Natural resources and human development: Evidence from mineral-dependent African countries by means of exploratory graphical analysis

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In this study, we propose a new approach for the visual inspection of interactions between human development and economic growth and a set of variables that reflect the dependence of mineral resources. We focus on the ten African countries with the highest share of mineral exports compared to total exports in the period from 2007 to 2016. First, we provide a descriptive analysis and we rank the countries according to their average annual growth in relation to a set of proxies of resource dependence and economic indicators during the sample period. Second, we cluster the different states by means of a dimensionality-reduction technique that enabled synthesising the information in the rankings into two factors: (a) economic growth and human development, and (b) growth in mineral resource dependence. Finally, we project all countries into a perceptual map and observe four clusters that roughly correspond to the main African regions, and whose distribution shows a slightly negative slope (indicative of a weak inverse relationship between mineral dependence and development). Regarding the interactions among variables, we observe a tenuous negative association between average growth in human development and the relative weight of mineral rents. These results, coupled with the fact that the average growth in resource rents does not materialise in higher economic growth, indicate that corruption may be impeding economic development, especially if it is understood under a more inclusive perspective that incorporates health and education. This finding underscores the need to promote institutional quality and to develop a mining strategy to help revert the effects of the resource curse in mineral-dependent African countries. Accordingly, we propose a series of policy measures based on four main objectives: competitiveness, transparency, sustainability and inclusiveness.

***Keywords*:** resource curse; economic growth; human development; mining; multivariate analysis; Africa

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Highlights

- Ranking of Africa’s most mineral-dependent economies between 2007 and 2016
- Dimensionality-reduction approach to summarise information into two components
- Exploratory graphical analysis to map interactions between countries and indicators
- Countries can be grouped into four major areas reflecting Africa’s main regions
- Weak inverse relationship between growth in human development and mineral rents

1. Introduction

In recent decades, there has been empirical evidence that some resource-rich countries in certain areas tend to grow at a slower rate than countries with fewer natural resources (Arezki and van der Ploeg, 2011; Gylfason, 2001, 2006; Isham et al., 2005). This inverse association between natural resource dependence and economic growth, which challenges the conventional view that natural resources are key for economic development, is referred to as the natural resource curse (NRC) (Auty, 1993).

This strand of literature focuses on non-renewable assets (e.g. oil, gas and minerals), and has identified several economic and political mechanisms that explain these paradoxical empirical findings. Nevertheless, a new trend in the literature has emerged more recently, in which several concerns are raised with respect to data and sample collection, as well as statistical issues such as multicollinearity and endogeneity. Badeeb et al. (2017) and Van der Ploeg and Poelhekke (2016) suggest that using time-series and panel frameworks enable a clearer picture of the potential existence of the curse.

In this study we provide an analytical framework based on a dimensionality-reduction technique that allows working with panel data and, in turn, avoids the problems derived from cross-sectional causal analysis. We use the evolution of a set of macroeconomic variables including economic growth, human development, government expenditure, industry value added, mineral rents and the share of mineral exports, to position the ten most mineral-dependent African countries. We synthesise this information across two dimensions, deriving a perceptual map that displays the interactions between indicators and the relative positioning of countries according to the average growth of all the variables during the sample period. We use annual percentage growth rates of all variables to avoid the issues inherent when working with non-stationary data (Clements and Hendry, 1998).

To circumvent some of the problems that may arise when dealing with time series from developing countries, such as the presence of outliers, we generate an ordinal series for each indicator following the two-step procedure proposed by Claveria (2016). As a first step, we rank the countries according to the average annual growth of the selected indicators between 2007 and 2016. By assigning a descending numerical value to each country corresponding to its ranking, we generate a set of categorical data we then use to cluster and position the different states by means of Categorical Principal Component Analysis (CATPCA).

This approach is a complementary technique to multiple correspondence analysis that can handle nominal, ordinal and numerical variables simultaneously and can deal with nonlinearities in the relationships among them. This multivariate procedure allows us to synthesise all information into two components, which we project on a two-dimensional perceptual map. The generated biplot condenses the dynamics between economic growth-related variables and resource-dependence indicators during the last decade by positioning each country with respect to the others (based on the scores in the two computed factors), and overlapping the vectors with the component loadings associated with each indicator.

To our knowledge, this is the first attempt to apply CATPCA to the analysis of the resource curse. On the one hand, this empirical study extends the coverage of previous research by assessing the utility of visualisation techniques in order to shed some light regarding the complex interactions amongst human development, economic growth and other macroeconomic variables reflecting mineral-dependence. On the other hand, we propose an alternative approach to evaluating the dynamic interplay of key factors behind the resource curse based on the relative positioning of economies (with respect to the main attributes affecting economic development). According to our findings, a series of implications arise that highlight the importance of designing a mining strategy that helps reverse the effects of the curse in mineral-dependent African countries. We propose a series of policy measures grouped in four main objectives: competitiveness, transparency, sustainability and inclusiveness.

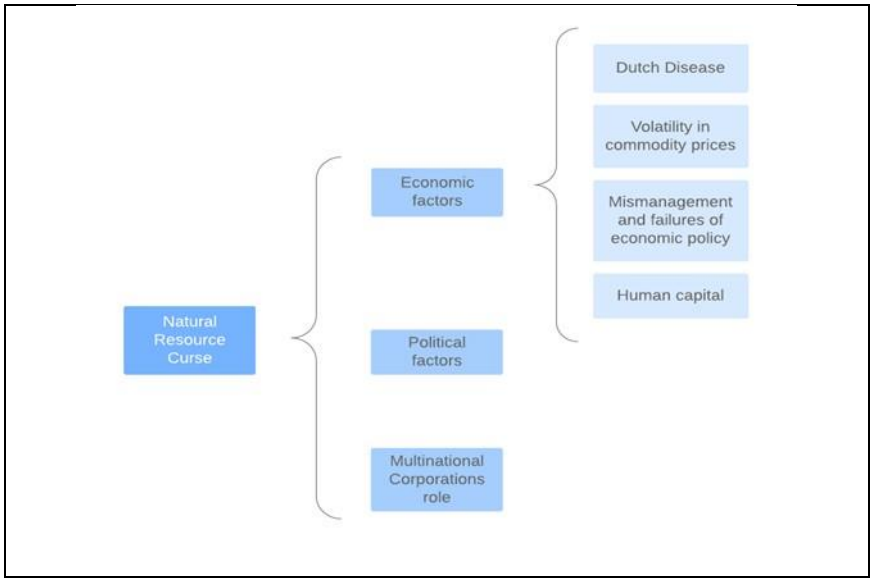
The remainder of the study is structured as follows. The next section provides a review of the literature. In Section 3, we describe the data and rank the selected countries based on their average growth rate over the sample period. In Section 4, we cluster the nations applying CATPCA. Finally, Section 5 concludes.

