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Sustainability as source of competitive advantages in mature sectors

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Abstract

Purpose – The purpose of this paper is to explore how sustainability can become a source of competitive advantage for mature manufacturing sectors where technologies are standardized, and innovation is mainly generated across the value chain and not by individual companies.

Design/methodology/approach – From the methodological point of view, this research estimates the sustainability status of ceramic production in the Sassuolo district (Italy), using the Life Cycle Sustainability Assessment (LCSA) model, and changing the observation point for the analysis, from the enterprise (micro level) to the entire sector (meso level).

Findings – This paper provides an analysis of the environmental, economic and social impacts of the four main types of ceramic tiles manufactured in Italy, both in aggregate terms for the entire sector and per square meter of product.

Practical implications – The methodological approach used in this research is easy to replicate both for companies when designing their sustainability strategies and for public decision makers when assessing the sustainability performance of a sector or supply chain.

Social implications – For the first time, a socio-economic impact assessment is proposed for the ceramic sector, conducted in parallel with the environmental impact assessment through stakeholder mapping and prioritization.

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Originality/value – This paper conceptualizes the theme of relations and interdependencies between ceramic producers organized in industrial districts and the territories in which they operate in order to determine empirically the sustainability performance of Italian ceramic sector, using the LCSA model with a territorial extension that presupposes an innovative contribution to current literature and practice.

Keywords Sustainability, Competitive advantage, Industrial district, Circular business model (CBM), Italian ceramic industry, Life Cycle Sustainability Assessment (LCSA)

Paper type Research paper

1. Introduction

The period that began in the first decade of the nineteenth century with Taylorism and continued for about 100 years was characterized by a focus on the manufacturing systems toward the continuous production of volumes of products, at ever lower costs (Abouzeedan and Hedner, 2012). Subsequently, since the 1980s, there has been a shift toward a new type of target linked to sustainability issues. The market-driven need was to manufacture eco-sustainable products using "clean" technologies. The last few years have seen the birth of "green" managerial approaches focused on operations and the consequent shift of the focus of sustainability on them (Frey *et al.*, 2013).

Today, sustainable development is one of the most difficult and important challenges to be met in the development of manufacturing processes (Stock and Seliger, 2016). The definition of universal sustainable development accepted is the one found in the publication *Our Common Future*, drafted in April 1987 by the World Commission on Environment and Development, better known as the "Brundtland Commission," a group created by the General Assembly of the United Nations: "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Dhahri and Omri 2018). From this point of view, sustainability is not to be understood as a state or an immutable vision, but rather as a continuous process, which needs to be based on three fundamental dimensions: environment, economy and society. The concept of sustainability, in this sense, is linked to the compatibility between the development of economic activities, the related social phenomena and the protection of the environment. Therefore, the ability to balance social, economic and environmental sustainability is the very meaning of the concept of sustainable development. Sikdar (2003) identified four different levels of analysis to approach sustainability issues:

(1) themes of global interest, to be addressed from a political point of view, on a global scale (e.g. ozone depletion, global warming, etc.);

(2) problems of local interest with a territorial dimension (e.g. land use, transport systems, etc.);

(3) problems related to the activities of individual companies or production sites (e.g. company relations with the environment and stakeholders); and

(4) development of specific sustainable technologies (specific to each manufacturing process).

The possibility of addressing the problem at different levels and the specific interests of each area oblige both economic agents and decision makers to adopt systemic and multidisciplinary analysis approaches, therefore adopting not only new technologies, but also innovation in the economic, legal, social and cultural fields. From the manufacturing point of view, key element for the analysis of sustainability of an industrial process is the "holistic" approach to system analysis that considers the object of the study as part of a complex system, referring to an adequate temporal and spatial horizon (Urbaniec *et al.*, 2017). This new sustainable approach moves away from the historical and linear manufacturing model of "take, make and dispose," to adopt the circular one: "reuse, reduce, and recycle" (Moreno *et al.*, 2016). The temporal variable of the holistic approach and the circular manufacturing model are strains related to the concept of life cycle of a product and a process. Each phase of the cycle has its own exchanges of energy and materials with the environment and socio-economic interactions with the territory and stakeholders (Gbededo *et al.*, 2018).

