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Do The Requirements Of Sustainable Development Really Contribute To The Development Of Moroccan Mining Companies?

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Abstract:
Sustainable development is one of the main issues facing the Kingdom of Morocco in the mining sector, given the negative impacts of mining activities on water quality, air quality, biodiversity and the environment in general. To reduce these impacts, the Moroccan government has set up a framework to encourage mining companies to integrate sustainable development requirements into their management decisions. From this perspective, sustainable development requirements appear to be a brake on the development of mining activities. Hence the question: "Do sustainable development requirements really contribute to the development of Moroccan mining companies?
This is the question to which this article provides some answers, based on documentary research, a case study of sustainable development practices at three Moroccan mining companies - Managem, OCP and CM Touissit - and an econometric study.
The results show that sustainable development requirements translate into 3 categories of practices: those dictated by the quest for performance, those dictated by the need to comply with regulations and those dictated by the quest for a better brand image. The former contribute directly to the development of Moroccan mining companies.

***Keywords**: Mining companies, Morocco, Performance, Sustainable development.*

Introduction:

The issue of sustainable development is attracting particular attention in the mining sector, in this case the Moroccan mining sector, because of the repercussions of mining activities, which tend to run counter to the objectives of sustainable development. By default, mining activities have a negative impact on air quality, water quality, biodiversity and many other aspects of the environment.

For this reason, the Moroccan government has put in place a regulatory framework to govern the practices of mining companies. The existence of sanctions suggests, a priori, that there is no direct link with the performance of mining companies. Hence the question: do the requirements of sustainable development really contribute to the development of Moroccan mining companies?

To answer this question, we carried out a case study of three Moroccan mining companies (Managem, OCP and CM Touissit), focusing on their sustainable development practices and their determining factors. An econometric study was also conducted between sustainable development practice and performance. Before presenting the relationship between these practices and the performance of mining companies, this article outlines the reasons why sustainable development is a key issue in the mining sector.

1. Sustainable development is a key issue for the mining industry, as it involves major environmental challenges.

The notion of sustainable development stems from an assessment regarding how economic and manufacturing models impact the global society and the environment. According to authors like Vaillancourt (1990, p.21)[1], "sustainable development" refers to those working to protect the environment, supporting the position that any real economic development should be environmentally sustainable whether in the short, medium or long term. With these principles underpinning their work, many authors suggest, endorse and defend conscientious management of the environment's resources, and urge that its heritage be preserved intact across generations, find it a priori paradoxical to speak of sustainable development in a sector that extracts non-renewable resources.
In fact, mining activities involve major environmental issues relating to renewable energies, water quality, air quality and biodiversity.

[1] Villeneuve Claude et al (2015). Mines et développement durable, comment aborder la quadrature du cercle? Points de Repère. p.5 Consulted online on 25/10/2022 on
[https://constellation.uqac.ca/id/eprint/5260/1/Villeneuve_etal_CollPointDeRepere_5_29.pdf]

Environmental issues

Today's mining industries rely more on non-renewable energy sources. Indeed, as several authors, including SEGERS, RIFFON, VILLENEUVE and TREMBLAY, have pointed out, in an environment where natural resources are limited, an activity based on the extraction of non-renewable resources cannot, by default, promote sustainable development.
Aligning such an activity with the objectives of sustainable development therefore requires human intervention, in this case the implementation of metal element recycling systems. Recycling is possible, but very difficult, especially as other elements are incorporated into metal alloys (Rombach 2006)[2].
What's more, only a small proportion of the resources consumed can be recycled, even for easily recyclable elements such as aluminum. However, aluminum recycling is limited to 30% of the total quantity produced annually (World Aluminum Institute 2015)[3].

The possible solution is to set up systems to improve recycling yields. This is entirely possible through the design and implementation of "integrated manufacturing streams and systems with an ecodesign vision" (UNEP, 2013)[4].
However, no matter how hard institutions and companies try to recycle, the use of certain natural resources is unidirectional in the sense that it leads to their destruction. These natural resources include fossil fuels and phosphate.
All in all, the consumption of non-renewable energy by the mining industries does not, by default, help to achieve sustainable development objectives. Here, human intervention is required.