2. Literature review

The seminal work of Gelb (1988), in which the author analysed the economic effects of oil rents, was the first to establish the NRC thesis. Sachs and Warner (1995, 1997, 1999, 2001) later applied cross-sectional studies to empirically test the negative relationship between natural resource dependence and economic growth, finding evidence in favour of the NRC. The literature has since focused on identifying the channels through which natural resource dependence could serve to hamper sustained economic growth.

The main casual mechanisms that link resource dependence to poorer economic performance can be grouped into two main categories: economic and political, to which we could add the increasing role of multinational corporations. Economic development channels can be in turn grouped in four main types: the "Dutch disease", named after the decline of Dutch manufacturing after the discovery of gas in Groningen; the volatility in commodity prices; pitfalls in economic policy; and human capital (see Fig. 1).

Fig. 1. Different causal channels by which the NRC may operate



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The Dutch disease can be regarded as a predecessor of the NRC thesis, and has come to encompass most of the economic negative effects resulting from the crowding out of other sectors in the economy via appreciation of the real exchange rate. It is considered one of the most prominent factors by which the NRC may operate (Iimi, 2007). The Dutch disease occurs when natural resource booms increase domestic income and the demand for goods – which, in turn, generates inflation and appreciation of the real exchange rate. This causes relative prices of non-resource commodities to increase and provokes a sectoral reallocation of economic resources.

For this phenomenon to occur, there must be coexistence of booming and declining sub-sectors within the traded goods sector. It is generally applied to denote a growing resource extractive sector and a progressively stagnant manufacturing or agricultural sector. The phenomenon results from the hard currency inflows associated with surging resource exports, leading to an appreciation of the real exchange rate (Pegg, 2010).

Corden and Neary (1982) and Corden (1984) first developed a model elaborating the Dutch disease. The authors distinguished two channels through which the phenomenon operates: the resource movement effect and the spending effect. The former occurs when the booming sector draws capital and labour away from other sectors; the spending effect occurs when extra income derived from the booming resource rents is spent on domestic goods and services.

The end result is higher costs and reduced competitiveness in the tradable sectors that face competitive international prices for their goods. Natural resource booms have been found to crowd out other important sectors of the economy (Dartey-Baah et al., 2012; Frankel, 2010; Papyrakis and Gerlagh, 2004). In such cases, the economy becomes resource-dependent and heavily exposed to the volatility of commodity prices.

The volatile nature of natural resource prices in global markets, as opposed to that of commodity prices, has also been found to reduce economic growth, as market instability favours uncertainty – which, in turn, impedes effective economic planning (Davis and Tilton, 2005; Van der Ploeg, 2011). Economic mismanagement can be the result of ready access to resource rents, which can relieve pressure on governments with regard to tax-collection and fiscal discipline (Iimi, 2007; Ross, 2007). Very much related to the latter, dependence on natural resources may also reduce people's incentives to accumulate human capital due to high levels of non-wage income or resource-based wages. Gylfason et al. (1999) found evidence that school enrolment at all levels is inversely related to natural resource dependence.

Political factors, in turn, can be grouped into two main channels: rent-seeking behaviour (also known as the "political Dutch disease"), and the role of institutions (Mehlum et al., 2006; Zallé, 2019). The windfall of resource revenues increases the power of elites – a situation that ends up widening inequalities. This can also lead to internal conflicts and corruption (Arezki and Gylfason, 2013; Battacharyya and Hodler, 2010; Hodler, 2006).

Recent studies (Adams et al., 2019; Kolk and Lenfant, 2010) have found evidence that some actions undertaken by multinational corporations (e.g. outsourcing, transfer pricing, tax avoidance) are one of the main causes for the NRC within developing economies, especially in oil-rich countries. The trade-off between ethics and business profit that corporations sometimes face may be aggravated in countries with weak institutions that put less pressure to comply regulations. Accordingly, as a major agent involved in the exploitation of natural resources, corporations could be amplifying the

effect of the previous factors when certain conditions occur. Their impact would be mainly conditioned on the specific socio-political circumstances of each country. In this sense, Arvanitis and Weigert (2017) highlighted the importance of combining bottom-up with top-down approaches in which multinational corporations could play a crucial role.

Other authors have found evidence of the effect of additional economic variables on the negative association between resource dependence and economic growth. Chief among these are investment (Papyrakis and Gerlagh, 2007); human capital (Stijns, 2006; Zallé, 2019) and fiscal policy (Bornhorst et al., 2008). Hammond (2011) noted that the causes and the remedies for the NRC are multidimensional.

The growing tendency to incorporate additional explanatory variables in the models has had a double effect. On the one hand, it has allowed an increase in the spectrum of causal channels. James (2015) established an alternative explanation for the NRC: the slow-growing resource sector. Boos and Holm-Müller (2013) stressed the role of savings.

On the other hand, the inclusion of such additional factors has led to a progressive questioning of the notion of the curse, both with regard to the degree of the negative relationship between abundance of resources and economic growth (Dietz et al., 2007; Van der Ploeg and Poelhekke, 2009) and, as well, with respect to the sign of the relationship between the two (Alexeev and Conrad, 2009; Boschini et al., 2013; Brunnschweiler, 2008; Brunnschweiler and Bulte, 2008; Cavalcanti et al., 2011).

Papyrakis and Gerlagh (2004) found that natural resources had a negative impact on growth if considered in isolation but exerted a positive direct impact on growth if other explanatory variables (e.g. corruption, openness, terms of trade, and schooling) were included. Farhadi et al. (2015) found that the negative growth effects of resource rents could turn positive in countries that enjoy greater economic freedom. Shao and Yang (2014) found that allocation efficiency of production factors could be a critical factor in evading the curse and that sufficient human capital was an essential guarantee for its avoidance. As noted by Bulte et al. (2005), all this evidence suggests that the resource curse is not only existent but, in fact, a more encompassing phenomenon than previously considered.

The inclusion of additional explanatory factors, has not only led to the obtention of a weaker linkage between resources and growth, but even a positive relationship between the two. Alexeev and Conrad (2009) found the effect of a large endowment of oil and other mineral resources on long-term economic growth to be on balance positive.