Moreover, following the institutional theory (Campbell, 2007), the consequences of entrepreneurial decisions are not limited to the company itself but extend to the various spheres of social life and affect the various economic and social parties and territories which are no longer neutral places. Therefore, as long as firms' impacts do not fit norms, values or game rules of the society, companies will be poorly evaluated. The introduction of rules for safeguarding the environment and tools for monitoring company activities is important not only for protecting consumers by defending principles of civilization but also for companies that are striving to produce high-quality products. Accordingly, this capacity can be considered a strategic factor with great impact on competitive advantage building in the medium/long run, with special emphasis in mature sectors where sources of differentiation are less likely (Rodriguez *et al.*, 2002). This is the case in the construction sector (Goldstein, 2007), to which the ceramic industry sector also belongs, producing floor and wall tiles and, in fact, the construction industry is the final user of ceramic products (Pacheco-Torgal and Jalali, 2010).

This paper is structured as follows. Section 2 develops a detailed analysis of the current literature describing the relationships between economic activities and environment and territories and introducing the concepts of life cycle and circular economy as a way to sustainability. Section 3 describes the research design by presenting the research questions and the methods employed. Section 4 shows the experimental results of the environmental, economic and social assessments of ceramic products. The paper concludes with Section 5 presenting the discussion and conclusions of the study and providing suggestions for future research.

2. Theoretical framework

2.1 Environment and economic activity

Economic activity, like all human activity, takes place within the natural environment. The economic system and the natural environment are therefore interdependent, which determines both the way in which the economic system affects the environment and the limits that the environment places on the evolution and expansion of the economic system (Xepapadeas, 2005). The environmental limits that the economic system must consider are established by the laws of thermodynamics. The first law of thermodynamics is presented first in the form of the law of the conservation of matter: matter can neither be increased nor destroyed but only transformed (Jia *et al.*, 2017). The material flows from the environment to the economic system are the same as the flows that return from the economic system to the environment; the economic process can only transform the material extracted from the environment to eventually return the same material to the environment in the form of waste (Perrings, 1986).

The processes of transformation of matter that take place in the economic system imply the use of energy, defined as the "capacity to do work." The first law of thermodynamics states that energy, like matter, can neither be created nor destroyed; energy can only be transformed, converted from one form to another (Dafermos *et al.*, 2017). This energy conversion has an important effect, highlighted by the second law of thermodynamics. This law states that in every energetic transformation a part of the energy is dispersed in a form that can no longer be used to perform further work (Kharrazi *et al.*, 2014). The environment is an essential resource base for the functioning of the economic system. The scarcity of resources, that is the fact that they are useful and at the same time available in limited quantities compared to the request, is the condition for the talk about of economic resources (Bergstrom and Randall, 2016). If environmental resource activity is over-exploited beyond regeneration or assimilation capacity, environmental resources tend to run out and the ability of the environment to provide its services to the economy in the future is compromised. This creates a conflict between exploitation and conservation of the environment which is economically relevant as the environment performs important economic functions not only because the flows of services it offers are exploited, but also because there is an interest in the conservation of the stocks of goods it contains (Miller *et al.*, 2014).

When environmental exploitation goes beyond the natural capacities of regeneration and assimilation, it is an alternative use of non-environmental economic resources (such as capital and labor) that goes against the objective of conservation. In this case, the exploitation and preservation of the environment become alternative purposes of resource allocation (Neumayer, 2001).

The essence of the concept of sustainable development is that the exploitation of environmental resources should be contained within the limits of regeneration capacity so that the stock of these resources is not depleted. If the stock of environmental resources is to remain constant in the long term, the exploitation flow of these resources must also be kept constant within the limits of their natural regeneration capacity (Holden *et al.*, 2017). But the only way in which the flow of use of environmental resources can remain constant in the presence of a continuous growth of the domestic gross product of an economy is that the flow of use of the environment per unit of gross domestic product is continuously reduced over time (Costanza *et al.*, 2016). This also requires a profound structural modification of production processes. For this reason, economic growth to be sustainable must be based more and more on the material recycling (Haas *et al.*, 2015), on a non-dissipative form of energy use and on an increasing weight of the intangible production component in the gross domestic product (Baldwin *et al.*, 2012).

