Sustainable development indicators as a tool for monitoring unfair international market competition of mineral commodities

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ABSTRACT

Although mineral commodities used to play and still play a very crucial role in the development of civilization over the centuries, their extraction, transportation, transformation and use are at present sources of great concern in terms of sustainability. Some of the most discussed environmental problems are in fact closely related to the utilization of minerals as materials and fossil fuels.

The paper analyses the origins of sustainability weakness of mineral supply through Environmental Economics models, which have interpreted the phenomena of pollution and non-renewable resource depletion as a market failure. Conventional market tools have proved to be unable to perform an optimal allocation of those resources that are priceless or have open access. An external intervention is needed in order to reduce the excessive exploitation of environmental and natural resources.

Some of the solutions proposed by policymakers and subsequently implemented by governments are briefly considered and the achieved results are discussed. In several cases the public intervention, where the attempt was to restore the sustainability conditions, has failed.

Restrictive environmental protection regulations have resulted in severe limitations to the mining activity, without, on the other hand, achieving the expected results in terms of sustainability.

Some of these regulations instigate unfair international competition practices among those producers who do care about the environment, but who have high production costs, and those who supply cheap raw material but whose low costs hide heavy environmental impacts.

Nowadays, most of the world's supply of minerals is being produced in developing countries, with severe global environmental impacts.

As effective tools for monitoring the problem, sustainable development indicators could be used by policymakers to duly associate the comprehensive environmental impacts for each mining product, depending on its origin and extraction history.

1. INTRODUCTION: MINING, DEVELOPMENT AND ENVIRONMENTAL CONCERNS

Mining provides basic mineral raw materials and energy for human existence and a modern lifestyle but, as it can result in environmental and social damage, it represents both a resource and a threat to sustainable development.

Mineral commodities, fuels, industrial and construction materials are required in all economic sectors, from agriculture to "new technology" industries. Although the weight of mining sector has fallen below 1% of gross domestic product in most countries, its contribution to the manufacturing industry and downstream sectors is unquestionable and remarkable.

All this considered, in order to drive the world's growing population towards a sustainable development, in which the three dimensions - economic, social and environmental - are equally considered, it is of utmost importance not to misunderstand the role of mining.

During the last decades, as a consequence of the severe ecological damage caused by the great economic growth, the perception of environmental problems and the way of facing and solving them has progressively changed.

Starting from a first approach aimed at protecting and restoring the environment, the focus of attention has been addressed, through the careful management of resources, up to the concepts and methodologies of the sustainable development.

As in other sectors of industry, mining, which has been extensively monitored from an environmental point of view, has changed to a great extent, but not without difficulties, towards standards of eco-efficiency. With particular regard to industrialized countries, the philosophy of producing mineral commodities that meet the market parameters and the quality of the environment has been very much taken into account (Richards 2002).

Nevertheless, it has widely been recognized that many of the actual environmental concerns, such as pollution and depletion of non-renewable resources, can be ascribed to the excessive use of materials whose primary supply is mainly provided by mining. As a consequence of this, at present, a great deal of effort and resources are conveyed into the monitoring and research of those processes, which are more efficient from an environmental point of view. At this aim, all those processes that allow a relative dematerialization of the economy (a total dematerialization is not possible), in the sense of producing goods, for a given purpose, by using less natural resources, are welcome. Simultaneously, a great deal of attention is paid to those processes and products that allow a de-coupling of the production from unwanted environmental effects, with careful attention being paid to all the stages of the life-cycle: production, use, recycling and disposal.

The next section deepens the environmental aspects of sustainability/mining relationship, while the social and economic dimensions will be discussed again in the last section.

2. THE MARKET APPROACH / PUBLIC INTERVENTION FAILURE

The model of industrial growth, which arose from classical economic principles and has led humanity to the present level of development, kept several of the actual environmental concerns hidden for a long time.

With reference to the supply of raw minerals, in a free market based system where economic operators act within an outdated context of environmental restrictions absence, as several years ago, the world demand / supply is sketched in Figure 1. The intersection between the world supply S_w, considered as the sum of the cost of production factors, and world's demand D_w identifies the consumption q and the price P.

For decades mineral resources were thought as unlimited and water, air, and land territory were considered, due to their priceless status, open-access resources. This was the paradigm for mining and other industries, which led to the well known environmental concerns: depletion of non-renewable resources, pollution (global warming, ozone depletion, acid rain, etc).