Using panel data for the US, Boyce and Emery (2011) obtained a negative relation between resource abundance and economic growth but a positive one with income levels. Cavalcanti et al. (2016) found that oil abundance had a positive effect on both income levels and economic growth. Using an innovative threshold-estimation technique, Sarmidi et al. (2014) found that the impact of natural resources was meaningful to economic growth only after a certain threshold point of institutional quality has been attained.

Due to the lack of consensus, Havranek et al. (2016) conducted a meta-analysis and found that approximately 40% of the studies scrutinised obtained a negative effect of natural richness on long-term economic growth; another 40% saw no effect, and 20% saw a positive one. For a detailed review of the NRC and recent quantitative evidence see Badeeb et al. (2017) and Van der Ploeg and Poelhekke (2016).

In recent years, a new strand of the literature has emphasised some statistical shortcomings of prior empirical research, having to do with the time sample, the proxy for natural abundance (Brunnschweiler and Bulte, 2008) and, as well, the type of analysis applied (Stijns, 2005). Most existing research is based on cross-country causal analysis, with the subsequent problems of multicollinearity and endogeneity that are often found to arise. As a result several authors advocate for the use of different techniques in order to re-assess the NRC thesis (Apergis and Payne, 2014; Van der Ploeg and Poelhekke, 2016). New modelling techniques also allow to deal with nonlinearities. Liu (2014), for example, found evidence of non-linear impacts of natural resource production, while Mehrara (2009) showed that failure to account for nonlinearities may conceal the existence of the resource curse – particularly during booms.

To circumvent some of these issues, in this study we propose a multivariate procedure based on a two-step approach. On the one hand, instead of using cross-country data, we use a panel that includes time series for different indicators and countries, and rank the countries according to the average growth experienced in the last ten years. On the other hand, this approach allows us to generate categorical data, avoiding issues caused by the presence of outliers and applying a dimensionality-reduction technique that captures nonlinearities in the relationships between variables. The CATPCA approach enables to synthesise the information in two components, which are then projected in a two-dimensional map together with the relative positioning of the countries.

3. Data and methods

In this study, we combine macroeconomic time series from the World Bank (https://data.worldbank.org/) with the annual Human Development Index (HDI) provided by the United Nations (http://hdr.undp.org/en/content/human-development-index-hdi). The HDI is a composite indicator of life expectancy, education, and income per capita (Alzate, 2006), whose introduction allows us to incorporate the interactions between natural dependence and development beyond a strictly economic sense. All data can be freely downloaded. The sample period extends from 2007 to 2016.

The analysis focuses on resource-dependent African countries. We have selected a sample of ten countries which are distributed across the four main regions of Africa: West Africa, Equatorial Africa, East Africa and South Africa (Fig. 2). The selection criterion is based on the economic dependence on ores and metals, measured as the average share of ores and metals exports compared to the total exports over the sample period (see Table 1).

Fig. 2. Map with the distribution of the countries analysed

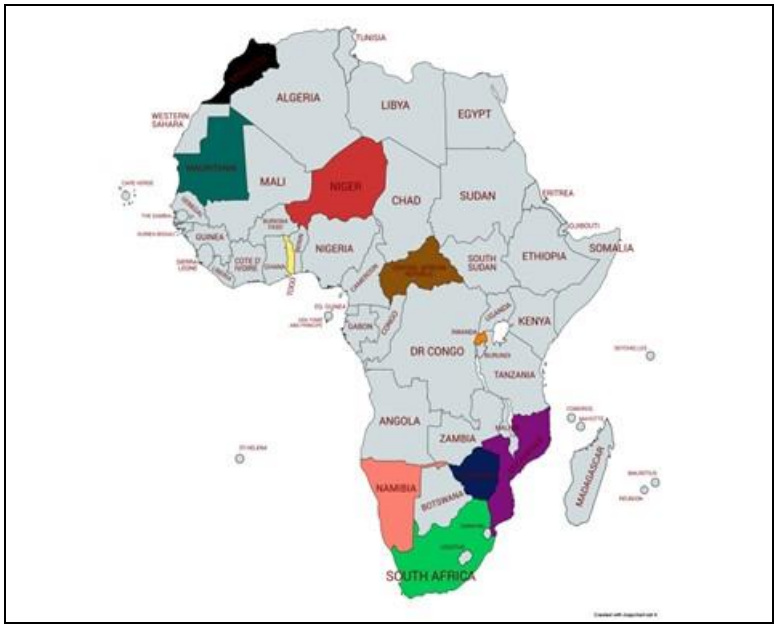

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Table 1
Average share of mineral exports over total exports (2007-2016)

Niger	47.0
Mauritania	46.7
Mozambique	40.6
Rwanda	37.0
Central African Republic	35.2
Zimbabwe	30.2
Namibia	28.1
South Africa	27.9
Togo	16.3
Morocco	10.3

The macroeconomic variables included in the analysis are the gross domestic product (GDP) per capita to measure economic growth, total government spending, and industrial value added (AVI) at constant prices. We have used the share of exports of ores and metals over total exports to proxy the dependence on mineral resources, and have also included the share of mineral rents over GDP, which are obtained as the difference between the value of production for a stock of minerals at world prices and their total costs of production.

In Table 2, we present the summary statistics of all the variables included in the analysis. While cross-country differences in the share of exports of ores and metals are small, Mauritania presents by far the highest share of mineral rents over GDP during the sample period. In terms of GDP per capita and HDI, South Africa is the country with the highest values, followed by Namibia and Morocco.

To avoid the issues derived from working with non-stationary time series (Clements and Hendry, 1998) and to circumvent some of the problems that may arise when dealing with time series from developing countries, such as the presence of outliers, hereafter we use the annual percentage growth rates of the variables. Growth rates are dimensionless measures of the amount of increase (or decrease) of a specific variable from one year to another in percentage terms. This allows us to undertake a comparative analysis of the evolution of the different indicators.

Multivariate techniques for dimensionality reduction have been widely used in economic studies, but not within this strand of the literature. Some of the most-applied procedures are PCA, cluster analysis, correspondence analysis, and factor analysis. See Hair et al. (2009) and Jolliffe (2002) for a detailed description of multivariate methods.