Aside from non-renewable energy, mining also has an impact on water quality.

In this context, water quality refers to the quality of groundwater and surface water in general, in a given territory, in this case Morocco. The higher the quality of water, the more sustainable the environment. However, by its very nature, mining activity deteriorates water quality.
Mining requires the construction of boreholes, roads, tailings facilities and many other mining infrastructures. These various operations require land to be cleared, cleared and excavated, leading to alteration of ground structure and disruption of the hydraulic regime and watersheds (CEA, 2011; Société Abitibi-Témiscamingue 2012).
In addition, mining industries use a very large volume of water. To achieve this, they often have to divert one or more watercourses (PGUILLEBON and BIHOUIX 2010)[5].

In addition, areas where mine tailings are stored produce mine drainage water, leading to deterioration in water quality. Moreover, according to PELLETIER, this drainage is likely to attract ultra-toxic leaching contaminants, even in small quantities, and to cause the presence of radioactive elements. (PELLETIER 2012).
Other mining industries resort to the sea for their mining discharges when location conditions favor this, especially in developing countries. In developed countries, such actions generate fines and penalties for mining industries.

By default, mining activity has a negative impact not only on water quality, but also on air quality.

In this context, air quality refers to the degree of atmospheric pollution in a given region. In Morocco, it is measured by the number of days on which certain noxious gases have reached their peak[6]. These gases include "lead, sulfur dioxide, nitrogen dioxide, stratospheric ozone and suspended particulate matter". Air quality is positively correlated with sustainable development. The higher the air quality in a region, the more sustainable development is.
However, mining activity has a negative impact on air quality. It leads to the emission of carbon dioxide and various greenhouse gases. These emissions contribute enormously to air pollution.
What's more, according to several authors, including AUBERTIN (2002), BUSSIERE (2005) and PLANTE (2009), mining activity produces so-called airborne dust, which deteriorates air quality.
This shows that mining competitiveness is negatively correlated with air quality, and in turn with sustainable development in this respect.

[2] Arnim Gleich, Robert U. Ayres, Stefan Gößling-Reisemann (2006); Sustainable Metals Management Securing Our Future - Steps Towards a Closed Loop Economy; Springer, p. 295–312.
[3]Harald U. Sverdrup, Kristin Vala Ragnarsdottir, Deniz Koca; (2015); Aluminium for the future: Modelling the global production, market supply, demand, price and long term development of the global reserves; Resources, Conservation and Recycling;Volume 103, October 2015, Pages 139-154.
[4]United Nations Environment Programme. (2013); Metal Recycling: Opportunities, Limits, Infrastructure; UNEP Publications.
[5] Philippe Bihouix, Benoît de Guillebon (2010). Quel futur pour les métaux ? Raréfaction des métaux : un nouveau défi pour la société. EDP sciences, Les Ulis, France.
[6] Royaume du Maroc, Le Ministère délégué auprès du Ministre de l'Energie, des Mines, de l'Eau et de l'Environnement (2014). Les indicateurs du développement durable au Maroc. 4e Rapport National. p.78

Apart from air quality, mining activity also has a negative impact on biodiversity.

Biodiversity can have several meanings according to the specific circumstances surrounding its use. In the present context, it has two components[7]:

- Ecosystems, which refer to all areas legally identified on the basis of their characteristics, including parks, nature reserves and biological reserves.
- Threatened species, which refers to the proportion of species at risk of extinction as a result of an incident caused voluntarily or involuntarily by a natural or legal person.

By default, mining activity impacts negatively the ecosystem and increases the number of endangered species. In fact, it can release heavy metals that are harmful for various biological organisms (ALVAREZ et al, 2009)[8].

The impact of mining on biodiversity is not only remarkable during the life of a given mine, but also after its closure. Mining removes the original vegetation on site, displaces wildlife, destroys the original ground cover and releases liquids that are harmful to the health of certain species[9].

Many species, including small mammals, fish, reptiles and rodents, can be seriously affected by mining activity. And when a mine closes, the land does not revert to the way it was at the start of operations. Instead, it becomes totally disrupted, with holes and tailings ponds. In addition, many sites are abandoned by the mining industries without prior restoration.

