**Mineral Exploitation and Education in the Democratic Republic of Congo: The Role of Governance**

***Abstract***

The Democratic Republic of the Congo (DRC) is rich in mineral resources, yet its education system remains underdeveloped, raising questions about the role of governance in shaping the effect of mineral exploitation on education. Against this problematic, the present study examines the relationship between mineral exploitation and education in the DRC, focusing on both short- and long-term effects and the mediating role of governance. Using descriptive and analytical models based on autoregressive distributed lag (ARDL) approaches applied to data from 1990 to 2023, the study finds that mineral exploitation has a negative and significant short-term correlation with education access but a positive and significant long-term correlation. Mediation analysis further reveals that while mineral exploitation directly benefits education, it indirectly harms it by weakening corruption control. These findings suggest that governance quality is vital in determining whether mineral wealth supports or undermines education. To improve the education system and promote sustainable development, the study recommends allocating a portion of mining revenues to education, strengthening grassroots education investments, and enhancing transparency and accountability in the mining sector to ensure that local communities benefit from mineral exploitation.

*Keywords: Minerals, Education, ARDL, DRC, Mediation.*

**Introduction**

Natural resource wealth has proven to be a factor of growth exclusivity (Raheem et al., 2018). Growth elitism characterizes the entire natural resource supply chain, from discovery to sale. Specifically, governments or their agents hold property rights over natural resources. In this case, the direct impact of the supply chain is the personal enrichment of the owners. Secondly, by allowing the private sector to become a stakeholder, the self-interest of governments can be hampered by overtaxing the investments needed to discover natural resources (Raheem et al., 2018). Another channel is that if political elites or other powerful groups prioritize access to resource wealth, they use it to their advantage rather than investing the resulting wealth in overall growth (Warner, 2012). The precise macroeconomic impact of natural resource wealth is also difficult to pin down, as the results remain non-consensual (Frankel, 2012). However, it is widely believed that resource-rich countries tend to experience lower growth rates over the long term and have been thought to be victims of the so-called "resource curse" (Sachs and Warner, 1995). However, as Gylfason (2001) argues, if the profits from natural resource rents are put to good use, they can be used to care for, educate, and provide employment for the population.

The exploitation of minerals has a considerable impact on education worldwide, influencing not only access to education but also its quality. In many resource-rich countries, mining can lead to a complex dynamic where immediate economic benefits are often offset by negative social and environmental consequences. For example, studies have shown that in regions where mining is predominant, children drop out of school to work in hazardous conditions in mines, jeopardizing their education and future (Baker et al., 2016). What's more, the lack of adequate educational infrastructure and pedagogical resources in these mineral areas exacerbates the situation, leading to high dropout rates and poor academic performance (Wang and Zhang, 2024: Kelly et al., 2023: Cardona Vallès, 2024).

In the case of the Democratic Republic of Congo (DRC), rich in minerals such as coltan, copper, and gold, anarchic mining has direct repercussions on the education system. According to the United Nations (2019) report, mining in the DRC is often associated with armed conflict, environmental degradation, and poverty, creating a cycle of vulnerability that particularly affects children and young people. The latter are often forced to drop out of school to work in the mines, jeopardizing their future and that of the nation. Indeed, the need to generate immediate income for families pushes many children to drop out of school, compromising their future and that of the nation (Malpede, 2021).

Mining also has an impact on educational infrastructure. Mining areas, often far from urban centers, lack adequate schools and teaching resources. Investment in education is often neglected in favor of revenues generated by the exploitation of natural resources. This situation is exacerbated by corruption and a lack of political will, which hamper educational development efforts (Bamuamba, 2001; Kelly et al., 2022). As a result, the Congolese education system finds itself in a downward spiral, with children from mining communities at a particular disadvantage. In addition, the exploitation of minerals has consequences for the quality of education. Teachers, often poorly paid and poorly trained, struggle to provide quality education. Schools located near mining sites suffer from a lack of educational programs adapted to the needs of children, who are often exposed to trauma linked to their working environment (Kabamba, 2021). Students, faced with difficult realities, are less likely to succeed academically, perpetuating the cycle of poverty and illiteracy.

In addition, the succession of wars and, above all, the demographic explosion, have contributed to the complexity of the Congolese education system. Almost 44% of those enrolled in grade 1 of primary school are over the official age (6 years), and 11% are repeaters. The latter are more likely to seek income from mining activities. As the wastage rate at the end of primary school is high, the access rate to secondary school is around 48%. As for higher education, repetition and drop-out rates are very high, particularly in areas of heavy mining (North Kivu and Katanga). Given the above, the main question of this work is: *What is the effect of mineral exploitation on education in the DRC? Better still, this work will analyze the role of governance in the nexus.* This article differs from existing work in three key respects. **Firstly**, it adopts a multidimensional approach, integrating economic, social, and environmental perspectives to analyze the effects of mining on education in the DRC. **Secondly**, it draws on recent empirical data and specific case studies to illustrate local dynamics and the challenges faced by affected communities. **Finally**, it proposes concrete recommendations for improving access to and quality of education in mining areas, emphasizing the importance of a collaborative approach between governmental actors, NGOs, and local communities.

The rest of the article is organized into three sections. Section 2 presents a selective review of the literature. Section 3 outlines the various stages of the empirical strategy and discusses the results. Section 4 concludes with policy recommendations.

1. **Literature review: mineral and education**

**2.1. Theoretical Review**

**2.1.1. Ambiguous relationship**

Right up until the 1980s, neo-liberal economists such as Rostow (1961) and Balassa et al. (1980) argued in their work that natural resources were a major advantage if economies were to grow and develop rapidly. For Rostow (1961), for example, the abundance of raw materials is a precondition for the take-off of less advanced countries towards industrial development. Balassa et al (1980) showed that natural resources contribute to industrial development, as they provide funds for physical capital formation and increase demand for industrial products. Since the work of Sachs and Warner (1995), a large body of literature has examined the link between natural resources and economic growth, and converging suspicions of a possible negative eﬀect of abundance of on the economic growth of countries remain and are based on proven studies: we speak of the curse of natural resources. This idea that natural resources can be an economic curse rather than a blessing emerged in the 1980s, while the term resource curse was first used in 1993 about countries with an abundance of natural resources (particularly non-renewable resources) that tend to have lower economic growth than countries with fewer natural resources (Auty, 1993: Tchapchet-Tchouto et al., 2024).