Table 2
Summary statistics (2007-2016)

	Ores and metal exports		Mineral rents		GDP per capita		HDI		AVI		Government spending	
	mean	RSD	mean	RSD	mean	RSD	mean	RSD	mean	RSD	mean	RSD
Central African Rep.	35.21	71.11%	0.08	43.11%	393.20	17.41%	0.35	3.00%	241.46	8.82%	122.12	26.46%
Mauritania	46.66	45.01%	33.66	26.91%	1255.13	3.60%	0.50	3.03%	1870.59	9.70%	937.48	9.97%
Morocco	10.30	25.55%	3.06	61.90%	2938.76	7.14%	0.63	3.58%	24881.07	18.62%	18120.53	29.34%
Mozambique	40.57	40.25%	0.05	48.80%	447.48	10.51%	0.41	4.43%	2029.43	9.66%	2387.54	13.92%
Namibia	28.10	11.17%	2.55	43.78%	5475.32	7.60%	0.61	4.43%	3433.56	9.66%	3180.42	13.92%
Niger	47.04	38.54%	0.71	40.44%	361.43	6.13%	0.33	5.86%	1193.89	31.94%	998.21	19.78%
Rwanda	37.04	23.12%	0.24	77.57%	609.19	13.18%	0.49	4.84%	1070.22	26.59%	952.72	24.90%
South Africa	27.92	8.20%	3.30	19.99%	7407.66	2.08%	0.66	3.66%	104731.93	2.57%	78378.24	7.98%
Togo	16.33	15.79%	14.29	36.69%	558.48	8.99%	0.47	4.27%	394.61	22.86%	464.61	32.65%
Zimbabwe	30.19	30.36%	4.18	30.54%	942.86	16.59%	0.49	7.26%	2646.12	24.53%	3115.87	36.01%

Note: RSD refers to the relative standard deviation. It is a measure of relative dispersion also known as the coefficient of variation, which is obtained as the ratio of the standard deviation to the absolute value of the mean. AVI and government spending are expressed in millions.

Dimensionality-reduction techniques allow the generation of lower-dimensional representations of data that preserve as much information as possible about the original dataset, therefore facilitating the detection of underlying structures in the relationships between variables (Chandra and Menezes, 2001). Dimensionality-reduction techniques are used in a wide range of studies, from the design of indicators (Fetscherin and Stephano, 2016) to segmentation studies (Sinclari-Maragh et al., 2015).

In order to deal with nonlinear relationships in the data and with qualitative information, the PCA framework has been progressively extended. CATPCA can be regarded as an extension of PCA (Meulman et al., 20012). The technique is also known as nonlinear PCA. CATPCA presents several advantages over standard PCA: it allows incorporating nominal and ordinal variables and does not assume that the relationships between variables are linear. As a result, CATPCA can uncover nonlinear patterns between variables. An additional advantage of CATPCA is that, due to the nonlinear transformations of the nominal and ordinal variables achieved by optimal quantification, it tends to concentrate more variation in the first few principal components (De Leeuw and Meulman, 1986).

In this study, we use CATPCA to position and cluster ten resource-dependent African economies. We generate two-dimensional projections based on the rankings of the countries with respect to their average annual growth in a set of economic indicators that proxy both economic growth and mineral dependence.

While the connection between natural resources and economic growth has been widely analysed by means of causal analysis, to our knowledge it has not yet been addressed by means of dimensionality-reduction techniques. Hence, this study aims to highlight the utility of CATPCA for generating maps that offer a preliminary image of the relative positioning of countries and the interactions among natural dependence, human development and economic growth, as well as other macroeconomic variables.

Following Claveria's (2016) two-step procedure, in Table 3 we have ranked the countries in decreasing order according to the average annual growth experienced over the period extending from 2007 to 2016 for each variable.

In Table 3 we can observe that, as opposed to South Africa, Rwanda usually tops the rankings for most variables in a fashion similar to Mozambique. Countries such as the Central African Republic obtain the lowest positions in most economic indicators but very high ones with respect to mineral dependence. This result suggests that, while mineral dependence and rents have greatly increased, this increase in rents has not materialised in terms of higher average economic growth and human development.

Table 3. Ranking of countries

GDP per capita	HDI	Industrial value added (IVA)	Government spending (G)	Mineral rents over GDP	Share of mineral exports over total exports
1	**2**	**3**	**4**	**5**	**6**
Rwanda	Zimbabwe	Rwanda	Zimbabwe	Rwanda	Central African Republic
Mozambique	Niger	Niger	Mozambique	Morocco	Mozambique
Zimbabwe	Rwanda	Togo	Rwanda	Central African Republic	Mauritania
Togo	Mozambique	Mozambique	Togo	Mozambique	Zimbabwe
Morocco	Namibia	Zimbabwe	Niger	Togo	Togo
Namibia	Central African Republic	Morocco	Namibia	Namibia	Rwanda
Niger	South Africa	Namibia	Morocco	Mauritania	Niger
South Africa	Morocco	Mauritania	Central African Republic	Zimbabwe	Morocco
Mauritania	Togo	South Africa	South Africa	South Africa	Namibia
Central African Republic	Mauritania	Central African Republic	Mauritania	Niger	South Africa

Notes: Countries are ranked in decreasing order according to their annual average growth rates during the sample period (2007-2016).

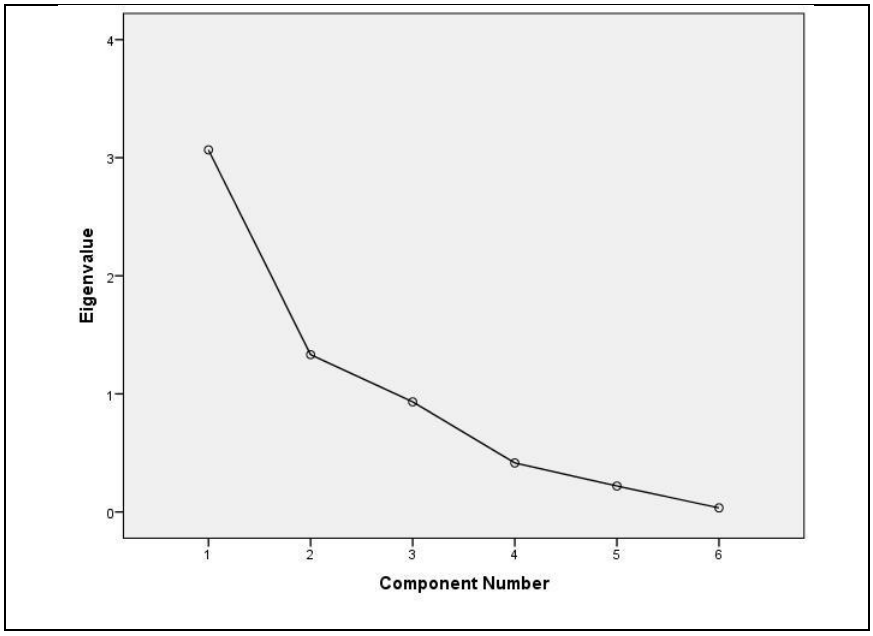
4. Results

In this section we implement CATPCA to (a) reduce the dimensionality of data and (b) generate a biplot that overlaps the relative positioning of the economies and the variables. Following Claveria's (2016) two-step procedure, after ranking the economies in decreasing order according to the average annual growth experienced over the period under study (2007 to 2016) for each variable, we assign a numerical value to each country corresponding to its position, obtaining a set of categorical data that we use to cluster the different states. The grouping of all countries is done by means of CATPCA using IBM SPSS Statistics 24.