Admittedly, sustainable development involves major environmental issues in the mining sector.

However, it is not just an environmental issue, as it also has economic implications.

Economically speaking, mining resources constitute an important source of capital for generating economic value, which can be partly used for consumption and partly reinvested in the production of other capital assets to promote economic dynamism and growth.

In fact, exploiting mining resources involves heavy investment over many years, and it is therefore with considerable interest that governments, through their industrial and mining programs, demonstrate their determination to implement appropriate strategies to enhance the contribution of these resources towards wealth creation within their respective regions.

Mining is a significant engine driving development in most countries, and it is clear that private investments in this sector are likely to be attracted if the countries in question establish a regulatory framework which encourages investment in the mining sector.

Fiscal income generated by the mining industry represents over 20% of government income, but its full revenue earning capacity has still not been exploited. Over the years ahead, numerous resources should be exploited, and this striking figure only reflects the beginnings of the strong economic expansion still to come.[10].

Most mineral-rich countries tend towards economic specialization, creating a form of economic dependence. The abundant supply of mineral resources was seen for many years as a strong engine of economic growth, and was also the focus of critical analyses, notably by Prebisch and Singer (1950), whose work proved that nations with abundant natural resources, in concentrating exclusively on exploiting those resources, progressively worsened their own trade conditions, particularly with developing countriesEventually, these nations would become increasingly depoverished, as they maintained their role as primary exporters in international trade, exporting commodities priced down through the years, and importing manufactures from developed countries. A further trend seen in countries specializing in exploiting mineral reserves is the so-called "Dutch disease", referred to by Sachs and Warner (1995) as the result of problems experienced by the Dutch economy in exploiting their natural gaz deposits. The economic performance of such nations deteriorated when they became overly dependent on mineral exports. Increased international demands led to a rise in the national currency conversion factor, which in turn redirected the majority of investments into the mining sector, as well as the workforce away from other domestic production sectors, leading to a drop off of both manufacturing and farming activities, as well as exports.

However, further studies, like Kolstad (2007) and Béland and Tiagi (2009), have demonstrated how good governance and the right policies and economic incentives would contribute to ensuring that extractive resources generate a ripple effect leading to industrialization.

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[7] Royaume du Maroc, Le Ministère délégué auprès du Ministre de l'Energie, des Mines, de l'Eau et de l'Environnement (2014). Les indicateurs du développement durable au Maroc. 4e Rapport National. Ibid, p.105

[8] Antonio M. Álvarez-Valero; Reinaldo Sáez; Rafael Pérez-López; Joaquín Delgado; José M. Nieto (2009). Evaluation of heavy metal bio-availability from Almagrera pyrite-rich tailings dam (Iberian Pyrite Belt, SW Spain) based on a sequential extraction procedure. , 102(2), 0–94. doi:10.1016/j.gexplo.2009.02.005.

[9] Conseil international des mines et métaux. 2006. Guide de bonnes pratiques : exploitation minière et biodiversité [en ligne]. Londres, Royaume-Uni. Disponible à http://hub.icmm.com/document/925.

[10] Sudeshna Ghosh Banerjee, Zayra Romo, Gary McMahon, Perrine Toledano, Peter Robinson et Inés Pérez Arroyo (2012) ; Le potentiel transformateur de l'industrie minière Une opportunité pour l'électrification de l'Afrique subsaharienne.

Sustainable development also involves social issues in the mining sector.

Reforms implemented in the extractive sector throughout the years have focused simultaneously on the preservation of the environment and on issues related to community and local development. The aim of these reforms is to increase added value at local communities' disposal through programs aimed at strengthening human and social capacities. Mining companies seeking to extract mineral deposits from specific locations or areas must consider the effects on the local community, given that mining operations often involve major development work and occupy large tracts of agricultural land that belong directly to the local people over a long period of time.

Mining activities are notorious for having a negative environmental impact, by causing pollution of the air, water, fauna and flora, particularly among locals. On several occasions, this has resulted in social unrest, leading to protests and even the shutdown of operations at certain mine locations.

