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Sustainability Metrics and Green Finance for Chemicals

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Abstract

In this article we investigate the aspects that link sustainable finance and sustainable chemistry on the basis of the theoretical definitions currently available. Our aim is to analyse what reflections have been made by scholars and to identify a further effort to understand the dynamics underlying these two fundamental sectors within the transition process of the global economy. In section 1 we analyse the relationship between sustainability and economic development, in section 2 we define the boundary of the role of sustainable finance, in section 3 we address the discussion and in section 4 we present our conclusions.

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1. Introduction

Sustainability, at business level, can be accordingly defined as meeting the needs of an organisation's direct and indirect stakeholders without compromising its ability to meet the needs of future stakeholders (Dyllick & Hockerts, 2002).
The path towards the achievement of a sustainable society and a climate-neutral economy encompasses different disciplines which finance has more recently joined as a key element of the transition process (Migliorelli, 2021).
The European Parliament defines sustainable finance as “an evolution of green finance, as it takes into consideration environmental, social and governance (ESG) issues and risks, with the aim of increasing long-term investments in sustainable economic activities and projects” Green and sustainable finance.
UN Sustainable Development Goal 12, responsible consumption and production, offers a key element in a sustainable development of our planet as it is closely linked to the exploitation of renewable and non-renewable resources. The environment is declined as a relevant Corporate Social responsibility (CSR) component as production activities have a direct impact on the natural environment and human living conditions (Huang, Liu & Sun, 2019).
The relationship between stainability and CRS is deeply investigated in literature. Recently, Sanchez-Teba et. All (2021), by a bibliometric analysis carried out with SciMAT over the period 2003–2021, found that the number of articles related to CSR and sustainability is steadily increasing and that the main driving themes have been CSR, sustainability and environment. Asiaei et al., (2021) found that sustainability performance measurement plays an intervening role between CSR and organizational performance. More, Okafor et al. (2021) demonstrate that tech companies that spend more on CSR experience a corresponding increase in revenue and profitability (Gulzar et al., 2019).
The interaction between unsustainable economic growth and chemical pollutants is demonstrated in research that highlights the conflicting prediction between the effects of increasing unsustainable economic growth and the dynamics of air pollution which, among other things, has accelerated deaths from COVID-19 (Magazzino, et al., 2021). Indeed, the key question remains whether, and under what circumstances, an organisation should be engaged with sustainability practices (Maletic et al., 2014).
Sustainable finance should take into account a project that raises private or public resources allocated to support future sustainable business investments through, for example, a GIFT approach (Becchetti, Cordella, Morone, 2022). Many researchers have disclosed the entrepreneurial difficulties with traditional chemical processes and production goods (Morone et al., 2019) and investments necessary to start a process that allows production with green and sustainable chemistry (GSC) methods integrated with sustainable environmental, social and governance (ESG) models (Michelon et al., 2012).
In this sense, an analysis conducted by Magazzino et al., (2021), for the period 1926-2008, demonstrated that, with reference to Italy, the relationship between

energy consumption and economic growth varies and reverses the trend based on the observed period.

Indeed, production activities require precise rules and extensive coordination at multiple levels of analysis in a process that involves all stakeholders, and which increasingly express the desire for information such as pollution prevention and non- renewable resources consumption estimation (e.g., Berthelot et al., 2003; Cormier et al., 2004, Cho et al., 2010).

Indeed, the key question remains whether and under what circumstances an organisation should be engaged with sustainability practices (Maletic et al., 2014).

In this context, the correct balance between economic development and non-renewable resources consumption identifies the necessary government support those businesses need to implement sustainable growth and development processes (Keijzers, 2002).

For a deeper understanding of this concept, it is mandatory to define certain measurement tools that might allow effective green production processes to be started in order to prevent environmental protection from stifling business development and vice versa. This article aims to systematize the knowledge developed so far to identify a possible sustainable path to go further.

2. Sustainability and economic development

The compromise between economic development and environmental sustainability can only be reached through the definition of shared metrics that allow for continuous planning and control in modern organic synthesis and green chemistry metrics (Andraos, 2019).

In this sense, a first view of the distribution of this phenomenon through comparison of developed and underdeveloped countries is offered by Kuznets (1955); in his study, he investigates with five specifications the concentration of income in correspondence with per capita income, in order to understand the relationship between economic growth and trend in income inequality. Later studies (Grossman & Krueger, 1991) identify, by the EKC functions, the relationship between gross national income per capita and the emissions in Kg/per capita. The succession of multiple historical evolutions in the measurement systems of polluting emissions is the effect of the complexity of the topic, and only in the 90's was the relationship between kg/waste-emissions and kg/product introduced. The challenge in performing sustainability assessment of chemical processes is the relationship between the availability and quality of information and the impact of the decisions that must be made start a relationship at each level (Argoti, 2019).