We have used the Kaiser-Guttman method to determine the number of factors to retain (Yeomans and Golder, 1982). According to this criterion, only the factors that have eigenvalues greater than one are retained for interpretation. Eigenvalues represent the amount of variance accounted for by a specific component. Each component has an eigenvalue, so the sum of all

eigenvalues equals the number of variables in a component analysis. In the screeplot of Fig. 3 we graph the eigenvalues of the correlation matrix of the quantified variables. We can observe that only the first two factors have eigenvalues larger than the unity. As a result, the appropriate number of components to be chosen is two.

Fig. 3. Scree plot



As mentioned before, CATPCA transforms the original set of correlated variables into a smaller set of uncorrelated variables (Linting et al., 2007). First, in order to deal with nominal and ordinal variables, CATPCA begins by applying an optimal quantification procedure, the result of which can be seen in the transformation plots which display the nonlinear function that relates the category quantifications versus the original categories (Fig. 4).

In Table 4, we present a summary of the model. Regarding the goodness of fit of the components, the first two factors account for more than 93% of the variance of the variables under analysis, indicating a good fit.

Fig. 4. Transformation plots

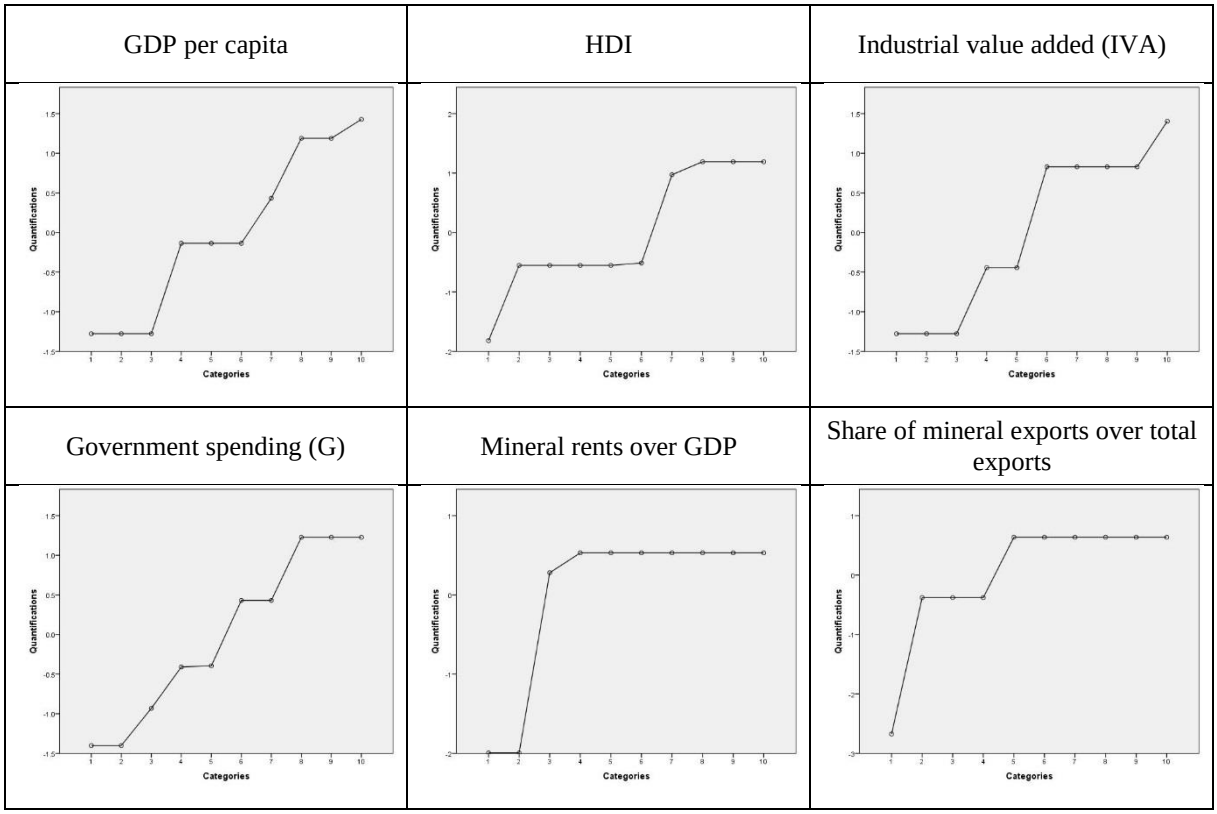


Table 4
CATPCA analysis - Summary

Dimension	Cronbach's alpha	Variance	
		Total (eigenvalue)	% of variance
1	0.886	3.94	65.75
2	0.659	1.64	27.42
Total	0.985*	5.59	93.17

Notes: *Cronbach's alpha mean is based on the mean of the eigenvalue.