Social demands to denounce environmental nuisance are no longer confined to the local level. Through successive years, these communities have gained the backing of other stakeholders, including national and international organizations, labor groups and voluntary associations, to advocate their cause and assert their rights. In some cases, these demands may impact financially on listed mining companies, with a fall in their share price, or even tarnish their image and lead to boyscotts of their products. However, it's essential to recognize that there are numerous aspects in which the mining industry plays a part in the local community's development. They finance and implement numerous community projects, which involve redistributing assets arising from mining operations, and help to maintain community ties surrounding mine zones, which are indispensable to the smooth running of their activities.

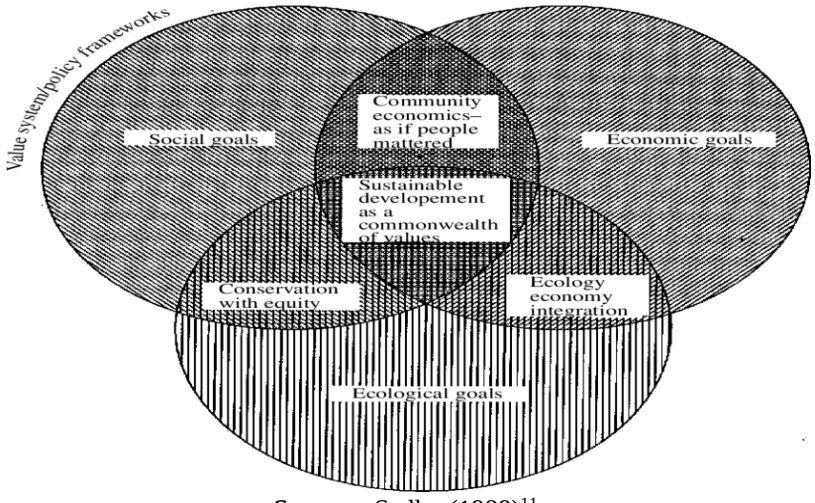
In addition, extractive industries finance the construction of development infrastructures including school buildings, medical centers and electrical installations in many of the surrounding areas. At some locations, mining industries have been highly creative in establishing microfinance mechanisms to support the involvement of local women in revenue-generating businesses. A further major element of the mining industry's contribution is the rise of small and medium-sized enterprises in the vicinity of the mines, supplying products and associated services to the mines. Outsourcing to local businesses is supported by mining code reforms in several countries in order to promote local entrepreneurship and development.

Given the challenges of sustainable development, environmental, social and economic requirements need to be translated into mining company practices.

2. Sustainable development requirements in the mining sector

The requirements of sustainable development fall within its 3 dimensions as defined by SADLER Bary and JACOBS Peter in 1998. These dimensions are illustrated in the figure below.

Figure 1: SADLER and JACOBS model of sustainable development



Source : Sadler (1988)[11]

Sustainable development requirements are translated into practices. These practices cover the various social, environmental and economic dimensions of sustainable development. To summarize them, we conducted a case study of 3 Moroccan mining companies (Managem, OCP and CM Touissit) based on a survey and analysis of their 2022 ESG report. The study revealed a range of sustainable development practices among mining companies.

[11] Consulted online on[https://www.researchgate.net/publication/223295234_On_sustainability_the_environment_and_management_accounting/figures?lo=1

The study of the determinants of these practices enabled us to understand that not all sustainable development practices have the same impact on a mining company's performance and development.

2.1. Some practices are performance-driven.

Performance-driven sustainable development practices include preserving water resources, optimizing energy consumption, managing talent, contributing to employee families and opening up villages.

Preserving water resources

Mining activities consume a great deal of water. By way of example, the table below shows Managem's water consumption from 2020 to 2022.

Indicator	2020	2021	2022**
Water consumption (m^3)	8 972 759	9 957 320	11 671 398
Water consumption ratio per tonnage processed (m^3/TT)	1.4	1.26	1.2
Recycling rate	62%	65%	60%

Source : Managem

Water is a fundamental resource not only for mining activities, but also for local populations. For this reason, mining companies must ensure good water management. This management, aimed at preserving water resources, involves defining targets, generally on an annual basis, monitoring water consumption on the basis of predefined indicators, and adjusting actions to meet targets. Generally speaking, preserving water resources is one of the main missions of the Audit and Internal Control Department. This preservation is also reflected in adequate employee training and general awareness of the issue as part of the dissemination of water management programs. It also requires site managers to ensure that the quantities required to extract the various materials are respected. Preserving water resources also requires mining companies to recycle water and use it whenever possible, instead of using fresh water.