Auty (1993) introduced the phrase “resource curse” to refer to the paradox that natural resource wealth appears to generate poor economic growth rather than prosperity. This hypothesis was conﬁrmed empirically by Sachs and Warner (1995, 1997, 2001), who show a signiﬁcant and robust inverse relationship between the share of natural resource exports in GDP and economic growth. Their results have been replicated by Davis (2013) and elaborated by numerous other scholars. Auty (2001), for example, ﬁnds that per capita income grows more slowly in countries with abundant natural resources.

The literature has identified several manifestations of this curse, including the vulnerability of resource-dependent societies to conﬂicts and political instability. The work of Collier and Hoeffler (1998) is the first study to explore the impact of natural resources on political violence. The authors sought to determine the economic causes of civil war and introduced natural resources into their analysis to represent taxing capacity, which motivates political violence. The authors found that an initial increase in natural resources leads to a higher risk of civil war. However, at the higher level, captured by the squared term, natural resources reduce the risk of war. Collier and Hoeffler (2002) found that commodity exports have a non-linear but positive impact on the probability of civil war. The authors concluded this result in their later work on greed and grievance theories of political violence. The grievance model included democracy, which proved insignificant in the final model (Collier and Hoeffler, 2004). Generally speaking, this broader debate focused on two main arguments. The first, which reﬂect behaviorist ideas, focused on the motivations of rebel organizations. It suggested that civil wars are caused by grievances arising from wealth inequalities, limited political rights, or ethnic and religious divisions. The second argument, which reflects ideas associated with the rational actor perspective, focused on the economic incentives and opportunities faced by rebel organizations (Collier, 2000). In contrast to the grievance argument, it assumes that rebellions are caused by greed, i.e., the desire of rebel leaders to enrich themselves and their supporters.

**2.1.2. Role of governance and institutions**

Since the work of North (1991) and Acemoglu et al. (2001), it has been established that institutions matter[[1]](#footnote-1). In eﬀect, when the quality of institutions is poor, budgetary procedures lack transparency, and the executive has significant discretionary power over public spending (Wantchekon et al., 2002). Several works in the literature also support this argument, arguing that the quality of institutions also plays a role in explaining the natural resource curse (Mehlum et al., 2006; Van der Ploeg, 2011). For Philippot (2011), one of the mechanisms put forward is that of poor institutional quality. Natural resources would prevent the development of good institutions conducive to economic development. All authors agree that the curse of natural resources is a purely institutional phenomenon. Sala-i-Martin and Subramanian (2013) show that when controlled for institutional quality, natural resources no longer have a direct negative eﬀect on growth. Mehlum et al. (2006), for their part, conclude that if institutions are of good quality (conducive to productive activities), natural resources promote growth. Kaufmann et al. (2010) deﬁne governance as “the traditions and institutions by which authority is exercised in a country”. Based on this deﬁnition, Kaufmann et al. (2010) measure the quality of governance along six dimensions: voice and accountability; political stability and absence of violence; government eﬃcacity; regulatory quality; rule of law; and control of corruption.

**2.1.3. Natural Resource Governance for Education and Development**

Human capital and growth are the subject of much attention in the literature. From a theoretical point of view, there are at least three mechanisms by which education can affect economic growth. Firstly, as in the microeconomic perspective, education increases the human capital inherent in the workforce, which in turn increases labor productivity and thus transient growth towards a higher equilibrium level of output (as in neoclassical theories of augmented growth, Mankiw et al., 1992). Secondly, education can increase the innovative capacity of the economy, and new knowledge about new technologies, products, and processes promotes growth (as in endogenous growth theories, Lucas 1988; Romer 1990a, Aghion and Howitt, 1998). Thirdly, education can facilitate the dissemination and transmission of the knowledge needed to understand and process new information and to successfully implement new technologies designed by others, again promoting economic growth (Benhabib and Spiegel, 2005; Kelly & Rutazihana, 2024). Hanushek and Woessmann (2008) examine what the research says about the role of education in promoting economic well-being.

**2.2. Empirical Review**

This literature review examines the relationship between education and the exploitation of natural resources, including mining, highlighting the resulting challenges and opportunities for economic development.

Related to these concerns, Takyi (2024) explores the impact of mining on children's education in the community of Kenyasi, Ghana, over two years (2021-2023). Using a mixed methodology, the study reveals that 60% of children surveyed have missed days of school due to mining activities, and those who do attend have lower academic performance. In addition, 45% of parents report a decrease in their children's school engagement, reinforcing concerns about the long-term effects of mining on educational development.

Álvarez and Vergara (2022) analyze the impact of natural resources on educational attainment in Chile, using longitudinal data from 1990 to 2017. Their study focuses on copper mining and its influence on educational outcomes. Applying ordinary least squares (OLS) estimation methods and fixed-effects models, the authors identify unobservable effects that could impact their results. They find that, although revenues from the mining industry have increased investment in education, the focus on resource exploitation has also led to disinvestment in other essential areas, affecting the accessibility and quality of education.

Extending their analysis, Ahlerup et al (2020) explore the relationship between gold mining and educational outcomes in Africa, focusing on the resource curse hypothesis. Through econometric analysis using fixed-effects regression models and OLS techniques, they show that gold mining has negative effects on education in several African countries. The results indicate that revenues generated by the gold industry are not systematically reinvested in education, thus contributing to the deterioration of educational outcomes. In addition, the authors point out that resource-rich regions can face problems of governance and corruption, diverting the resources needed for educational investment.