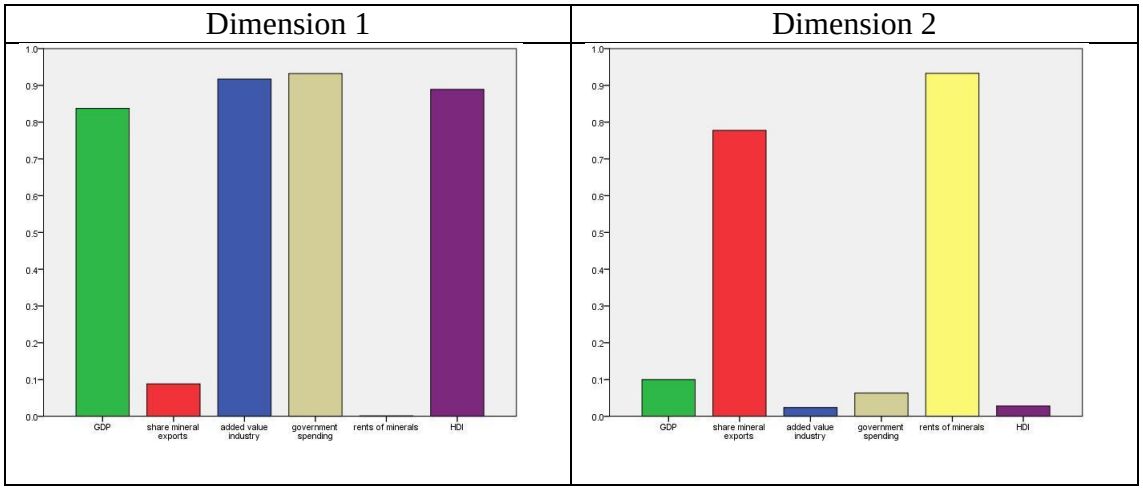
Table 5 shows the obtained component loadings, which we then use to label the two dimensions to which we have reduced the dataset. We also applied Varimax rotation to facilitate interpretation of the components thereby derived. In Fig. 5, we show the weight of each of these components. The four factors with the highest loadings in the first dimension are the rankings pertaining to the average growth of macroeconomic variables, economic growth and human development. Therefore, the first dimension better captures the aspects reflecting development of the economy, whereas the second dimension describes those more related to the relative weight and the profitability of the mineral sector. Accordingly, we label the first dimension as "economic development" and the second as "mineral dependence".

Table 5
Rotated component loadings – CATPCA

Position	Dimension	
	1	2
GDP per capita	0.915	0.316
Share of minerals exports	0.297	0.882
Industrial value added	0.958	0.154
Government spending	0.965	0.251
Mineral rents	-0.033	0.966
Human development	0.943	-0.167

Notes: Rotation method: Varimax with Kaiser Normalisation. Component loadings indicate Pearson correlations between the quantified variables and the principal components (ranging between -1 and 1).

Fig. 5. Variance accounted for in the first two dimensions



The two-dimensional scatterplot in Fig. 6 represents the coordinates of the first two retained dimensions for each country. In the plot one can observe a slightly negative slope in the positioning of the economies along both dimensions, which is indicative of a certain inverse relationship between growth in mineral dependence and economic development. The most remarkable case in this regard is Mauritania, with the top position regarding dependence in mineral resources and the lowest regarding economic growth. Namibia and Morocco are very close together near the centre of coordinates, with intermediate scores in both dimensions, indicating a very similar relative positioning. Rwanda obtained the top position in terms of economic growth. In the opposite extreme, apart from the rest of the countries, South Africa is located at the bottom of the second dimension and has low scores in both dimensions.

Fig. 6. Object points labelled by country

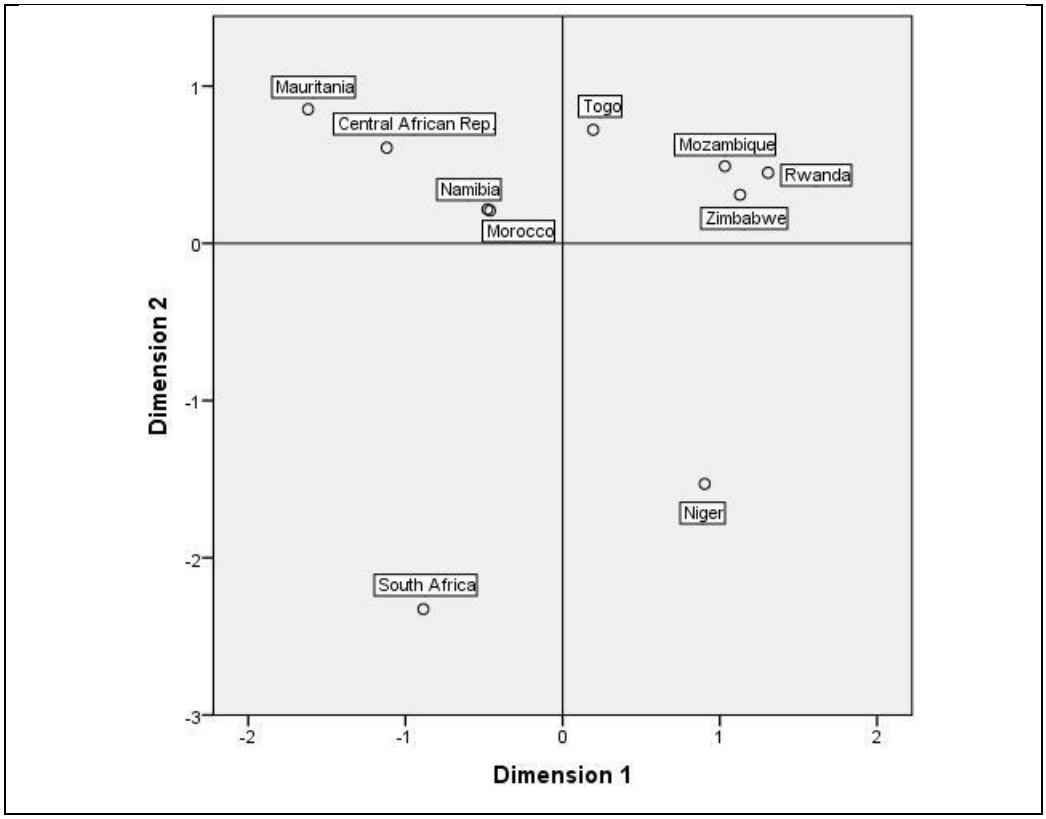


Fig. 6 displays four clusters of destinations that roughly correspond to the main African regions. To a certain extent, the first top quadrant is dominated by western African economies (Morocco, Mauritania, Namibia), while in the second top quadrant there is a predominance of eastern states (Mozambique, Rwanda, Zimbabwe), containing countries with high scores in both dimensions.

In the upper left quadrant, Mauritania is the country that experienced the highest average increase in dependence on mineral extraction and the lowest in human and economic development. In this sense, we want to note that the Mauritanian economy is characterised by the scarce diversification of production, as the extractive industry accounts for almost one fifth of GDP and is mostly concentrated in one public company, which is the second producer of iron ore in the continent.