Optimizing energy consumption

Like water, energy is a vital resource for mining operations. By way of example, the table below shows the energy consumption of Compagnie Minière de Touissit from 2020 to 2022.

Energy consumption per source

	2020	2021	2022
Energy consumption (MWh)	28 326.6	31 184.8	34 231.1
Fuel consumption (m^3)	139.5	142.2	189.9
Oil consumption (m^3)	77.1	84	99.7
Fat consumption (m^3)	5.6	4.5	6.1

- **Source:** CMTouissit (2022, p.34)

Energy management programs include programs for monitoring and controlling energy consumption, programs for substituting non-renewable energies with renewable energies, and programs for digitizing energy management tools.
For all the companies studied, optimizing energy management is one of the main objectives, with various programs. For example, Compagnie Minière de Touissit is committed to implementing a policy whose ultimate aim is to significantly reduce the consumption of non-renewable energy sources through the use of renewable energies. With this in mind, the company is working with various players to employ green energy solutions in the Tighza[12] mine. For its part, Managem uses digitalization to manage energy and energy consumption. At Guemasse, for example, the Group has implemented a platform for collecting energy data and tracking performance indicators on dashboards to optimize consumption in real time[13]. The OCP Group is also working on the substitution of non-renewable energies by green energies. With this in mind, the Group intends to meet the energy needs of all its plants with green energies by 2027[14].

[12] Compagnie Minière de Touissit (2022). Rapport Financier Annuel 2022, p.34
[13] Managem (2022). Rapport Financier Annuel 2022, Une stratégie de développement et une transformation en marche, p.45
[14] OCP (2022). Rapport Financier Annuel 2022, p.4

Talent management

Talent management in the present framework refers to all the processes and strategies put in place to attract, recruit, develop, retain and promote the most competent and high-performing employees[15]. This involves creating an environment conducive to professional fulfilment, continuous learning and career progression. The starting point for good talent management is the definition of talent within companies; and traditionally, it has been common practice for companies to cross-reference people's performance with their potential. By talent, we mean the person who demonstrates high performance and has the potential for rapid development in given areas of expertise.

Contribution to employee families

In order to create a favorable environment for their staff, many mining companies offer financial contributions to their families. These contributions can take a variety of forms: the organization of low-cost family trips with payment facilities, the provision of vacation accommodation for staff families, gifts and presents for children on the occasion of festivities and many others. Contributions to staff families create a sense of attachment and belonging to the mining company, thus improving staff productivity.

Reducing operational risks

Due to the very nature of mining activities, the employees of mining companies are exposed to accidents and illnesses, particularly those working underground and those exposed to mining products. For this reason, mining companies are obliged by default to implement plans to continually reduce the operational risks inherent in their activities.

These plans include preventive actions such as training, awareness-raising and seminars on the various risks inherent in each workstation and the steps to be taken to reduce exposure to these risks. They also include measures to be taken quickly in the event of accidents to limit the damage, and continuous improvement actions based on feedback from previous accidents. Generally speaking, operational risk reduction plans are part of the "Occupational Health and Safety" culture of mining companies.

Opening up villages

In the course of their mining activities, many companies find themselves in isolated villages: access to the village is difficult due to the absence or deterioration of roads. Such conditions make travel difficult not only for the local population, but also for employees working or due to work on the site.

To achieve this, many companies have to open up the villages in which their operations are located by rehabilitating, upgrading or building roads and access tracks to the villages. Opening up villages benefits not only the mining companies themselves, but also local populations and the State.

2.2. Other practices are dictated by regulations

These practices have no direct impact on performance. This is why they are regulated. They include simple carbon footprinting, biodiversity protection, responsible purchasing, responsible recruitment and reclamation of mining waste.