Cockx and Francken (2016) examine the relationship between natural resource exploitation and public spending on education. Their study aims to determine whether natural resource wealth leads to lower educational investment, thus contributing to a "resource curse". Using an econometric approach with regression models, the authors assess the impact of natural resource revenues on education budgets in various countries, while controlling for variables such as GDP and other socio-economic indicators. The results reveal that resource-rich countries often devote a proportionately smaller share of their budgets to education, particularly in developing countries where revenues are poorly managed. This dynamic can have detrimental consequences for long-term human and economic development, underlining the importance of prudent resource management.

Following on from this, James (2017) uses an econometric approach based on multiple linear regression models to analyze the impact of natural resources on educational outcomes. Applying an OLS method, he examines the relationships between natural resource wealth, measured by production and exploitation, and educational outcomes, such as standardized test scores and graduation rates. James also controls for several variables, including average household income and other socio-economic factors. His analysis, enriched by longitudinal data and robustness tests, shows that natural resource wealth has a significant but often negative impact on educational outcomes. Resource-rich regions generally show lower test scores and lower graduation rates, reinforcing the findings of previous studies.

Douangngeune et al (2005) look at national contexts, comparing Thailand, Japan, and South Korea. Their study analyzes how differences in natural resource exploitation and investment in education have influenced the economic development trajectories of these countries. Although Thailand has abundant natural resources, its development has been hampered by a lack of investment in education, resulting in a less skilled workforce than in Japan and South Korea. The latter two countries, despite their more limited resources, have invested massively in education, fostering innovation and productivity. The authors underline the importance of policies that balance the exploitation of resources and investment in human capital for sustained economic development.

Hinton et al (2003) continue this line of thought by examining the educational challenges faced by mining communities. Their research, conducted between 2001 and 2002, reveals that these communities suffer from a lack of infrastructure and educational resources, limiting access to education. In line with these challenges, Bebbington and Bury (2009) examine the socio-economic effects of mining on rural communities in Latin America between 2004 and 2006. Their study shows that although mining generates income, these profits are not always reinvested in education, exacerbating inequalities.

Gylfason (2001) discusses the complex relationship between natural resource abundance, education, and economic development. Through an econometric analysis of data from the 1980s and 1990s, he highlights that neglect of education in resource-rich countries can lead to a "resource curse", where wealth does not translate into sustainable development. He concludes that to achieve sustained economic development, it is essential for these countries to prioritize education, underlining the importance of a balance between resource exploitation and human capital. Conversely, Lederman and Maloney (2003) challenged these findings using more sophisticated econometric techniques. Their study of 92 countries between 1970 and 1999 showed a positive effect of mining on human capital, measured by education levels. The authors explain that access to natural resource revenues enables greater investment in education and worker training. Similarly, in an underrated article on resource abundance and economic growth, Davis (1995) finds that indicators of human capital accumulation are higher in mining countries than in non-mining countries. Himawan and Clark (2021). They tracked 390 Indonesian districts between 2006 and 2015 to estimate the effect of four measures of resource dependence on high school enrolment rates. They address the potential endogeneity of their dependence measures by using abundance and physical output change instruments in IV-GMM estimation. With the notable exception of local government dependence on coal revenues, they find that most dependence measures contribute to higher enrolment rates. Stijns (2006) estimates linear correlations (Pearson) across 70 countries to determine whether various abundance and dependence indicators affect current measures of education. Rescaling the measures of subsoil wealth per capita previously used by Gylfason (2001a) and Birdsall et al. (2001), Stijns (2006) finds a positive correlation between the latter and the number of years of schooling and the share of public expenditure devoted to education. More generally, Stijns finds a positive effect of most, but not all, measures of affluence on educational outcomes. Stijns (2009) extends his study using a non-parametric approach and again finds that higher mineral wealth is related to higher educational attainment and other input measures. Stijn's complementary study is unusual in that it controls for political instability and violence, and finds that, although they weaken the positive impact of mineral wealth, they do not reverse it (Mousavi and Clark, 2021). More recently, Caselli and Michaels (2013) focused on the impact of oil production on household welfare in Brazil between 1970 and 2000. Their analysis, based on municipal data, reveals mixed results. Although there was an increase in public spending on education and health, the authors found no significant effect on human capital indicators such as school enrolment rates or life expectancy. Ultimately, the question of the impact of natural resource exploitation on human capital remains open to debate. The results seem to depend on the institutional context, the quality of governance, and public investment choices in the countries concerned, according to these authors. Turan and Yanikkaya (2020) also examine the effects of total, mining, gas, and oil rents on total public, education, health, and infrastructure spending using estimation methods and dynamic panel data for over 100 countries for the period 1980-2015. The results indicate that total resource rents do not have a significant impact on total public spending and infrastructure spending. However, they do provide strong evidence of the negative effect of rents on public spending on education and health. The results provide substantial evidence for the conclusion that the notorious resource curse can also be explained by its negative effect on human capital accumulation. Next, they examined whether the level of democracy is important when studying the effects of rents on public spending. They found that total resource rents only have a negative impact on education spending in autocratic countries. These results indicate that policy-makers should take the necessary steps to eliminate the negative effects of rents on public spending on education and health, to increase human capital formation (Wassou et al., 2024).

1. **Methodology**

**3.1. Empirical model**

*Auto* *Regressive Distributed Lag*/ARDL models, also known as "autoregressive models with staggered or distributed lags", belong to the class of dynamic models. Indeed, these models have the particularity of taking into account temporal dynamics (relating to adjustment lag, or expectations, etc.), to explain a variable in time series, to improve forecasts and the effectiveness of policies (actions, decisions, etc.), in contrast to simple (non-dynamic) models whose instantaneous explanation (immediate effect or not spread over time) only partially restores the variation of the variable to be explained (Pesaran et al.2021). Within the family of dynamic models, three types can be distinguished.