Such problems have been explained, in the western world, as Market Failures: the market tool is inefficient and unable to perform a best allocation of those goods that do not have a market value. As a consequence of this, while the market has proved its efficiency in the management of market-valued and scarce resources, the environmental factors are overexploited. The point is that, even though most of the services provided by the environment are priceless, their use causes an additional cost that must be paid by society: health care expenses, loss of natural facilities, penalization of future generations. As was later recognized, some important costs, connected to production, were not taken into account and it is because of this that the S_w curve in Figure 1 is underestimated.

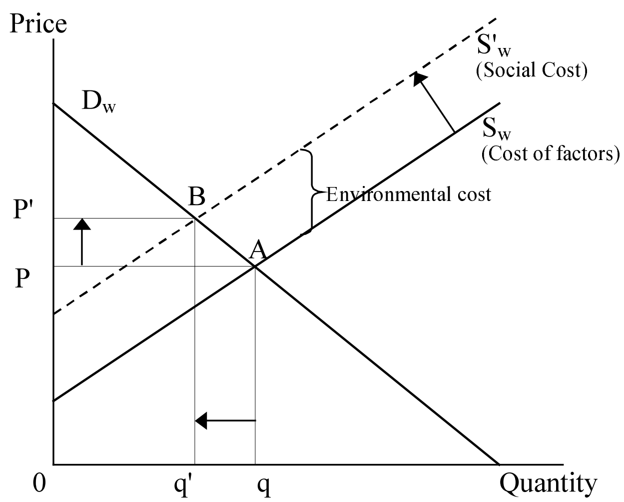

Figure 1: Typical Supply/Demand of mineral commodities and cost of factors/social costs.

Finally, as the services provided by the environment have been recognized as production factors, as labor and capital are, it has been understood that their use must be compensated.

This means that the real costs of mineral commodities were under-estimated and the correct costs should have been the sum of industrial costs plus environmental/social costs. As a consequence, the supply curve S_W will rise to S'_w which is usually called Social Cost and which represents the overall cost that society must pay to make use of a non-renewable / potentially pollutant resource. This overall cost is partially paid by the mining enterprise (internal cost) and partially by society (external cost). The latter is known as externality.

The operation of including the social costs in the internal costs, through the application of the "Polluter-Pays Principle", which was proposed by OECD in 1972 and which has been widely accepted, has been and remains a great challenge for environmental policymakers.

This operation of "Internalization of Externalities", if correctly performed, would enable the market tool to operate the best allocation of all resources, including the environment. The working point of Figure 1 would move from A to B with a consequent reduction of mineral consumption at a higher price, which would correspond to a social-optimal level of non-renewable resource use and environmental pressure. According to this philosophy, we are consuming and polluting too much because the price of minerals is too low.

The path followed by institutions, to enable the market to effectively face environmental problems has passed from non prescriptive to highly prescriptive regulations (Lambert 2001). The more prescriptive "command and control" approaches result in compulsory standards that put the onus on government regulators in order to optimise environmental problems whose entity, evolution and interaction with human activity are sometimes not well known or quantified. In some of these cases, the abuse of the Precautionary Principle might result in damage to the overall economy (Murray 1997).

Relatively non prescriptive approaches, such as ecological taxes and economic incentives, which share the responsibility of taking care of the environment between institutions and companies, and which stimulate innovation, have proved to work in a number of developed mining countries (Lambert 2001).

Nevertheless, several difficulties have been encountered and much more has to be done. However, in order to be effective in terms of sustainability, environmental policies must result in a reasonable increase of production costs and operate in a context of international agreement in which single country escapes should not be allowed (Turner et al., 1994).

2.1 A Possible Interpretation

Despite the theories of environmental economy and the driving principles undertaken by institutions, such as dematerialization and de-coupling of the economy, the world's statistics on mineral commodity supply show contra-dictory trends that are not easy to interpret.

As reported in Figure 2, the trend of world's consumption of most minerals showed an increase over the last century, which would seemingly denote a failure in the absolute dematerialization attempt. However, for several sectors and commodities, the statistics show a decrease in terms of material and energy use per unit of Gross National Product (Wagner, 2001), which implies a relative dematerialization and an eco-efficiency improvement.