The most recent strategic documents of the European Union and the relative EU policies aim at combining competitiveness of member countries' enterprises and economies, social cohesion and sustainable development (Maes and Jacobs, 2017). Further intergovernmental programs promote the same strategic objectives of economic, social and environmental sustainability (Hák *et al.*, 2016). These documents identify local authorities, businesses and civil society as the actors responsible for implementing the strategic objectives set, although the key role of local authorities as relevant players in the promotion and implementation of policies and governance tools for sustainable environmental, economic and social development is highlighted. About the role of companies in contributing to greater socio-economic and environmental sustainability, the European Union has recently promoted the approach and concept of corporate social responsibility. This is a way of voluntary integration, beyond the legal obligations, by companies of the social and environmental implications in their commercial operations and in their relations with the various stakeholders. In order to address environmental issues, adequate information and knowledge is needed to underpin the choice of the most effective actions. Moreover, knowledge must be effectively usable and meaningful. The purpose of this information should be to provide an overview of sustainability, to overcome a sectoral view of the issues and to focus as much as possible on key elements. Finally, the issues addressed should not be limited to strictly environmental issues but should also include social and economic concerns (Rajeev *et al.*, 2017). An appropriate indicator system based on the laws of thermodynamics can be used to assess the pressures that economic and social activities exert on the environment, the resulting changes in the state of the environment, the resulting impacts (e.g. on ecosystems, human health, resource availability) and the political and social responses to these impacts through improvement actions. Sustainability indicators should reflect the mutual links between the environmental, economic and social aspects of development (Waas *et al.*, 2014). The sustainability assessment may cover:

- territorial systems (cities, regions and states) (Mazzi *et al.*, 2017), environmental components (the atmosphere, soil and water) (Peterson *et al.*, 2017) and, finally, socio-economic components (economic sectors, population) (Iribarren *et al.*, 2016); and
- actions relating to development policies (in the fields of energy (Cosmi *et al.*, 2015), transport (de Oliveira Cavalcanti *et al.*, 2017), urban areas (Dizdaroglu, 2015), the protection and valorization of ecosystems (Moscatelli *et al.*, 2017) and cultural heritage (Settembre Blundo *et al.*, 2014), actions aimed at social integration and cohesion).

2.2 Environment and territory

Industrial districts (ID) are the structures where the interaction between territories and firms in the supply chain is best observed (De Marchi *et al.*, 2017). The organizational structure of the ID explains the variables that are at the base of the localization and investment choices of the entrepreneurs and that therefore affect the local development (Manniche and Testa, 2018). The development process acquires definitively its character of "social process" and no longer only a technical process. Within an ID, the territory represents a determining factor in the processes of economic and social growth because the anthropological, historical, cultural and environmental factors that contradict it affect the specificity of the models of productive organization of the district (Biggeri and Ferrannini, 2014). However, in the analysis of IDs, the relationship between companies and their local context has long lacked a fundamental dimension in the logic of sustainability: that of environmental protection, that is, the link that exists between productive activities and pollution phenomena related to them. This is inconsistent with the growing importance of sustainable development principles in business strategies and public decision makers' agendas. Only recently there has been a growing interest (both theoretically and empirically) in sustainability as a driver of growth in IDs (Lin and Hu, 2017; Arbolino *et al.*, 2018; Le Heron and Hayter, 2018). Given the importance of the socio-territorial context to district businesses, it is inevitable that the issue of environmental sustainability will also become crucial from the point of view of development (Daddi *et al.*, 2012).