Simple carbon footprint

In the course of their activities, mining companies emit carbon dioxide (CO2). In order to measure and control CO2 emissions with a view to reducing them, a tool has been designed by ADEME. This tool is called the carbon balance. Since 2011, this tool has been managed by the Bilan Carbone Association. In addition to CO2, companies also emit greenhouse gases. To assess these emissions, companies use the simple carbon footprint. Carbon footprints and simple carbon footprints enable mining companies to ensure compliance with national and international environmental standards. They help reduce the negative impact of mining activities on the atmosphere.

All the companies studied have a simple carbon footprint. Managem carries out a simple carbon balance for all its activities located in Morocco. This enables the company to determine which jobs emit the most greenhouse gases, and to implement measures to reduce these emissions[16]. Managem employees also receive training in this area. OCP also uses a simple carbon footprint as part of its policy to reduce its greenhouse gas emissions by 45.5% by 2020[17]. CMTouissit also uses a simple carbon footprint.

Protecting biodiversity

Mining activities intrinsically affect biodiversity. For this reason, many companies implement biodiversity protection or preservation programs. These programs essentially involve closing and rehabilitating mines at the end, closing shafts, rehabilitating dykes, creating green spaces, reforestation and many other actions. Biodiversity protection programs are generally drawn up at the preliminary design stage of mining projects, in order to assess potential impacts on biodiversity and prepare mitigation plans.

[15] Cécile Dejoux, Maurice Thévenet (2005) ; La gestion des talents Ed. 2 ; Dunod; p.91

[16] Managem (2022). Rapport Financier Annuel 2022, Une stratégie de développement et une transformation en marche, p.70

[17] OCP (2022). Rapport Financier Annuel 2022, p.12

Biodiversity protection has implications for the mining company, local populations and the state. That's why negative impacts on biodiversity attract sanctions on the mining company.

Responsible purchasing

As part of their activities, mining companies purchase goods and services that they use throughout their operating cycle. Responsible purchasing means choosing suppliers in a way that reduces or eliminates environmental impact and respects human rights. The principles to be respected for a purchase to be qualified as "responsible" are set out in the ISO 20400 standard. Of the companies surveyed, only Managem explicitly states that it has a charter for responsible purchasing[18].

Responsible recruitment

As part of their business activities, companies need manpower for both business and support functions. To meet these needs, companies are called upon to recruit. Recruitment is considered responsible when it complies with current regulations specific to the position to be filled. For example, any recruitment of children or women at the bottom of a mine is not responsible, and may result in sanctions. Responsible recruitment also includes taking into account the principles of non-discrimination in terms of gender and the disabled. In this way, women can occupy management positions or positions in support functions in general.

Recovery of mine rejects

Mine rejects are more or less transformed products from the ore processing and beneficiation phase (washing rejects), containing any chemical, mineral or organic additives (BRGM 1999). The reclamation of mine tailings is part of an active management approach to mining waste. The aim is to implement ways of reusing mining waste outside mining sites. Mining waste has physical, chemical and mineralogical properties that could potentially be useful for other industries.

Audit and internal control

This essentially concerns environmental auditing and internal control. These are processes used by companies and organizations to evaluate and improve their environmental management practices. Although they have similar objectives, they focus on slightly different aspects and can be complementary.

Environmental auditing is a process of in-depth examination of an organization's practices, performance and compliance with regard to environmental issues. It can be carried out internally by a dedicated team, or by independent external auditors. The main aim of environmental auditing is to assess compliance with environmental regulations, detect non-compliance problems, identify potential environmental risks and propose improvement measures, while environmental internal control refers to the internal measures and processes put in place by an organization to ensure effective and responsible management of its environmental activities. It aims to identify and minimize environmental risks, ensure regulatory compliance and promote sustainability. Environmental internal control generally involves regular internal monitoring, validation and verification procedures.

Publishing sustainability reports

In Morocco, it is mandatory for publicly-traded companies to publish an ESG report, which contains information on the company's sustainable development practices. The same applies in France. This is the case for most mining companies, as they go public because of the capital intensity required for mining activities.

2.3. Other practices are driven by brand image

These include funding local projects and local sports activities.