Figure 3 gives the historical trend of mineral commodities, excluding oil, real prices, which doubtless shows a decrease. Can this decrease be entirely ascribed to technological progresses and the efficiency of mineral production or does it mean that the actual prices do not fully reflect the social cost of mining?

It is not easy to answer this question but, in this case, it would mean that the natural/mining

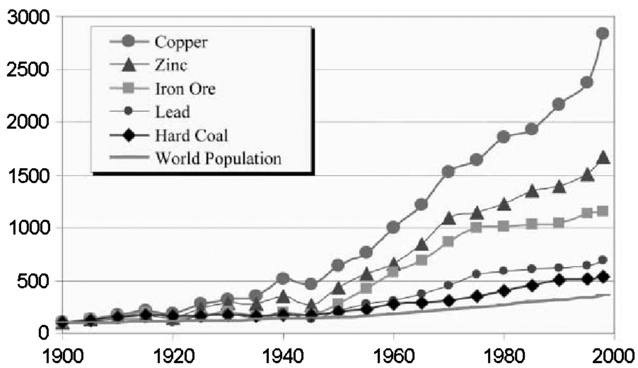

Figure 2: World population and world mineral production series (1900 = 100) (Wagner, 2001).

resources are too heavily exploited and the resulting pollution is worse than it would socially be acceptable.

All this considered, it is interesting to remark that, as several statistics and authors reported (Dinis da Gama 1999, Murray 1997, Torrible 2002, Wagner & Fettweis 2001), the world's mineral production is moving from developed to developing countries.

Figure 4 sketches a possible interpretation of what could happen if the efforts aimed at combining mining and sustainability were to be followed by only a limited number of actors, for example, the European Union. Due to environmental restrictions, the supply curve of the EU moves from S_{eu} to S'_{eu} and the working point would move from the initial position A to B. The EU producers would be interested in decreasing their production but also in selling it for a higher price, which is indicated by the coordinates of B. Nevertheless, due to the fact that environmental restrictions are not universally applied, the price, which for several commodities is determined at a world level, remains unchanged as indicated by the horizontal line P_w. As a consequence, EU producers are no longer willing to supply the quantity identified by B, but they would produce in correspondence to C. The rest of the EU demand must be imported.

The results of a non-global environmental policy resulted in unfair competitive advantages. In such a condition, the EU would consume more minerals than it would consume in case the full social costs (point B) of mineral production are considered, which represents an inefficient allocation of resources. Moreover, the EU production of minerals is greatly reduced, resulting in a shrinkage of the sector and therefore in overall economic damage.

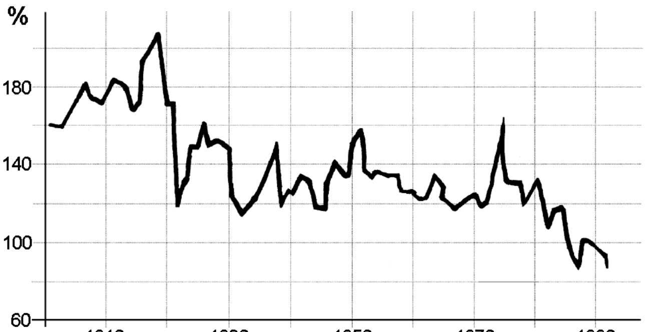

Figure 3: Real prices of mineral commodities, excluding oil, over the period 1900-92 (1990 = 100) (Wagner, 2001).

3. THE USE AND EVOLUTION OF INDICATORS

The progress towards standards of sustainability can be attained through the integration of environmental, economic and social policies in a wide spatial and temporal context. In spite of the inconsistencies that still make the debate on several issues controversial, the sustainability philosophy deserves credit for having changed the linear and sectional approach to the solution of problems into a circular, integrated and multidisciplinary one.

Such an approach involves a great number of public and private actors in a very demanding challenge. This leads to a large set of issues. As a consequence, a huge amount of information has to be handled and shared. In such a context, Indicators are an essential tool both for the measurement of the condition and the evolution of the steps undertaken, and as a prediction instrument. Through the quantification and simplification of the information that they hold, they represent a link between theoretical sustainability statements and practical effects.

The proposal of Sustainable Development Indicators, issued by numerous institutions for numerous purposes, has been quite impressive over recent years.