In literature, the limitations related to the use of raw materials, human capital employed, and industrial development proposed by Smith, Malthus, Ricardo, Mill, as a whole are forerunners of the modern vision of sustainable development, through a circular economy model that generates profit for shareholders (Reed, 2002) limiting the use of natural resources (limited raw materials stocks) and protecting the environment.

The study of materials can encourage sustainability, understood as a "balance between the satisfaction of present needs without compromising the ability of future generations to meet their own" (Brundtland Report 1987). In this sense, the weak sustainability is a result of the process of replacing natural resources with alternative resources (while strong sustainability derives exclusively from the protection of natural resources).

The key problem is that the reliability of metrics associated with material efficiency is quite definite, since all of them depend only on reliable inputs and outputs, whereas reliability associated with environmental impacts will always be inclined to a higher degree of uncertainty due to gaps in the raw parameter data. Until this issue persists, it makes reliable comparative ranking difficult and opens to resolution less debate affecting the entire field of green metrics analysis (Andraos et al., 2016).

In this context, Carlsen (2021), by studying Eurostat SDG 12 data[2], declares that to have an "environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment" by 2020 is so far not achieved.

Moreover, bad news comes from all around the world. By a non-radial directional distance function (Zhang & Xie, 2015) environmental production characteristics, including shadow prices of carbon emission, Total-factor Energy Efficiency (TFEE) and elasticity of substitution for output can be computed. Multiple studies, based on this methodology, underline that though the chemical sector in China develops rapidly, it actually does not perform in an environmentally friendly way in most periods in the recent past, showing worrying trends on all parameters as a consequence of inconsistent regulatory plans for sustainability, and a general lack of supervision (Jiahuey et al., 2019).

However, when the regulatory plans for sustainability are applied, an innovation stimulation effect for businesses emerges with potential positive repercussions on the sector (Jiahuey et al., 2019). By greening their operations, organisations have demonstrated benefits in them, including cost reduction, productivity, and innovation (Asiaei et al., 2021, Okafor et al., 2021).

Organisations need new insights for innovation and exploration of the unknown to contribute to sustainable business management, but, innovation, particularly when boosted by the level of competitiveness, must be attentively driven by governments, according to both sustainability exploration and exploitation, as it might represent an environment consumption high impact activity (Maletic et al., 2014 and Iraldo et al., 2009).

[2] Consumption of toxic chemicals (Eurostat, 2020b), resource productivity (Eurostat, 2020c), average CO2 emissions from new passenger cars (Eurostat, 2020d), circular material use rate (Eurostat, 2020e), generation of waste excluding major mineral wastes (Eurostat, 2020f)

3. The role of green finance

The genesis of the link between environmental protection and finance dates back to the 90s.

Devas (1994) defines the impact of sustainable production on the financial sector, while Salazar (1998) identifies social finance as a path of development linking the financial sector to the sustainable manufacturing industry.

Further studies empathize the relationship between environmental and economic performance (Wagner & Schaltegger, 2004 and Hart et al., 1996) and, more recently, the interaction between corporate environmental strategy/performance and economic performance (Wagner, 2010).

In the long term, the positive effect of the CSR involvement of an organisation on its financial success (Asiaei et al., 2021) seems to suggest that a business argument for CSR is introduced (Okafor et al., 2021) but, at the same time, environmental activities require a substantial investment with a long-term implication for firms, and can have a significant impact on a firm's capital structure. In other case the managing corporate performance, for many authors, show that some causality is related to lagging between periods for financial performance and CSR (Aras et al., 2010).

The concept of sustainable finance has undergone considerable changes over time and has evolved through heterogeneous definitions that often harm the credibility of the markets. These risks include green and sustainable washing, the rebranding of financial flows, and the disordered adjustment in the cost of capital spreads between industries. In this sense, (Migliorelli, 2021) argues that sustainable finance should be called "finance for sustainability", and implementing the standards should make clear reference to the relevant sustainability dimensions (Sustainable Development Goals and the Paris Agreement) and to the sectors or activities that positively contribute to these dimensions. A definition of sustainable finance can be traced back to the introduction of the ESG concept or method, that the sustainable financial system has the task of incorporating sustainability considerations by considering all long-term risks and benefits. In this context, in developing a definition of sustainable finance, the contribution of each industrial Sector and/or economic activity to the achievement or improvement in one or more of the relevant dimensions of sustainability must be considered. This must be done in order to identify areas that deserve "sustainable" funding.