For this research, we'll be using the autoregressive distributed lag (ARDL) model. These models combine the characteristics of both autoregressive (AR) models and *distributed lag* (DL) models, whose general form is specified as follows:

(1)

In other words, equation (1) is such that :

𝑌𝑡= 𝜃 + 𝛼1𝑌𝑡-1+ ⋯ + 𝛼𝑝𝑌𝑡−𝑝 + 𝛽0𝑋𝑡 + ⋯ + 𝛽𝑞𝑋𝑡−𝑞 +  + (1𝑑) (2)

With𝑡 ~(0, 𝜎) representing the error term, 𝛽𝑖 reflects the short-term effect of 𝑋𝑡 on 𝑌𝑡. To this end, taking into account the long-term relationship such as 𝑌𝑡 = 𝛿 + 𝜌𝑋𝑡 +

 It is possible to calculate the long-term effect of𝑋𝑡 on𝑌𝑡 (i.e.," ") as follows: 𝜌 =∑ 𝛽 𝑗⁄ (1 - ∑ 𝛼𝑖) ((3))

**3.1.1. Variable specification**

1. ***Dependent variable***

Access to primary education is our dependent variable, which is considered an important determinant of economic well-being. The theoretical literature on growth emphasizes at least three mechanisms by which education can affect economic activity. Firstly, education can increase the human capital inherent in the workforce, thereby raising labor productivity and thus transient growth towards a higher equilibrium level of output (Mankiw et al., 1992). Secondly, education can increase the innovative capacity of the economy, and new knowledge about new technologies, products, and services promotes growth, as developed in endogenous growth theories (Lucas, 1988; Romer, 1990; Aghion and Howitt, 1998). Thirdly, education can facilitate the dissemination and transmission of the knowledge needed to understand and process new information, and to successfully implement new technologies designed by others; this also promotes economic growth (Nelson and Phelps, 1966; Benhabib and Spiegel, 1994).

1. ***Independent variable***

Mineral exploitation is our independent variable of interest. It is captured by the mining rent in the base model, which corresponds to the difference between the production value of a stock of minerals at world prices (ores) and their total production cost. This variable is used in the basic model. For robustness, we use the quantity of mining. The minerals included in the calculation are: tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate. This choice of proxy is consistent with studies by Arezki and Gylfason (2013) and Crivelli and Gupta (2014). There are several reasons for choosing this measure over others. Firstly, the availability of mining rents in countries minimizes the risk of sample selection bias, and also provides a reasonably long time dimension (Kamguia et al., 2022). Second, this work supports Antonakakis et al.'s (2017) argument that examining the resource curse hypothesis requires a variable that can capture the extent to which political elites exhibit rent-seeking behavior. Moreover, dependence on mining rents provides a measure of the rent-seeking behavior of Congolese leaders, since the more dependent an economy is on its resources, the greater the likelihood that political elites will engage in rent-seeking behavior (Sachs and Warner, 2001).

1. ***Control variables***

We retained five control variables, which are ꞉ the internet, Gross Domestic Product, tax evasion, foreign direct investment, and public investment.

* **Internet**: This variable captures Information and Communication Technologies (ICT). Indeed, ICT improves educational attainment by encouraging learning through continuous discussion, offline discussion, guided instruction, self-study, critical thinking, research, and data analysis (Yuen et al., 2003; Feuzeu & Kelly, 2025). The use of the Internet can improve outcomes, teaching, and administration, and create important capabilities in disadvantaged groups (Sharma, 2003), and at the same time influence the educational teaching and research process. It is captured by the number of people using the Internet connection.
* **Gross Domestic Product** (GDP**)**, captured by GDP per capita, reflects the level of spending in an economy. In the literature on education and economic growth, several studies attempt to support this relationship with economic facts constructed according to well-defined canons. This is the causal relationship between education and GDP (Mankiw et al., 1992). However, a return to income accumulation can be analyzed in the context of the effect of people's standard of living on education. According to the Global Education Monitoring report (GEM, 2022), to achieve the 2030 goal for universal basic education, i.e., pre-primary, primary, and secondary education, low- and lower-middle-income countries need to spend US$461 billion per year. However, the results can vary according to the efficiency of the population's standard of living. On average, households cover 25% of the cost of education. Households contribute far more to the cost of education in lower-middle-income countries (44%) than in high-income countries (20%). For his part, Charlot (1997) analyzes the links between education and growth, constructing a typology of countries according to the efficiency of their education systems. His results show that the level of education has a positive influence on national income.
* **Public investment**: This variable refers to various national investments. It refers specifically to public spending on education. We include it here because we believe that investment in the public sector promotes access to education. Public investment is financed by taxes on income from work and property, by consumption taxes, or by public borrowing corresponding to foreign debts. Indeed, spending on public education, in addition to subsidies to private schools at primary, secondary, and tertiary levels, is captured as a percentage of GDP. Organizations such as the World Bank allocate significant budgets to expanding schooling in developing countries. In its 2015 annual report, the World Bank stresses that education is one of the best ways to end poverty. The Bank's investments in education projects now total over $14 billion (World Bank, 2015). However, increased spending on education does not necessarily lead to an improvement in the quality of education. In one of its recent feature articles, the World Bank (2016) illustrated the alarming state of education quality in 10 French-speaking African countries, despite massive investment in education and access to schooling over the past 15 years. Most students assessed in these countries show significant deficits in language and mathematics tests. Organizations such as the World Bank allocate significant budgets to expanding schooling in developing countries. In its 2015 annual report, the World Bank highlighted education as one of the best ways to end poverty. The Bank's investments in education projects now total over $14 billion (World Bank, 2015).
* **Foreign direct investment (FDI):** In the literature, FDI is generally recognized as a driver of economic growth and development. Some studies show that the effect of FDI spillovers is insignificant or even negative in developing host countries (Aitken and Harrison, 1999; Wooster and Diebel, 2010; Fatima, 2016; Nguéda & Kelly, 2022). This can occur when product design and multinational decision-making are concentrated in developed countries, while low-skilled labor-intensive production and assembly activities are located in developing countries. The DRC, with its wealth of natural resources, attracts this type of vertical FDI, where foreign investment is mainly motivated by low labor costs and the availability of resources. However, this dynamic can increase demand for low-skilled labor, to the detriment of education. Moreover, developing countries, including the DRC, can rapidly lower their labor standards, leading to a "race to the bottom", to remain attractive to global investors (Palley, 2002). In this context, FDI can have undesirable effects on school enrolment, potentially increasing the opportunity cost of school activities, which could limit access to education for many Congolese children. Egger et al (2005) show that net inward FDI increases individual incentives to acquire higher education, thereby raising the marginal productivity of skilled workers relative to unskilled workers, and leading to strong economic growth. In this way, FDI contributes to the training of a skilled workforce, and in the process, encourages primary school enrolment.
* **Tax evasion**: used in our model to explain the level of education. Indeed, tax revenues, which finance part of education spending, generally have a negative marginal effect, as shown by the results of Blankenau et al. (2007) and Kneller et al. (1999). However, their impact on per capita economic growth is not significant. There is, therefore, a relationship between public spending on education and taxation, as household spending on education in sub-Saharan Africa accounts for 46% of government spending on education (UNESCO, 2012). If, therefore, tax revenues were to leave their field of predilection, the opportunity cost they could entail would be of the order of at least 30%. In general, African countries are infested with a high level of informal employment and enterprise, which are obstacles to the optimal mobilization of tax revenues.