Next to Mauritania there is the Central African Republic, where the coup d'état at the end of 2013 may serve to explain its low position in economic growth and development. It is an economy that is very vulnerable to external shocks, since it is subject to fluctuations of international commodity prices, which affect the flow of export earnings and the development of other sectors. Within the same quadrant, Namibia still has an economy characterised by its

duality as a result of apartheid. In recent years, the weight of the mining sub-sector has increased, as is shown by its high position regarding growth in mineral dependence. Its low position with respect to economic growth can be due to the fact that its level of income per capita is already one of the highest in sub-Saharan Africa – in spite of great inequities. Finally, very closely positioned to Namibia we find Morocco, which is the world's leading producer and exporter of phosphates, with around 30% of the world's reserves. This fact may explain its high score with regard to mineral dependence.

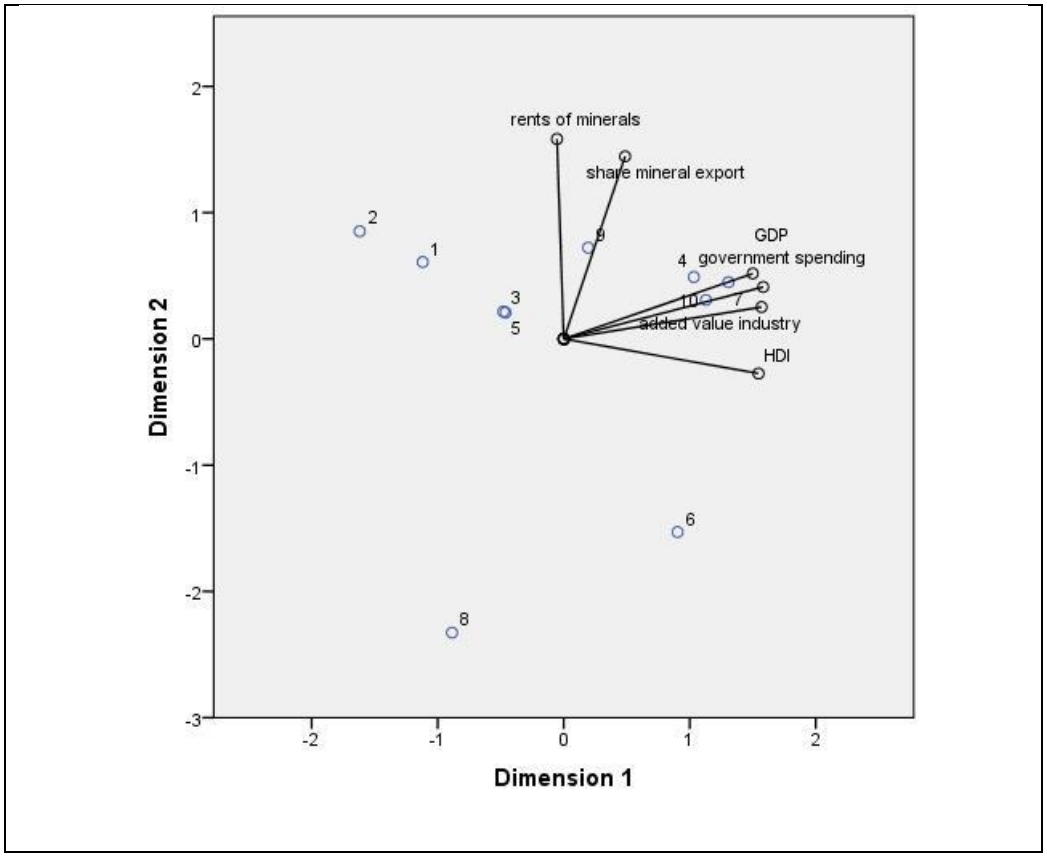
The opposite case would be that of Niger, with the second-lowest position regarding growth in mineral dependence and a high position with regard to growth in economic development. Although Niger exploits the world's largest uranium deposits, it is one of the least developed countries (thus, this relatively high economic growth can, in part, be explained by its starting position). The country with the lowest position in the second dimension is South Africa, which also obtains a relative low position in the first dimension – associated with economic development. This can be due to the fact that the country entered a slowdown phase in 2013. The situation worsened in 2015 due to the rise in interest rates and the severe drought the country went through, with an attendant fall in prices of raw materials.

As mentioned before, in the right top quadrant there is a predominance of eastern African economies (Mozambique, Rwanda, and Zimbabwe), in which one can find countries with high scores in both dimensions. In a similar way to Botswana – which is a resource-rich country, often used as a counter-example of the resource curse hypothesis (Bevan et al., 2019; Fosu and Gyapong, 2011; Iimi, 2007; Pegg, 2010); Rwanda obtains high scores both in "economic development" and "mineral dependence". The large public investment projects in the country to support the growth of the tourism industry and trade may explain its positioning. In the case of Mozambique, the recent discovery and exploitation of natural gas reserves in the north of the country, which are among the largest in the world, could be one of the main reasons for its close position to Rwanda. Zimbabwe's economy has been suffering a progressive loss of weight in the industrial and agricultural sectors in favour of the tertiary sector, being mining the main industrial sector in exports. With regard to Togo, in recent years its economic growth has been mainly fostered by large injections of international aid and investment in infrastructures.

The biplot in Fig. 7 overlaps the object scores (countries) and the component loadings (indicators). The coordinates of the end point of each vector are given by the loadings of each variable on the two components. Long vectors are indicative of a good fit. The variables that are close together in the plot are positively related, while the variables with vectors that make

approximately a 180º angle with each other are closely and negatively related. Finally, variables that are not related correspond with vectors making a 90º angle.

Fig. 7. Biplot with rotated component loadings and objects – CATPCA



Note: The vectors correspond to each variable. The scores correspond to each country. For visual clarity, we have coded each country with a number: Central African Rep. (1), Mauritania (2), Morocco (3), Mozambique (4), Namibia (5), Niger (6), Rwanda (7), South Africa (8), Togo (9), and Zimbabwe (10).

Regarding the interactions among variables, on the one hand, in the biplot we observe that the association between the average growth in share of mineral exports and economic growth is higher than the one obtained for human development. On the other hand, we corroborate a tenuous negative linkage between average growth in human development and in the relative weight of mineral rents. Accordingly, there seems to be more evidence in favour of the NRC under a more inclusive perspective of development that incorporates fundamental aspects such as health and education, than under one that does not go beyond the strictly economic factors. In this sense, Tiba and Frikha (2019) recently used the modified human development index (Costantini and Monni, 2008; Gürlük, 2009) to evaluate the NRC and found positive externalities generated by sufficient investment in human capital. Shao and Yang (2014) also noted the need of a sufficient stock of human capital to evade the curse.