In Italy, the geographical concentration of supply chains (based on an integrated system of production, where the entire process is controlled and managed in close collaboration with the best local producers) has allowed many companies to share in the industrial risk linked to development in harmony with the local situation. The system of districts, in fact, has had the ability to create development by reducing the distortions of capitalist systems and enhancing the integration of the industrial reality with the social and environmental fabric (Camuffo and Grandinetti, 2011). Economic theory has long recognized that agglomeration economies are able to improve the productivity of enterprises and encourage processes of territorial concentration of productive activity in districts (Sunley and Martin, 2017). In the decade of the 1990s, these ideas represented the starting point for numerous theoretical studies, which forcefully brought out the link between territory and economic development (Phelps, 1992; McCann, 1995; Harrison *et al.*, 1996; Asheim, 1996; Ottaviano and Puga, 1998). However, research has focused almost exclusively on the benefits of economic development without considering the social costs involved. Today, in economic analysis, space ceases to be considered only a source of cost for businesses, and increasingly assumes the role of a favorable (or unfavorable) milieu, creating economic or non-economic externalities (Pandit *et al.*, 2017). Space thus becomes the place where economic agents meet to organize forms of collaboration (Thrift and Amin, 2017).

A local district system can be seen as a network of locally concentrated enterprises whose stability derives from a dynamic yet balanced relationship with the community and the networks of interaction that characterize individual enterprises (Hervás-Oliver *et al.*, 2017). This balance is dynamic because even in local systems it is possible to highlight the presence of a life cycle whose trend follows that of the product, the greater production specialization of a local system. This is the case of the Sassuolo ceramic district located in the provinces of Modena and Reggio Emilia in Italy, analyzed in this paper (Hervas-Oliver and Davide, 2017). The dynamism of this balance can favor, both from a theoretical and managerial point of view, the adoption of a life cycle methodological approach, to explain the dynamics of some of the most famous district systems and to describe the prevailing modes of interaction among economic operators (Carli and Morrison, 2018). However, the adoption of a life cycle perspective requires that the main social actors do not limit their responsibility to the stages of the supply chain that they directly control but would constitute the prerequisite for a solid sustainability assessment, in order to identify opportunities for reducing environmental impact, industrial costs and, as a consequence, greater efficiency in the use of resources (Ceschin, 2013; Mathe, 2014).

2.3 Life cycle paradigm from a territorial approach

The implementation of sustainability policies requires the development of increasingly refined quantitative and qualitative tools for analyzing the environmental, economic and social impacts, the triple bottom line associated with collective and individual choices, both with more limited effects and with more complex medium and long-term implications (Onat *et al.*, 2014). Life Cycle Sustainability Assessment (LCSA) can be a suitable tool for this purpose, since through a mathematical model, it describes the set of business solutions that integrate into the decision-making processes supporting the development of a product (from its conception to its withdrawal from the market), both from the view of the life cycle and the economic, environmental and social assessments necessary for the management of processes, with a total sharing of data related to it between the various company functions (Onat *et al.*, 2017). This quantitative analysis tool allows one to implement the principles of sustainability in business strategies and practices through the integration of three different impact assessment tools: Environmental Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Social Life Cycle Assessment (S-LCA). The LCA is the main operational tool for determining environmental impact during the entire life cycle of the product (Speck *et al.*, 2016). This procedure is standardized by the ISO 14040-44:2006 standards. The LCC is an economic evaluation methodology that allows the identification of all future costs and benefits associated with the life cycle of a product (Schau *et al.*, 2011). The normative reference for the LCC is ISO 15686-5:2017. The S-LCA is the methodology for assessing the positive and negative social impacts generated by a product over its entire life cycle on the various stakeholders involved. This methodology still needs methodological development and the current reference framework is represented by the publication UNEP/SETAC Life Cycle Initiative (Petti *et al.*, 2018). The integration of the three impact assessment methods is expressed in Klöpffer's conceptual formula (Klöpffer and Grahl, 2014):

$$\mathrm{LCSA} = \mathrm{LCA} + \mathrm{LCC} + \mathrm{S} - \mathrm{LCA}. \tag{1}$$

Sustainability assessment is not the sum of the results provided by the three analysis systems, as might appear from the formula, but it is necessary to read the results of each methodology in combination with those of the others. The LCA and LCC procedural schemes are the same, both defined by ISO standards: goal and scope definition; inventory analysis, impact assessment and interpretation of results. Therefore, environmental and economic impact assessments can follow the same path, integrating the indicators of each analysis. To integrate the social dimension, in this paper the same objective and the same definition of scope already adopted for LCA and LCC were maintained, while for the interpretation part, three different interpretative scenarios were identified that have been then combined with each other to arrive at a new construction of reality.

