appropriates all existing rents, which is known as resource nationalism (González et al., 2023). Since 1990, with the start of what is known as the New Mining Era, Chile has implemented a second institutional framework in which sub-surface resources have been granted concessions for exploitation without charging rents for this privilege, particularly in copper mining.[2] Recently, these mining activities have been subjected to special taxes during periods of high

[2] The Political Constitution of 1980 reaffirms the State's absolute, exclusive, inalienable, and imprescriptible ownership of mines, which means private property only holds in the surface (Zuñiga Urbina, 2005).

profitability (see IGF, 2018).

Currently, a third institutional framework for lithium exploitation is being discussed. An alliance has been agreed upon between the State of Chile and the private sector, with the former holding a 51% ownership stake and maintaining control. This represents a shift from the previous arrangement in copper exploitation, where the State held 49% ownership, leaving control to the private sector. Additionally, the new framework introduces a 1% royalty to the current mining tax schedule, which is applicable to the firms described in the second institutional framework.

A fourth institutional framework example can be stated by referencing another Latin American country. As an emerging resource exporter, Ecuador changed its arrangement with oil exploitation companies, ending the concession and entering into an agreement that guaranteed to cover costs and a reasonable rate of return. This change, made during Rafael Correa's administration (2007-17), means that when the price generates Ricardian rents, the State of Ecuador appropriates them.[3] However, exploitation can result in losses for the State when the price fails to cover costs. This arrangement generated significant revenue for Ecuador during the natural resource price boom in the first decade of the 21st century but also exposed it to considerable future revenue volatility.

Future research should aim to provide countries and regions with more and better knowledge and evaluations of these different frameworks. Given the diverse political contexts worldwide, it is crucial to evaluate which framework is most advantageous for capturing most of the generated rents and making them an engine for national diversification and development (González et al., 2023). However, such analysis requires more transparent data on mining operations and productivity, which is still very opaque and often simply inaccessible in many regions. A country's institutional frameworks for mining operations may have implications far beyond its national budget, potentially creating tension between in-country revenue maximisation and the pace of the global energy transition.

2.7. Mining beyond our mines: deep-sea mining and space mining

Deep-sea mining is transitioning from exploration to full-scale exploitation, with various studies highlighting the topic and claiming that significant research is needed to truly understand the societal and environmental impacts and contributions of deep-sea mining beyond corporate profits (Lèbre et al., 2023; Yu, 2024). On the other hand, space mining, often viewed sceptically, is only considered economically feasible under restrictive scenarios (Proctor et al., 2021; Hein et al., 2020). Beyond economic viability and potential unintended environmental consequences, fundamental challenges for both deep-sea and space mining lie in legal and international relations issues due to their transnational nature.

Current literature underscores the need to reevaluate the conventional techno-economic assessment (TEA) frameworks used in these contexts. Traditional TEA models assume stable future revenues and costs, an approach that may not hold given the unique risks associated with deep-sea and space mining, including catastrophic risks that are significantly higher than in terrestrial projects (Weitzman, 2009; Martin and Pindyck, 2015). This necessitates new research to integrate such risks into economic models and explore alternative discounting factors that reflect the unconventional markets and non-market valuation frameworks likely to emerge from these activities.

Furthermore, addressing the complex legal challenges of transnational mining operations requires rethinking international legal frameworks. Current regulations, including the 1967 Outer Space Treaty, fall short in today's technological environment, with studies calling for more comprehensive legal structures that facilitate international cooperation and ensure sustainable practices across nations (Saletta and Orrman-Rossiter, 2018; Svec, 2022; Xu and Su, 2022).

Ultimately, deep-sea and space mining requires new policy and evaluation approaches and legal innovations to navigate the complexities of these frontier industries and ensure their contribution to global economic development while minimising their environmental and social impacts. It is also important to better understand the socio-economic impacts that these activities will bring onto communities through their direct impact (such as the impacts of deep-sea mining on fishing communities) and indirect participation in (often ancillary) activities (such as ports or areas within a space mining freights impact area). Future research will be needed on the potential loss of competitiveness of existing terrestrial operations due to deep-sea and space resource extractions and the ensuing consequences for affected mining-dependent communities.

3. Concluding remarks

The ongoing global transition towards a low-carbon economy brings up novel dynamics that merit careful consideration. There is substantial potential for investigation into the intersection of climate change issues and the ramifications of the energy transition on the political economics of resource-rich nations. Moreover, an unchartered territory for studying the political economy of natural resources exists at the convergence of technical advancements, including artificial intelligence, automation and conventional resource extraction methods. *Resources Policy* is poised to continue its influential role in shaping these discourses, guiding scholarly inquiry towards actionable insights that can inform sustainable resource governance and practices globally.

Future research should explore how resource management can promote social progress and development while fostering equitable resource governance. In some ways, the transition might mirror past transitions in production and technology, with insights readily applicable to the current transition. In other ways, this transition and the emerging technological context might differ, with technologies such as artificial intelligence dramatically reshaping certain processes. Whether mirroring past transitions or not, the opportunity to harness the changes for broad and sustainable improvements in wellbeing remains.

Resources Policy plays a pivotal role in synthesising multidisciplinary insights from environmental studies, economics, and political science, examining how resource diversity impacts social inclusion, environmental sustainability, and economic resilience. The journal's global relevance is underscored by its ability to catalyse informed policy discourse, highlighting the need for comprehensive strategies to address the complexities of natural resource management.

Resources Policy will continue to evolve with research in mineral and fossil energy policy over the next 50 years. As interest in research in sustainability and its impact on material needs continues to grow worldwide, *Resources Policy* will continue to provide a quality outlet for publishing this scholarly work, with an editorial staff consisting of active scholars in such areas from all over the world.

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