While the obtained results are not directly indicative of a negative relationship between economic growth and mineral dependence, neither are they indicative of the reverse situation. This mixed evidence is in line with recent research. Gerelmaa and Kotani (2016) used quantile regression methods to test the existence of the NRC decade by decade since 1970 up to 2010 and found that the hypothesis only held up to 1990. Similarly, Dwumfour and Ntow-Gyamfi (2018) examined the relationship between natural resources, financial development and institutional quality in African countries, finding evidence of the curse especially in Sub-Saharan countries with low and middle income, and stressing the major role played by the quality of institutions in the promotion of economic growth.

In this sense, in the biplot we also can observe that the rankings regarding GDP per capita, government spending and industrial value added tend to coalesce together, indicating a close and positive relation among them but very little relation with the rest of the variables, especially with the average growth in rents of the extracting industry. The fact that the growth in income from the mineral sector does not materialise in higher economic growth, somehow hints at the potential role of poor institutional quality and corruption as factors obstructing human development. Tiba and Frikha (2019) and Zallé (2019) recently found evidence in favour of the NRC in African countries, highlighting the crucial role played by institutional quality in mitigating its adverse effects. Similarly, Amiri et al. (2019) found evidence of the existence of a resource curse in countries with poor quality institutions, in which resource rents exerted a detrimental effect on other productive sectors of the economy. Sinha and Sengupta (2019) noted that in open economies, weak institutional mechanisms worsened the economic effects of the NRC.

In recent years, there have been several initiatives to promote greater transparency and regulatory reform. The Extractive Industries Transparency Initiative (EITI) has been successful in protecting some nations from selected elements of the NRC (Corrigan, 2014; Mawejje, 2019; Vijge et al., 2019). Nevertheless, as Adams et al. (2019) have recently noted, membership in the EITI and revenue management policies have become useful for averting the NRC when complemented with country-level institutional factors. Katz and Pietrobelli (2018), Pedersen et al. (2019), and Poncian and Jose (2019) also have alluded to the importance of civil society participation in mitigating the effects of the NRC.

In the next section we propose a series of measures aimed at reversing the effects of the NRC in mineral-dependent African countries. In order to promote institutional quality and help create jobs, we propose a mining strategy based four main objectives: competitiveness, transparency, sustainability and inclusiveness.

5. Conclusion and policy implications

This study aims to provide researchers with an analytical framework to visualise the interplay between natural resource dependence, human development and other macroeconomic factors, and to position economies with respect to those interactions. The proposed approach is based on a dimensionality-reduction technique that can handle ordinal and numerical variables simultaneously and can deal with nonlinearities in the relationship between them.

With this objective, we first undertook a descriptive analysis of the evolution of a set of macroeconomic variables related to both economic growth and resource dependence in Africa's most mineral-dependent economies over the period extending from 2007 to 2016. Then, countries were ranked according to the average annual growth experienced over the sample period for all variables. By assigning a descending numerical value to each country corresponding to its ranking, we generated a set of categorical data that was summarised into two components: "economic development" and "economic performance of extracting activity".

We generated a biplot to analyse both the relative positioning of the countries and the interactions between the different variables. We found a weak negative linkage between average growth in human development and in the relative weight of mineral rents. Nevertheless, the rankings regarding economic growth, government spending and industrial value added showed no relation with those of the rents of the extracting industry and the share of mineral exports. The fact that income from the mineral sector does not seem to permeate the rest of the economy and foster growth suggests that corruption may be hampering economic development.

Therefore, the promotion of institutional quality becomes a key factor. To this end, it is crucial to developing institutional control mechanisms that encourage compliance with the law and guarantee the protection of investors in a climate of greater transparency that reduces economic uncertainty. With the aim of reversing the effects of the Dutch disease, the strengthening of institutions should be complemented by the design and implementation of local economic policies that foster investments in human capital and help to increase labour productivity in order to develop a competitive manufacturing sector.

If managed correctly, the extractive industry should be a large contributor to economic growth and social development. Therefore, we propose a series of policy measures aimed at creating a mining strategy that may help to revert the effects of the resource curse in mineral-dependent African countries. With this objective, we group this set of measures into four main objectives: competitiveness, transparency, sustainability and inclusiveness.

Regarding competitiveness, policies aimed at generating positive links between mining companies and suppliers, favouring independent engineering subcontractors capable of providing high quality services and efficient technology could help technological upgrading and increase operational efficiency. For the long-term expansion of the mining industry, the generation of a suitable level of public-private cooperation would help the introduction of measures that incentivise a major control of the concessions to reduce the number of unused ones.

To promote greater transparency, compliance with EITI principles and application of revenue-management policies, complemented with country-level institutional factors would be key in generating better governance. In this sense, additional regulatory reform measures aimed at obtaining more knowledge about the value of the sector's tax potential and about the tax optimisation practices of multinationals, would necessarily go through a greater disclosure of tax payments. In doing so, they could be of great help in mineral-dependent African countries in terms of increasing accountability.

The achievement of environmental sustainability demands must be taken into account when trying to develop a strategy for the mining industry. In this sense, a gradual shift of policies towards facilitating sustainable mining methods and resource efficiency is key. Measures that favour the introduction of more efficient price mechanisms and environmental management systems, and the encouragement of public-private partnership to preserve natural resources could help in minimising the impact upon the environment. As suggested by previous research, these initiatives need to be complemented by suitable changes in the educational curriculum for fostering long-term environmental awareness.

Finally, to reinforce the cycle between sustainability and transparency, active community engagement is essential. In order to increase participation of the local communities involved in the extractive process, measures aimed at favouring local employment, high quality training, suppliers of locally sourced raw materials, and the shared use of mining infrastructure by local business and communities have proven useful. The focus on local-specific circumstances, and the implication of civil society (so that they decide about how to participate and benefit from extracting resources) would help bring down social imbalance and income inequality and, ultimately, improve the quality of life in mineral-dependent African countries.

This study shows the potential of dimensionality-reduction and data-visualisation techniques to capture the complex set of linkages among natural resource dependence, human development and other economic factors, as well as for the positioning of economies according to the dynamic interplay among them. Our goal is to provide researchers with an alternative

approach to assessing the resource curse and to identify key attributes in the positioning of economies. Notwithstanding, this research is not without limitations. First, we want to note that this is a descriptive study, thus generalizable inferences cannot be drawn from the results. Due to the lack of available information, we have not included additional indicators that could give further insight into other factors by which the natural resource curse may operate. Another question left for future research is an extension of the analysis to other countries and comparison of the results with those obtained using other dimensionality-reduction techniques such as self-organising maps.

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