**3.1.2. Data and sources**

The data for this study comes from the World Bank's *World Development Indicators* (WDI) and covers the period 1990-2023. The periodicity of the variables was limited by data availability.

 Table 1 summarizes the variables used in this study. This table describes the variables, specifies their different measures or the proxies by which they can be apprehended, and the sources.

**Table 1: Variables, measurements, and sources.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Descriptions** | **Measures** | **Sources** |
| **Primary Education** | Primary education | Elementary school enrolment | World Bank (WDI 2023) |
| **Mining** | Mining | Mining income and quantity of ore mined |
| **GDP/capita** | Standard of living | GDP per capita |
| **FDI** | Rate of inward FDI for Congolese outside the country | Foreign direct investment, net flows (% of GDP) |
| **Public investment** | Public investment | Public expenditure on education (as % of total expenditure) |
| **Tax evasion** | Education expenditure  | Share of income not taxed |
| **Internet** | Internet | Number of people using the Internet connection |

**Source: Authors**

 **Table 2: Descriptive statistics**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables**  | **Obs.** | **mean** | **Std.****Dev.** | **Min** | **Max** | **Skew.** | **Kurt.** |
|  Primary Education  | 34 | 0.749 | 0.179 | 0.465 | 1.095 | 0.302 | 2.103 |
|  Mineral rents  | 32 | 3.912 | 5.467 | 0.077 | 28.813 | 3.049 | 14.494 |
|  Mining Production  | 34 | 1187.797 | 147.063 | 947.765 | 1473.23 |  |  |
|  Internet  | 34 | 1.611 | 2.103 | 0 | 6.21 | 0.897 | 2.117 |
|  GDP  | 33 | 1.742 | 6.163 | -13.469 | 9.47 | -0.832 | 2.613 |
|  IDE  | 30 | 0.361 | 0.416 | -0.023 | 1.435 | 1.327 | 3.745 |
|  Advertising investment  | 29 | 13.759 | 24.142 | -18.74 | 68.418 | 1.062 | 3.156 |
|  Tax evasion  | 32 | 6.153 | 2.512 | 0.78 | 11.411 | -0.08 | 2.236 |

**Source: Authors**

The descriptive statistics presented in Table 2 provide a detailed overview of the main variables studied, making it easier to understand their distribution and characteristics. These data reveal significant challenges in the Democratic Republic of Congo (DRC) concerning access to education and the distribution of mining rents. In terms of access to education, the enrolment rate at the primary level is relatively high (average of 0.749), but falls sharply at secondary (average of 39.423) and tertiary (average of 4.265) levels, with notable regional disparities, as evidenced by the high standard deviations. At the same time, mining annuities show a mean of 3.912 and a standard deviation of 5.467, indicating a very heterogeneous distribution, with some regions enjoying annuities considerably higher than the average. In sum, the descriptive statistics summarized in Table 2 reveal little variation, suggesting unbiased results. The variables analyzed are distinguished by their relative homogeneity (such as primary and university education, mining rents, Internet access, and foreign direct investment) or by their heterogeneity (such as secondary education, GDP, public investment, and tax evasion), with scattered values. Note that primary education and foreign direct investment are poorly represented in the sample. On average, only 0.749 pupils enrolled in primary education in the DRC paid for their schooling, but with the introduction of the free primary education policy, a significant increase in the number of pupils enrolled is expected.

**Table 3: Correlation matrix**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables**  | **(1)**  | **(2)**  | **(3)**  | **(4)**  | **(5)**  | **(6)**  | **(7)**  | **(8)**  | **(9)**  |
| (1) Educ Primary  | 1,000 |  |  |  |  |  |  |  |  |
| (2) Secondary Educ  | 0,589 | 1,000 |  |  |  |  |  |  |  |
| (3) Educ Academics  | 0,723 | 0,674 | 1,000 |  |  |  |  |  |  |
| (4) Mineral rents  | 0,614 | 0,513 | 0,825 | 1,000 |  |  |  |  |  |
| (5) Internet  | 0,880 | 0,781 | 0,692 | 0,534 | 1,000 |  |  |  |  |
| (6) GDP  | 0,339 | 0,733 | 0,735 | 0,426 | 0,462 | 1,000 |  |  |  |
| (7) IDE  | 0,501 | 0,350 | 0,630 | 0,311 | 0,539 | 0,511 | 1,000 |  |  |
| (8) Investment Pub  | 0,258 | 0,341 | 0,369 | 0,476 | 0,189 | 0,290 | 0,004 | 1,000 |  |
| (9) Tax evasion  | 0,614 | 0,481 | 0,765 | 0,577 | 0,559 | 0,699 | 0,642 | 0,283 | 1,000 |

**Source: Authors**

Table 3 shows that the correlations between the study variables, levels of education (primary, secondary, and university), and mineral rents are positive. The correlation coefficients between the dependent variable (*Education*) and the control variables lend themselves to a study between the two variables above.