The life cycle paradigm based on the three pillars of sustainability offers a systemic perspective for decision making (Ferreira *et al.*, 2017). The strategic choice between alternative options should be made by looking at the "pluses" and "minuses" that characterize a product, process or activity "from the cradle to the grave," reconciling, as far as possible, the environmental, economic and social concerns of economic operators within the supply chain and the territory (De Luca *et al.*, 2017). Sustainability analysis, as a tool to monitor a production process, or an integrated supply chain and to develop and valorize a territory, is a topic that is having growing interest in the literature (Loiseau *et al.*, 2018). To this end, the LCA guidelines have recently been adapted to carry out an environmental assessment of a territory. The expectations of this framework, called "Territorial LCA," are in line with the European Directive (2001/42/EC) on Strategic Environmental Assessment applied to spatial planning programs, i.e. to provide an environmental reference basis and compare spatial planning scenarios (Loiseau *et al.*, 2014). However, there is still no empirical evidence in the literature of the integration of the territorial factor into the assessment of economic and social impact, since studies are limited to the environmental dimension.

Integrating the territorial dimension in the impact assessment means moving the field of observation from the microeconomic level (the company and its processes and products) to the meso-economic level, then to the entire supply chain with its flows of materials, energy resources, semi-finished and finished products (Loiseau *et al.*, 2013). Meso-economic systems are dynamic, complex and open systems with dynamic elements that reflect the complexity of the ways in which macro-targets are achieved (Dopfer, 2012). The purpose of their operation is to achieve maximum efficiency from the use of their resources and know-how. Their efficient network structure of interdependent microeconomic agents connected through a division of task promotes the rational use of the available economic potential of the macro-system, balancing development and minimizing operational risks (Chorafakis and Laget, 2008). According to this definition, the concept of ID can be described as localized meso-economic systems, consisting of interconnected heterogeneous, but complementary, microeconomic agents and specific local institutions that determine the role of these agents and stimulate the innovation in these systems (Gareev, 2012). Historically, the combination of innovation and sustainability has not always been interpreted as positive. For a long time, the "extreme" vision of sustainability has focused on a path of almost regression of lifestyles. Any concessions to technology could be read as a threat and in this context, innovation was necessarily seen as an enemy (Schlosberg and Coles 2016). Fortunately, in recent years this almost fideistic vision of sustainability has been replaced by a more pragmatic and realistic vision in which economic results and sustainable development are pursued simultaneously (Boons *et al.*, 2013).

2.4 Circular economy and competitiveness

Sustainability, innovation and productivity can be integrated into new circular business models (CBMs) as a strategic choice for competitiveness (Oghazi and Mostaghel, 2018). In fact, sustainability with its systemic (holistic) approach orients production processes from a linear to a circular model that is the basis of the circular economy. In other words, it goes from a linear process that sees the use of raw materials and the generation of production waste that is thrown away, to a circular manufacturing paradigm that regenerates itself, transforming into a resource what is commonly considered waste (Dentchev *et al.*, 2016). The transition to a circular economy is a revolution and an opportunity, a passage that is first and foremost cultural. In fact, it is a question of exploiting what is hidden in waste and production scraps and the industrial system, at the end of the production and consumption cycle, must develop the capacity to absorb and reuse waste and scraps. So, a circular economy ensures economic and business growth through the recovery and reuse of materials. Companies gain more value from materials, expand their markets through product innovation and improve the reputation and commitment of their customers (Manninen *et al.*, 2018).