A critical, fairly comprehensive, but not exhaustive survey, run by Politecnico di Torino (Battaglia 2001) revealed an evolution of Indicators according to the following scheme, although the category boundaries are not always clear:

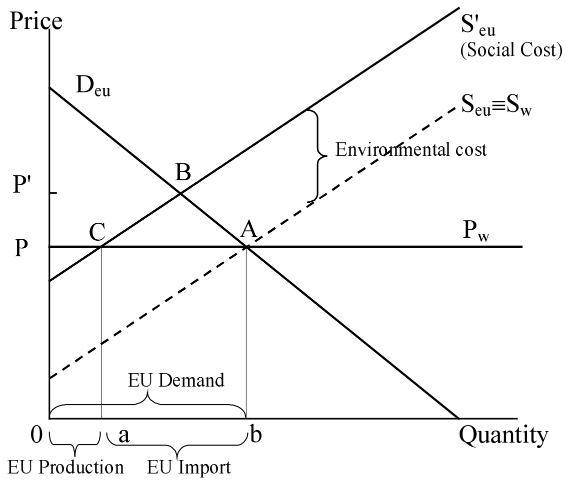

Figure 4: Interpretation: Unfair international competition - Market model

- Environmental Indicators
- Environmental Sustainability Indicators
- Sustainability Indicators

Environmental indicators are usually environmental performance indicators. They are the most commonly used and are basically made of sets of single purpose indexes relevant to specific environmental aspects. One of the main drawbacks is the great number of environmental aspects that have to be investigated, which often results in a large number of parameters. The best-known scheme, proposed by OCSE, divides indicators into a PSR (Pressure State Response) organization: the human activity exerts a Pressure on the environment which modifies its State; society Responds by undertaking actions to remedy the situation. LCA environmental potential effect indicators, such as GWP (global warming potential), ODP (ozone depletion potential) and non-renewable resource depletion indicators (Material and Energy requirement) also belong to this category.

Environmental Sustainability Indicators try to go beyond the multiparameter information given by the previous group through the use of a single parameter that is able to represent the overall environmental dimension. The Total Mass Requirement, Exergetic and Emergetic analysis, and Ecological Footprint are typical of this group.

Finally, Sustainability Indicators are complex indicators that supply a joined, equally weighed evaluation on environmental, social and economical performances. In principle, this kind of indicators can be an expansion of the indicators of the previous categories to the other dimensions of sustainability.

The choice of an indicator set depends on the context and the scope, but it is worth noting that the most popular are those that are driven from a Life Cycle Assessment methodology (Azapagic 2000, Lambert 2001). In fact, the LCA approach is quite effective in detecting hidden flows of materials and energy in both up or downstream processes or life phases. With respect to the impacts and resource consumption along the whole life, environmental sustainability indicators can be regarded as indexes of dematerialization and energy efficiency of the economy.

3.1 LCA of Italian Talc and Silica Sand

This section, based on earlier works (Badino et al. 1995a-b, Badino & Baldo 1998), is aimed at giving an example of how LCA indicators could fit into a context of international raw material trade and its sustainability. Table 1 shows the main LCA indicators that were achieved through Ecobalance surveys carried out on two Italian mining companies. The first data set

Table 1: Italian silica sand and talc LCA environmental indicators

Commodity	Total Production (t/y)	Energy Consumption (MJ/t)	Environmental Potential Effect Indicators (Quantity/t)	
Silica Sand A 2-1.5 mm Chemical and construction use	71484	88.46	Global warming: Acidification: Nutrient enrichment: Photosmog:	14000 mg CO_2 equiv. 7703 mg SO_2 equiv. 11300 mg NO_3 equiv. 280 mg C_2H_4 equiv.
Silica Sand B 1.5-0.1 mm Glass industry use	830610	226.53	Global warming: Acidification: Nutrient enrichment: Photosmog:	14010 mg CO_2 equiv. 7706 mg SO_2 equiv. 11300 mg NO_3 equiv. 280 mg C_2H_4 equiv.
Silica Sand C < 0.1 mm Ceramic industry use	327721	281.41	Global warming: Acidification: Nutrient enrichment: Photosmog:	14010 mg CO_2 equiv. 7706 mg SO_2 equiv. 11300 mg NO_3 equiv. 280 mg C_2H_4 equiv.
Talc < 0.1 mm Paper, rubber, pharmaceutical, chemical, plastic industry	44000	1070	Global warming: Acidification: Nutrient enrichment: Photosmog:	161520 mg CO_2 equiv. 90700 mg SO_2 equiv. 105800 mg NO_3 equiv. 3120 mg C_2H_4 equiv.

refers to the production of Silica Sand for glass and ceramics by Sibelco SpA at the quarry and treatment plant located at Robilante (CN) for the year 1993.