**3.2. Presentation of results and discussion**

**3.2.1. Preliminary analysis**

To correctly apply econometric simulations using the PMG (Pooled Mean Group) method without fear of biased results, the model variables must be either stationary at level, or integrated of order 1 (I(1)). Before estimating the ARDL (Autoregressive Distributed Lag) model, it is important to check the stationarity of the time series, which is done using tests such as the Augmented Dickey-Fuller (ADF) test. If certain variables are found to be non-stationary, it is necessary to differentiate them to make them stationary. Table 4 presents the results of the stationarity tests (ADF) for different variables, which show that the variables are mainly I(0) and I(1), making them suitable for the application of ARDL models. However, it should be noted that not all level values exceed the critical value of -1.645, derived from the IPS w-tbar statistic. With some values below this threshold, the null hypothesis of I(0) integration can be rejected.

Table 4: Stationarity tests (ADF)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Level | Integrated |  |  | Level | Integrated |  |
| Variable | Coefficient | Coefficient | Decision | Variable | Coefficient | Coefficient | Decision |
| **Education** | -0.531 | -5.822 | I(1) | **FDI** | -2.430 | -5.311 | I(1) |
|  | 0.9822 | 0.0000 |  |  | 0.3637 | 0.0001 |  |
| **Minerals** | -3.621 | -- | I(0) | **Investment** | -5.125 | -- | I(0) |
|  | 0.0281 | -- |  |  | 0.0001 | -- |  |
| **Internet** | -1.933 | -6.988 | I(1) | **Tax evasion** | -4.050 | -- | I(0) |
|  | 0.6373 | 0.0000 |  |  | 0.0075 | -- |  |
| **GDP** | -2.476 | -5.052 | I(1) |  |  |  |  |
|  | 0.3402 | 0.0002 |  |  |  |  |  |

 *Notes: p-values are shown in brackets*

 Source: authors

Figure 1 shows the transition between two states during the relationship between mineral rents and education. The figure presents a Wald statistic: 𝑊 ∈ (0, 𝜋). According to this figure, there is 5% significance for frequencies greater than 0.68 and 10% significance for frequencies less than 0.49. The null hypothesis of no causality from mineral rents to education, in Granger's sense, is rejected at 5% for frequencies greater than 6. In other words, mineral rents cause education.

**Figure 1: Spectral causality test**



**Source: Authors**

**3.2.2. Basic estimates**

Table 5 presents the results of an analysis of the effect of mining rents on access to education in the DRC, using the ARDL method. This method was developed by Pesaran et al (2001). The ARDL model was established to assess the effect of independent variables on each dependent variable relating to education. In fact, in the analysis, we use as the dependent variable "Primary school enrolment (gross)" taken from the World Bank.

The upper section of Table 5 shows the results for the short-term effect, while the lower section shows the results for the long-term effect. It can be seen that in the short term, mining rents are negatively and significantly associated with access to education in the DRC, whereas the effect is rather positive and significant in the long term. **In the short term,** mining rents are negatively and significantly associated with primary school enrolment rates across all specifications. Specifically, all other things being equal, a one-unit increase in mining rents leads to a 0.019 reduction in the rate of access to primary education in the DRC. Without claiming to be exhaustive, several reasons can be put forward. Firstly, the misallocation of profits from mining in the country. Indeed, the abundance of rents in no way encourages governments to pursue sound macroeconomic policies capable of fostering inclusive development. In this sense, Gylfason (2001) shows that resource wealth leads to a decline in the average number of years of schooling for girls, as well as in secondary school enrolment rates for boys and girls. For Black et al. (2005), this would depend on the substantial increase in high school dropout rates in the American Appalachian region in the 1970s, to the coal boom. Douglas and Walker (2016) also find a negative effect of coal dependence on high school completion rates in Appalachian counties.

**In the long term,** the relationship between mining rents and access to education is positive and significant. This result is similar to those of Himawan and Clark (2021) who analyzed in 390 Indonesian districts the effect of difference in shares of total tax revenue from mining, coal or oil/gas, and difference in total mining dependence in regional gross domestic product, on the difference in net enrolment ratio from 2007 to 2015. All other things being equal, a unit increase in mineral rents in the DRC over the long term induces an improvement in access to primary education of 0.028 (Column 6). There are several possible explanations for this. Firstly, as Farzanegan and Thum (2017) show, mineral rents lead to increased public spending on education in resource-rich countries. Countries invest more in primary and secondary education, thanks to oil revenues, thus improving access to education.

With regard to the control variables, we also observe signs consistent with the literature. Specifically, we observe that long-term Internet access is positive and significantly associated with access to education.

Public investment also has a positive and significant sign coefficient linked to access to education. Indeed, this investment promotes the development of human capital through the transfer of funds earmarked for investment in the social sector, in knowledge, and the improvement of skills. This result is close to the findings of Turan and Yanıkkaya (2020). In addition, investment in the education sector is also attracted, complementing domestic resources for the purpose of expanding educational opportunities. As far as tax evasion is concerned, there is a negative and significant relationship with access to education. State tax revenues lost through tax evasion reduce investment in the education sector. This contributes to reducing funding in school infrastructure, reducing access to education, and the quality of education (Anyanwu, 2017; Kelly, 2025).

FDI (column 6 of the results in our Table 5) shows that FDI has a positive and significant effect on access to primary education in the short term only. The results of Wang and Zhuang (2021), show that inward FDI has a positive and significant effect on primary school enrolment and completion rates for both girls and boys. However, FDI has no significant effect on secondary and tertiary enrolment for boys, and may have a negative and significant effect on secondary and tertiary enrolment for girls; this may imply growing gender inequality in education with increasing FDI.