Financing local projects

This enables local populations to develop income-generating activities, reduce unemployment in the area and thus contribute to the country's economic development. Of the three companies studied, Managem is the most active in financing local projects. The company makes its modest contribution to social entrepreneurship by financing projects in the communities where its mining sites are located. By way of example, in 2021 the company launched a program entitled "INJAZ FACTORY", designed to offer tailor-made training and comprehensive support to project leaders via the "Douf3a" sub-program, and to support local structures operating around Managem's mining activities through the "Cooper Up" sub-program[19].

[18] Managem (2022). Rapport Financier Annuel 2022, Une stratégie de développement et une transformation en marche, p.97

[19] Managem (2022). Rapport Financier Annuel 2022, Une stratégie de développement et une transformation en marche, p102

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Financing local sports activities.

Several companies finance sports activities in the villages surrounding the operating sites. This practice is part of cultural development and the blossoming of young people. While the promotion of sporting activities may seem unimportant for local development, it does contribute to the well-being of young people, who are an essential production factor for the mining business. The financing of local sporting activities can take various forms: sponsorship of sporting events, donations to sports clubs and many others.

All in all, certain practices contribute directly to the performance of mining companies. This can be verified by econometric studies. By way of example, we are going to carry out a causality study between the preservation of water resources and the performance of a mining company, in this case Managem.

3. Example of a causal relationship between a sustainable development practice and the performance of a mining company

First of all, it's important to introduce the general idea behind the test. Since it is not possible to go back in time, event D (relating to Sustainability) can cause event P (relating to Performance), if and only if it occurs before P. In this case, D can cause P, but P cannot cause D, because D occurred before P. In other words, the past causes the present, but the present cannot cause the past.

Formulating hypotheses:

In this case, the question is whether the preservation of the water resource causes the mining company's performance in the short term (Dp → Pe) or whether the mining company's performance causes the preservation of the water resource (Pe → Dp). Dp designates the variable relating to Sustainable Development, more specifically that relating to the preservation of water resources. Pe refers to the mining company's performance. The test yields the following two estimates:

$$\text{Estimate 1:} \quad Pe_t = \sum_{i=1}^{n} a_i Pe_{t-i} + \sum_{j=1}^{n} \beta_j Dp_{t-j} + u_t$$

$$\text{Estimate 2:} \quad Dp_t = \sum_{i=1}^{n} \gamma_i Dp_{t-i} + \sum_{j=1}^{n} \delta_j Pe_{t-j} + v_t$$

By default, the error estimates u_t and v_t are uncorrelated.

Estimate 1 means that the performance of a mining company (Pe) at a time t is linked to its past performance and the preservation of water resources in the past. Estimate 2 states that the preservation of the water resource at a time t is linked to past preservation of the water resource and past performance of the mining company.

Since only the past can cause the future, if water conservation (Dp) causes a mining company's performance (Pe), then the change in the value of the variable Dp (water conservation) should precede the change in the value of the company's performance (Pe). This reasoning is also valid in the opposite direction, i.e. in the case where the performance of a mining company (Pe) causes the preservation of the water resource (Dp).

a.Preservation of water resources causes performance: Dp → Pe

The hypotheses are presented as follows:

Ho: Preservation of water resources does not cause performance

H1: Preservation of water resources causes performance

Water conservation is measured by the ratio of water consumption per tonnage processed (m3/TT). Company performance is assessed by basic earnings per share. The values collected are presented in the table below.

Managem	Water consumption ratio per tonnage processed (m3/TT)	Basic earnings per share in MAD
2013	1.52	44.1
2014	1.63	19.9
2015	1.6	22.4
2016	1.63	31.5
2017	1.67	87.9
2018	1.8	27.00
2019	1.68	-23.40
2020	1.4	22.50
2021	1.26	86.20
2022	1.2	161.60

The unconstrained and constrained models of the causality test are written as follows:

The unconstrained model: $Pe_t = K + a_1 Pe_{t-1} + \beta_1 Dp_{t-1} + u_t$

The constrained model: $Pe_t = K + a_1 Pe_{t-1} + u_t$

To estimate the unconstrained model, we resort to simple linear regression on eviews software.
This linear regression gives us the following unconstrained model:
The unconstrained model:
$Pe_t = 485.0345 + 0.13166\ Pe_{t-1} - 279.8867\ Dp_{t-1} + u_t$
R^2 = 0.754743; n = 10 ; SCRU = 5852.133
To estimate the constrained model, we resort to a linear regression of the variable Pe_t as a function of a constant K and the variable Pe_{t-1}
This gives the following result.
The constrained model: $Pe_t = 24.34793 + 0.680505\ Pe_{t-1} + u_t$
R^2 = 0.184981; n = 10 ; SCRR = 19447.32
- Calculation of the F statistic

$$F = \frac{(SCRR-SCRU)/c}{SCRU/(n-c-1)} = \frac{(19447.32-5852.133)/2}{5852.133/(10-2-1)} = 8.13090791$$

- Calculating the critical value of F

$$Fs = F^{0.05}_{(n-k-1)} = 4.737414$$

- Test result
The F statistic is above its critical value Fs at a certain significance level (in this case 5%). We reject the Ho hypothesis. Consequently, we retain hypothesis H1: Water conservation causes performance.

b. Performance in preserving water resources: Pe → Dp
The assumptions are presented as follows:
Ho: Performance does not cause preservation of water resources
H1: Performance causes preservation of water resources
From estimation 2, we can write the constrained and unconstrained models:
The unconstrained model: $Dp_t = K + \gamma_1\ Dp_{t-1} + \delta_1\ Pe_{t-1} + v_t$
The constrained model: $Dp_t = K + \gamma_1\ Dp_{t-1} + v_t$
The coefficients of the unconstrained model are obtained from a linear regression of the variable 〖Dp〗_t as a function of the variable 〖Dp〗_(t-1) and the variable 〖Pe〗_(t-1).
The unconstrained model: $Dp_t = -0.522816 + 1.242157\ Dp_{t-1} + 0.002984\ Pe_{t-1} + v_t$
R^2 =0.801920 ; n = 9 ; SCRU = 0.06685
To estimate the coefficients of the constrained model, we perform a simple linear regression of the variable 〖Dp〗_t as a function of the variable 〖Dp〗_(t-1).
The constrained model : $Dp_t = 0.0009483 + 0.976847 Dp_{t-1} + v_t$
R^2 = 0.594328729 ; n = 9 ; SCRR = 0.136910
- Calculation of the F statistic

$$F = \frac{(SCRR-SCRU)/c}{SCRU/(n-c-1)} = \frac{(0.136910-0.06685)/2}{0.06685/(10-2-1)} = 3.668063$$

- Calculating the critical value of F

$$Fs = F^{0.05}_{(n-k-1)} = 4.737414$$

- Test result
The F statistic is below its critical value Fs at a certain significance level (in this case 5%). We accept the Ho hypothesis. Performance does not cause water conservation.
The Granger causality test using eviews software confirms almost the same results, as can be seen in the image below.

Pairwise Granger Causality Tests
Date: 09/06/23 Time: 09:12
Sample: 2013 2022
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
DP does not Granger Cause PE	9	13.9387	0.0097
PE does not Granger Cause DP		6.28810	0.0461

The probability that preserving water resources (Dp) in water does not cause performance (Pe) is 0.9%. This is less than 5%. So we reject Ho. Consequently, water conservation causes performance in the Granger sense.
On the other hand, the probability that performance (Pe) does not cause water conservation (Dp) is 4.61%. This is close to 5%. We can accept Ho. Performance does not cause water conservation in the Granger sense.

Conclusion

This article has shed light on the possibilities for reconciling sustainable development and the development of Moroccan mining companies. At first glance, it seems paradoxical to talk about sustainable development in a sector that extracts non-renewable resources. However, in hindsight, the article has shown that the requirements of sustainable development are expressed through corporate practices that are in line with the three economic, social and environmental dimensions of sustainable development. Some of these practices are motivated by the quest for better performance. They include preserving water resources, optimizing energy consumption, managing talent, contributing to employee families and opening up villages. They contribute directly to the mining company's development. Other practices do not directly contribute to the company's performance, but are necessary for the preservation of nature and society. For this reason, they are regulated. Practices dictated by regulations include simple carbon footprinting, protection of biodiversity, responsible purchasing, responsible recruitment and reclamation of mining waste. Other practices are dictated by the search for a better brand image. These include funding local projects and financing local sporting activities.

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