Compared to the sharing economy, which is revolutionizing the concept of ownership of goods and services (Hobson and Lynch, 2016), industrial and manufacturing products are at the heart of the circular economy. The circular economy refers to a development model where the waste of one company becomes the raw material of another. Therefore, the use of technology must have as its objective not only the improvement of business processes but also their sustainability. For this sustainable development and circular economy are two closely related: the circular economy develops using business models, technologies and skills consistent with sustainable development (De los Rios and Charnley, 2017). The technology allows to minimize the use of energy, water and raw materials, reduce polluting emissions and better organize the end of life of the product. At the same time, technological innovation leads to greater flexibility with an improvement in production speed and an increase in productivity and therefore in the consumption of resources. On the one hand, consumers are asking for products for an increasingly satisfactory experience, based on their real needs and habits, and on the other hand, the scarcity of resources requires the redesign of production processes in a sustainable way (Banaitė, 2016). The answer to this dilemma comes from the circular perspective of manufacture and use, in which the product goes from a mere consumable good to a good that can be monitored and reused.

However, traditional business models, structured to correlate with a small number of known stakeholders and needs that can be defined in a deterministic way, are now confronted with a context in which counterparties change rapidly and have needs that are just as variable, and, above all, independent of the mechanism for creating the characteristic value of the company itself, such as, for example, the action of public opinion on issues of an industrial nature (Urbinati *et al.*, 2017). This logic of functioning of a social nature, antithetical to respect to the one focused on the mere generation of profit, requires switching from a value measurement based only on monetary indicators (profits and remunerations), and with a short-term horizon, to one that, in the long term, allows the company to sustain the conditions at the basis of its success. This leads to the need to create reference schemes (Lewandowski, 2016) which base their decision-making criteria on multiple values (environmental, economic and social) and not only on organizational criteria aimed at maximizing profit, internalizing aspects hitherto considered as "externalities."

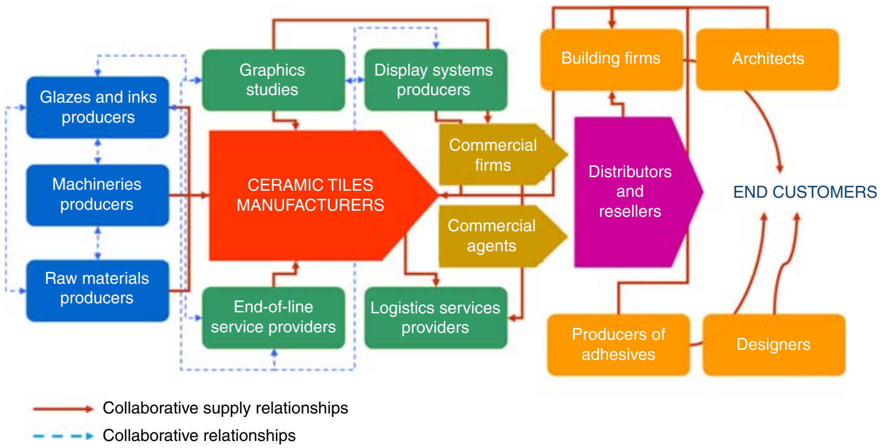
The key methodology to realize the transformation of the traditional business model into the circular one (CBMs) is the economic and social environmental impact assessment, thanks to the tools of LCA, LCC and S-LCA, respectively. They provide quantitative indicators that are indispensable for the design, manufacture, use and disposal of products, with an integrated approach to the entire life cycle and supply chain (Haupt and Zschokke, 2017). These tools can help companies reconcile corporate strategies with business and product strategies by aligning environmental and socio-economic product and process indicators with strategic objectives and key performance indicators (KPIs), identifying the contribution that the former can make to the latter (Prendeville and Bocken, 2017). It is a mapping that allows to focus on the priority areas of intervention and on those that can allow strategic innovations both in terms of technology and sustainability.

In these terms, sustainability can become a driving force for competitive advantage in resource-based industries such as the ceramic tile manufacturing sector. These industries can be considered as mature industrial sectors, because they are complex structures made up of a heterogeneous set of economic operators (von Tunzelmann and Acha 2005), and because innovation in them is not so much produced within individual companies, but rather at the network integration points that companies build within the supply chain (Simensen, 2018).