**Table 5: Mineral rents and access to education, ARDL regression**

|  |  |  |  |
| --- | --- | --- | --- |
| **VARIABLES**  | **Dependent variable : Primary education**  |  |  |
| **Short-term relationship**  |  |  |  |
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| D.Minerals  | -0.046\*\* | -0.017 | -0.048\*\* | -0.018\*\* | -0.020\*\* | -0.019\*\* |
|   | (0.016) | (0.019) | (0.002) | (0.007) | (0.008) | (0.008) |
| D.Internet  |  | -0.193\* | -0.240\*\* | -0.023 | -0.024 | -0.021 |
|   |  | (0.068) | (0.004) | (0.019) | (0.021) | (0.024) |
| D.PIB  |  |  | -0.005\*\* | 0.000 | 0.000 | 0.011 |
|   |  |  | (0.000) | (0.003) | (0.005) | (0.008) |
| D.FDI  |  |  |  | -0.006 | 0.002 | 0.102\* |
|   |  |  |  | (0.046) | (0.052) | (0.076) |
| D.Public investment  |  |  |  |  | 0.000 | 0.000 |
|   |  |  |  |  | (0.001) | (0.001)\* |
| D. Tax evasion   |  |  |  |  |  | -0.017(0.019) |
| Convergence coef.  | -1.436\*\*\* | -1.526\*\*\* | -1.842\*\*\* | -0.368\*\* | -0.372\*\* | -0.612\*\*\* |
|   Minerals  | (0.340) | (0.229) | (0.020) | (0.152) | (0.166) | (0.189) |
| Long-term relationship |  |  |  |  |
| 0.008\* | 0.013\*\* | 0.014\*\* | 0.049\*\* | 0.052\*\* | 0.028\* |
|   | (0.004)  | (0.003)  | (0.000)  | (0.019)  | (0.023)  | (0.014)  |
|  Internet  |   | 0.032\*  | 0.042\*\*\*  | 0.057\*\*  | 0.057\*\*  | 0.062\*\*\*  |
|   |   | (0.012)  | (0.001)  | (0.023)  | (0.024)  | (0.014)  |
| GDP  |   |   | -0.002\*\*  | -0.004  | -0.002  | -0.020\*\*  |
|   |   |   | (0.000)  | (0.009)  | (0.011)  | (0.008)  |
| FDI  |   |   |   | -0.114  | -0.131  | -0.136  |
|   |   |   |   | (0.119)  | (0.137)  | (0.093)  |
| Public investment  |   |   |   |   | -0.001  | -0.001  |
|   |   |   |   |   | (0.002)  | (0.002)  |
| Tax evasion   |    |    |    |    |    | 0.059\*\* (0.022)  |
| Constant  | 0.004  | -0.005  | -0.006\*  | 0.210\*\*  | 0.213\*\*  | 0.197\*  |
|   | (0.009)  | (0.010)  | (0.001)  | (0.090)  | (0.098)  | (0.094)  |
| Comments  | 28  | 27  | 25  | 28  | 27  | 25  |
| R-squared  | 0.862  | 0.964  | 0.965  | 0.446  | 0.446  | 0.658  |

Standard errors in parentheses \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Source: Authors**

**Figure 2: CUSUM test**

|  |  |
| --- | --- |
|  |  |
|  |  |
|  |  |

**Source: Authors**

Following the ARDL models presented in Table 5, we apply CUSUM tests to verify the stability of these models in the long term of primary education and its determinants, particularly with mineral rents. For the DRC, we note that for most models, the CUSUM test curve belongs to the confidence interval at the 5% threshold. These results suggest that the models we use to estimate the relationship between education and mineral rents, in addition to the other variables, are validated. The models are therefore stable, since they fall within the confidence interval between the two strong features.

**3.2.3. Sensitivity analysis**

Table 6 presents the results of the sensitivity analysis, considering primary education for men and primary education for women. In the literature, the average number of years of education is the most direct and preferred indicator of human capital accumulation at national level. Gylfason (2001) uses this data for women. It is important to present results by gender because, firstly, we expect the female education variable to reflect the median level of human capital accumulation. Secondly, women's education is considered important in its own right, if only in terms of labor market participation and demographic transition in developing countries (Stijns, 2006).

**Table 6: Sensitivity analysis *(male and female primary education*)**

 **Primary education women Primary education men**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **VARIABLES**  | **FMOLS** |  | **FMOLS** |  |
| **(1)** | **(2)** | **(3)** | **(4)** |
|  Minerals  | 0.165\*\*\* | 0.049\*\*\* | 0.116\*\*\* | 0.017 |
|   | (0.018) | (0.008) | (0.012) | (0.015) |
| Internet  |  | 0.071\*\*\* |  | 0.053\*\*\* |
|   |  | (0.004) |  | (0.007) |
| GDP  |  | 0.006\*\*\* |  | 0.014\*\*\* |
|   |  | (0.002) |  | (0.004) |
| Public investment  |  | 0.000\* |  | 0.000 |
|   |  | (0.000) |  | (0.000) |
| FDI  |  | -0.047\*\*\* |  | -0.119\*\*\* |
|   |  | (0.014) |  | (0.026) |
| Tax evasion  |  | 0.054\*\*\* |  | 0.056\*\*\* |
|   |  | (0.007) |  | (0.014) |
| Constant  | 4.279\*\*\* | 3.851\*\*\* | 4.491\*\*\* | 4.058\*\*\* |
|   | (0.031) | (0.044) | (0.021) | (0.082) |
| Comments  | 20 | 15 | 20 | 15 |
| R-squared  | 0.854 | 0.960 | 0.737 | 0.850 |

Standard errors in parentheses \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Source : Authors**

**3.2.4. Mediation analysis**

In order to deepen the analysis of the effect of mining rents on access to education in the DRC, we wish to study the mediation effect by considering the weight of colonization, political stability and the control of corruption as potential explanatory variables.

To this end, the model we use is inspired by Ang (2013). This author used this analysis technique to study the modern financial system. This technique is also used by Mignamissi et al (2023). Figure 3 illustrates intermediation as follows**:**

Figure 3: Modeling intermediation



**Source :** Authors

In Table 7, we formally evaluate the mediation effect, taking several statistics into account. We consider these mediation tests to evaluate the indirect effect of mining rents on access to education in the DRC, via colonial weight, political stability and corruption. The p-value is less than 5% in Table 7, prompting rejection of the null hypothesis of no historical mediation. Thus, the mediation effect is 73%. The same applies to mediation by political stability, for which the p-value is less than 5%, with a mediation rate of 38%. However, the level of mediation is raised to 20% in the case of corruption control. The control of corruption with a mediation rate of 20% indicates that, although less marked than that of political stability, this threshold suggests that better control of corruption has an indirect but nonetheless significant effect on the allocation of public resources.