Indeed, if the long-term value creation is approached from a financial point of view, it is necessary to consider both cash flows and risk jointly. In fact, environmental sustainability has a certain impact on flows because it has certain costs in the face of uncertain benefits. However, such investments can reduce the risks. On this point, the empirical evidence is more in agreement in signaling a negative relationship between ES factors and business risk (Godfrey et al., 2009, Oikonomou et al., 2012, Jo & Na, 2012, Becchetti et al., 2018) or systematic risk (El Ghoul et al., 2011, Eccles et al., 2014, Gregory et al., 2014). The creation of value through sustainability therefore, seems to be motivated more by the reduction of risk than by the generation of cash flows: the sustainable company is worth more and this greater value turns out to be a benefit not only for the shareholders but for all stakeholders involved.

Critically, we must understand whether it is sustainable finance that offers environmental protection benefits, or alternatively, a sustainable production process that feeds the financial resources defined as "green", allowing the reallocation of funds and producing profits related to sustainable development.

In this context, the need to distinguish between sources of financing coming from private equity from sources of public financing, appears to be of importance: in the light of described evidences, the two measures can certainly coexist to achieve an optimal balance (Taghizadeh-Hesary & Yoshino, 2019).

4. Discussion

Your text goes here. The financial profile of sustainable industry can be appropriately assessed by measuring the quality and quantity of raw materials (inputs) used to develop the production process with respect to the final product (output).

In 1992, a model was introduced that relates environmental pollution as the ratio of the amount of waste from raw materials to the amount of product generated (in kg) (Sheldon, 2011).

Factor E (pollution) is given by the actual quantity of waste produced in the production process, excluding the desired product. This factor takes into account all polluting elements including energy consumption and air pollution. Ideally, the E factor should tend to zero in order to obtain the least impact on the environment.

The quantification of the chemical production waste, through the E factor, allows to focus the attention of chemical and pharmaceutical companies on the need to change the concept of process efficiency based exclusively on the yield of the production process, allowing the elimination of waste and maximizing the use of raw materials. Indeed, in the last two decades, E factor has been widely adopted by the chemical and pharmaceutical industries (Alfonsi et al., 2008). In this sense, the logic of reducing polluting effects must lead to a detailed analysis of some characteristics of the input/output of production process, in particular the relationship:

$$\frac{\text{kg (waste)}}{\text{kg (product)}}$$

Waste/product formula

This formula must be reconsidered as a result of the use of new technologies, and the transformation processes of advanced materials, for example biocatalysis, etc., according to the following formulation:

E (pollution)= kg (raw material - replaceable materials - recyclable waste material - production pollution - technology)- kg (product - durability of the asset - recyclability of the product and materials - technology)

Transformation formula

When the difference tends to zero it means that the production process shows maximum efficiency in terms of lower environmental impact but at this stage, we do not know the reflected economic effects.

Can the correlation between reduction of the environmental impact (that generates higher production costs) and lower revenues be balanced by the introduction of new technologies, transformation of materials and replaceable raw materials? Or do we necessarily need policies to support companies that produce a lower environmental impact, regardless of revenues? (Margolis et al., 2003, 2008, 2009).

To try to answer the questions, it is appropriate to identify the most common transformation processes of the material (solid, gaseous, liquid) that generate diversified costs as a result of the complexity of the type of process. The areas of intervention concern the requalification of materials existing in nature (or recycled) using advanced technologies that induce chemical processes (combustion, pyrolysis, liquefaction, gasification, etc.) through bio-chemical processes (fermentation, biocatalysis, etc.) or by mechanical processes as summarized in figure 1.