The second one deals with the production of Talc by Lusenac SpA at the Fontane mine (TO) and the nearby treatment plant in 1994.

Both the LCA analysis were limited to the mining operations, transportation to the plant and treatment, regardless of the impact of energy productions. Therefore, the energy consumption and the environmental indicators refer to the direct energy used at the site.

The meaning of the analysis is twofold. On one hand, as far as the mineral commodity under examination is characterized by an environmental performance point of view, competition among talc suppliers is not only limited to an industrial and economic basis. On the other hand, due to the fact that talc and silica sands are raw materials for the production of a large number of goods (e.g. ceramic, pharmaceutical, glass, paper) such data are essential for an analysis of the eco-compatibility of downstream products.

As a consequence, such indicators might work as a form of eco-labeling, making it possible to associate its environmental impact to each product and, at the same time, re-compensate those producers who are more engaged in the application of sustainable policies.

However, a great deal has still to be done. There are issues relating to input data for LCA, which are not always of good quality, and to the boundaries of the assessed system, which often are not broad enough in space and wide in life phases (Lambert 2001).

4. CONCLUSIONS

Sustainable development requires, at the same time, both an ongoing remarkable supply of mineral commodities and limitations on its production process due to environmental and social considerations imposed by that philosophy.

However, the growing constraints on mining mean that market forces alone will not be sufficient to ensure a sustainable supply.

Indicators, on one hand, can lead and monitor progress towards eco-efficiency and sustainability objectives and, on the other hand, can make sure that everyone without exception pursues the challenge. This would limit the possibilities of any unfair international competition.

The overall objective of a fair, sustainable and efficient market can be obtained by the synergy of factors such as: sustainable development indicators driven through an LCA methodology, public interventions and private contributions.

REFERENCES

Azapagic, A. (2000) Indicators of sustainable development for the minerals extraction industry: environmental considerations – Technological challenges posed by sustainable development. Rio de Janeiro: May 2000, Villas Boas and Fellows Filho editors, 202-217.

Badino, V. et al. (1995a). Ecobilancio di un'attività mineraria: il caso delle sabbie silicee - GEAM No. 1, March 1995, 11-16.

Badino, V. et al. (1995b). Ecobalance of talc mineral production - III International Congress "Energy, Environment and technological innovation", Caracas (Venezuela), 5-11 November 1995, vol.II, 125-131.

Badino, V. & G.L. Baldo (1998). LCA, Istruzioni per l'Uso – Progetto Leonardo, Esculapio Editore (BO).

Battaglia, S. (2001). Strumenti e metodi per la verifica di sostenibilità delle trasformazioni del territorio – Master Degree Thesis, Polytechnic of Torino, December 2001.

Dinis da Gama, C. (1999). Abordagens Inovadoras para os Problemas Ambientais da Indústria Miniera - Revista "Ingenium", Ordem dos Engenheiros, Lisboa, June 1999, 76-79.

Lambert, I. B. (2001) Mining and sustainable development: Considerations for minerals supply – Natural Resources Forum, No.25, November 2001.

Murray, J.A. (1997). Economic impact of current environmental regulations on mining – Mining Environmental Handbook, Imperial College Press, 630-641.

Richards, J.P. (2002). Sustainable development and the minerals industry - Soc. Economic Geologists Newsletter, No. 48, January 2002, 8-12.

Torrible, C. (2002). Mining, minerals and metals for Europe: a global perspective – Proc. Conf. Sustainable Resource Policy for Europe, Euromines, Brussels, 25-26 November 2002.

Turner, K. R. et al. (1994). Environmental economics. An elementary introduction - Johns Hopkins University Press

Wagner, H. & G. B. L. Fettweis (2001). About science and technology in the field of mining in the Western world at the beginning of the new century – Resources Policy, No.27, 2001, 157-168.