**Table 7: Mediation analysis**

**(i) Mediator: Weight of the (ii) Mediator: Stability (iii) Mediator: Control**

 **colonization politics corruption**

**)**

**a**

**(1**

**)**

**b**

**(1**

**)**

**a**

**(2**

**)**

**b**

**(2**

**(3**

**)**

**a**

**(3**

**b**

**)**

**Weight of the Education Stability Education Control Education**

 **Dep. variables primary colonization primary politics** primary **corruption**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mining rents  | 0.208\*\* | 0.003\* |  | 0.088 | 0.005\*\* |  | -0.002 | 0.005\* |   |
|   | (0.100) | (0.010) |  | (0.064) | (0.010) |  | (0.007) | (0.014) |   |
| Settlement **weight**  |  | **0.040\*** |  |  |  |  |  |  |   |
|   |  | **(0.024)** |  |  |  |  |  |  |   |
| Political **stability**  |  |  |  |  | **0.044** |  |  |  |   |
|   |  |  |  |  | **(0.090)** |  |  |  |   |
| Corruption **control**  |  |  |  |  |  |  |  | **-0,115** |   |
|   |  |  |  |  |  |  |  | **(0,265)** |   |
| Control variables  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |   |
| Bootstrap  | 500 | 500 |  | 500 | 500 |  | 500 | 500 |   |
| Constant  | 2.145\*\*\* | 2.45\*\*\* |  | 3.770\*\*\* | 0.425\*\*\* |  | -1.434\*\*\* | 5,346\*\*\* |   |
|   | (0.578) | (0.653) |  | (0.222) | (0.110) |  | (0.034) | (0.231) |   |
| Comments  | 23 | 23 |  | 23 | 23 |  | 23 | 23 |   |
| **Composition effect** % of the total effect mediated | **73 %** |  |  | **38 %** |  |  | **20 %** |  |  |

*Notes: \*\*\*, \*\*, \* indicate significance at 1%, 5% and 10% level, respectively. Robust standard errors reported in parenthesis.*

**Source : Authors**

**3.2.5. Robustness analysis**

Looking at the results obtained from FMOLS and DOLS in Table 8 and Table 9, we can see that the results are in line with those of the basic model. Indeed, we observe that mining production is positively associated with access to primary education in the DRC at the 1% threshold. The results show that mining production in the DRC has a positive and statistically significant relationship with access to education at all levels (primary, secondary and tertiary). More specifically, an increase in mining production is accompanied by an improvement in primary (coefficient of 0.021), secondary (0.355) and tertiary (0.308) education, all significant at the 1% level. These results suggest that revenues generated by mining activity can contribute to the financing and development of the Congolese education system, thereby promoting better schooling of the population at all levels.

Table 8: Alternative estimation technique: DOLS (mining production)

|  |
| --- |
| Dependent variable : Primary education |
| Long-term relationship |  |
| Variable | Primary |
| Mining production | 0.021\*\* |
|  | (0.009) |
| Internet | 0.060\*\*\* |
|  | (0.010) |
| GDP | -0.021\*\*\* |
|  | (0.005) |
| Investment | -0.001 |
|  | (0.001) |
| FDI | -0.079 |
|  | (0.057) |
| Tax evasion | 0.050\*\*\* |
|  | (0.014) |
| Constance | 0.362\*\*\* |
|  | (0.062) |
| Comments | 26 |
| R2 | 0.948 |

**Source**: Author's calculations

 Table 9: Alternative estimation technique: FMOLS (Mining production)

|  |
| --- |
| Dependent variable : Primary education |
| Long-term relationship |  |
| Variable | Primary |
| Mining production | 0.005\*\*\* |
|  | (0.001) |
| Internet | 0.058\*\*\* |
|  | (0.004) |
| GDP | -0.013\*\*\* |
|  | (0.002) |
| Investment | -0.001 |
|  | (0.003) |
| FDI | -0.018 |
|  | (0.018) |
| Tax evasion | 0.039\*\*\* |
|  | (0.005) |
| Constance | 0.426\*\*\* |
|  | (0.024) |
| Comments | 26 |
| R-squared | 0.787 |

 Source: Author's calculations

1. **Conclusion**

This article aims to examine the effects of mineral exploitation on education in the DRC, highlighting the complex dynamics between mineral wealth and the education system. More specifically, we study the direct and indirect aspects of the effects of mineral exploitation on education in the DRC. The study period covers the years 1990 to 2023, during which the DRC experienced significant fluctuations in mining, as well as notable socio-economic impacts on education. The estimation method used is based on a staggered lag autoregressive model (ARDL), allowing analysis of long- and short-term relationships between the variables of interest.

The results of this research reveal a negative and significant short-term correlation and a positive and significant long-term association between mining rents and access to education, suggesting that revenues generated by mining could potentially fund educational infrastructure and improve access to education. However, this relationship is complicated by factors such as corruption, lack of political will and armed conflict, which often divert resources away from education. The sensitivity analyses and robustness tests carried out confirmed the robustness of the results, highlighting that the similar effects of mining on education are particularly exacerbated in regions where governance is fragile and investment in human capital is often neglected.

From these important findings emerge some non-exhaustive economic policy suggestions for the sustainable management of mining profits in the DRC, and for increasing the share of public expenditure devoted to education in particular. Firstly, strengthening the education system from the bottom up can be enhanced by earmarking part of the revenues from mining resources for a conditional or labelled cash transfer program for education, potentially with the support of the extractive industry. Secondly, it is imperative to promote transparent and accountable governance in the mining sector, to ensure that the benefits of mining truly accrue to local communities and contribute to the country's sustainable development.

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1. North (1990) deﬁnes institutions as: “Constraints devised by men to structure their interactions”. For him, institutions are made up of formal constraints (political and legal rules, economic rules and contracts) and informal constraints (norms of behavior, conventions, codes of conduct, culture, beliefs, ideology, routines and networks of friends). [↑](#footnote-ref-1)