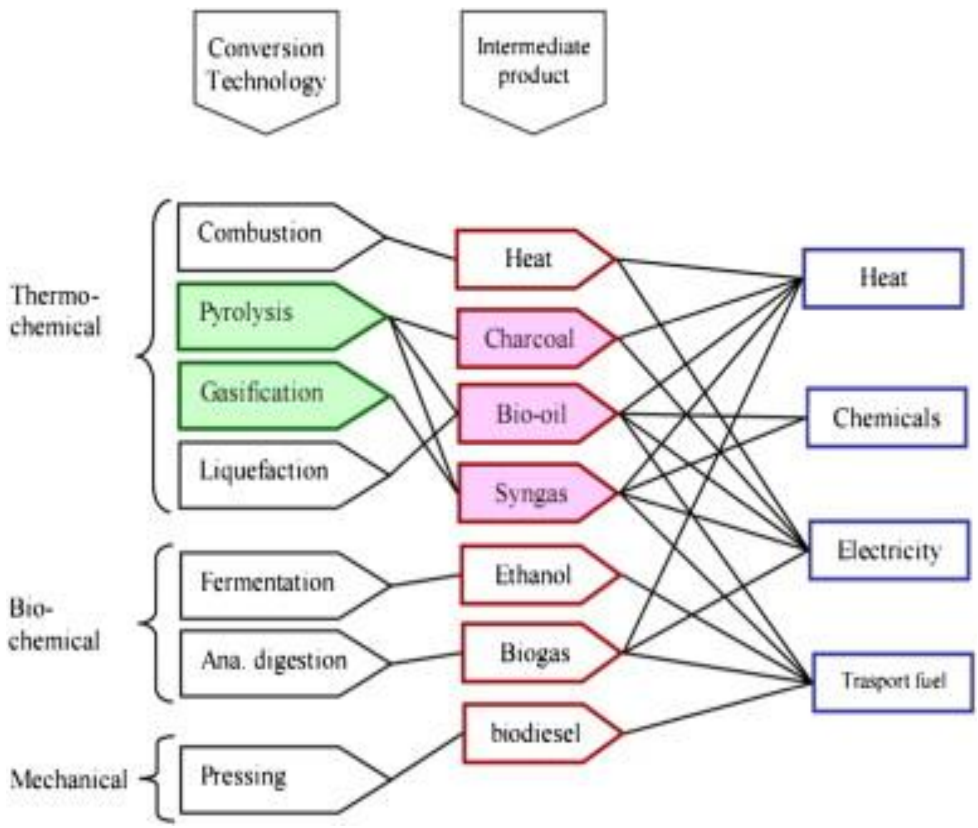

Figure 1: Main material conversion processes (Source: UNDP, UNEP, & UNEP RISO Centre 2010).

5. Conclusion

This paper, through a rigorous literature review and a multidisciplinary approach, contributes to the academic debate with precise considerations in terms of policy and opens further research questions for future investigations.

Environmental regulations can have a positive influence on the decisions that companies adopt in relation to innovation[3]. Moreover, countries with typically less innovative companies seem to be less affected by the environmental regulations, while the countries that already have a tradition of innovation embodied by the rights of exploiting inventions, are influenced the most (Martinez-Zarzoso et al., 2019).

A correct process of sustainable development must consider several converging goals to protect economic development (employment protection, growth in terms of GDP and GNI, business profits), and environment (Leal Filho et al., 2018). In

[3] Measured by the number of patent applications.

essence, governments should implement rewarding policies for businesses who adopt self-regenerating production processes (Kravchenko et al., 2019) by consolidating the use of recyclable raw materials, by planning the production according to product life cycle, by estimating the percentage of the material recovery and by producing through efficient and high-tech industrialized systems. Corporations are more likely to act in a socially responsible manner when they encounter state regulation that controls in an institutional context that encourages socially responsible behavior (Campbell, 2007).

Moreover, government policies should boost production processes able to implement distribution and consumption/reuse processes that take into account all the elements connected to the product (packaging etc.), as well as production processes able to implement a residual waste collection process, that can define the quantity of material that can be recycled and the residual waste (Rotter et al., 2004). This proposition is summarized by the Venn diagram (Venn, 1880) which, unlike the Euler diagram, defines the intersection of circumstances of different nature converging in a single process that, in our case, is defined as a circular economy.

The identified solution must find comfort in various actions and policies of the countries adhering to the environmental sustainability process (Hofmann & Khatun,2013). First, bureaucratic and financial simplifications must be implemented to encourage the opening of chemical industrial parks that implement the conversion of materials (also providing non-repayable financing). Second, as we know that a sustainable business may no longer be profitable but will most likely be less risky, it is appropriate to implement government plans to support the temporary reduction in revenues of environmentally sustainable businesses (Freedman, 1997). Third, businesses involved in "weak sustainability” should be helped in creating a network of connection with the industrial system that implements the regeneration of recycled materials and the replacement of natural materials with suitable synthetic materials.

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