3. Assumptions and methods

The research presented in this paper analyzes an important sector within the Italian industrial system: the ceramic industry. According to the latest Eurostat analysis, in 2016 Italy confirmed its position as Europe's second largest industrial economy, with a production of 647bn euros sold. The industrial production in value of Italy, equal to 13 percent of the entire production in the EU-28, is lower only than that of Germany (1,090bn euros or 22 percent of the total EU-28) but exceeds that of France, which with 498bn euros (about 10 percent of the total EU-28) is in third place in the European scenario. Then, at the bottom of the "podium," the UK (with a production sold equal to 7 percent of the total EU-28), Spain (6 percent) and Poland (4 percent). In the remaining European countries, production never exceeds 2 percent of the EU-28 total. In this manufacturing context, the ceramic industry has always been a flagship of Made in Italy and important for European industry. Confindustria Ceramica (Association of Italian Ceramic Producers) figures speak of a sector in strong growth: in 2017 the total turnover reached 5.54bn euros, exports rose to 84 percent (compared to 72 percent 10 years ago) while investments in the sector reached a record figure of 514.9m.

For the application and validation of the integrated model of sustainability analysis (LCSA), the Italian ceramic sector was chosen for its economic importance in the national and European fields, for its peculiarities as an energy-intensive industry and high intensity of use of raw materials. Moreover, the holistic approach that is the basis of the LCSA is well suited to industrial sectors organized in districts such as the Italian ceramic industry (Sassuolo), where the supply chain coincides with the value chain (Figure 1). At the center are the manufacturers of ceramic tiles, upstream suppliers (glazes and inks, machinery and raw materials) and downstream distributors and retailers of tiles. Around this chain there is an ancillary network of suppliers and collaborators who support the development, manufacture and market entry of the ceramic product. In a systemic perspective and at a meso level, this whole can be seen as a single production structure made up of many process units (at a micro level) integrated by an interweaving of relationships, both for casting and for even informal collaboration, therefore without contractual relations. Within this meso-economic system that integrates a plurality of micro units, innovation is generated and value is created. Finally, thanks to these network characteristics and the informality of the relations between economic agents, primary data sources are easier to access than in



Source: Our elaboration

Figure 1. Supply chain of the tiles ceramic industry

other industrial sectors. All these characteristics have led to consider the Italian ceramic sector as one of the best-case studies for the purposes of this research.

On the basis of these premises, the aim of this paper is first of all to empirically determine the environmental, economic and social impact of the main products of the ceramic district of Sassuolo, using the structure of the LCSA. Subsequently, and on the basis of the empirical data obtained from the assessments, to conceptualize some options aimed at integrating sustainability at the level of both business and corporate strategies. Finally, to demonstrate how LCSA can help economic agents to evolve traditional linear business models into CBMs.

In order to achieve the objectives of the study, research questions were formulated to focus the aim and follow its progress. The questions to be answered are as follows:

RQ1. What are the process factors that most influence the environmental impact of the ceramic product?

RQ2. How do these impacts affect the structure of industrial costs?

RQ3. What are the expectations of the main stakeholders regarding these impacts?

RQ4. How can sustainability principles be introduced into business models?

From the methodological point of view, the proposed procedure for the LCSA provides for the integration between the three tools of impact assessment (LCA, LCC and S-LCA), so in accordance with ISO 14040, ISO 14044 and ISO 15686 standards, the same main steps for each dimension (environment, economy and society), goal and scope, inventory analysis, impact assessment and interpretation, have been assumed. Finally, the traditional LCSA for the ceramic district was also updated, considering the territorial component by processing data relating to the management of the entire supply chain. For the study, the SimaPro 8.0.2 software and the IMPACT 2002 evaluation method were adopted to calculate the environmental impacts.

3.1 Goal and scope definition

The objective of the experimental analysis is to assess the environmental and socio-economic impact of ceramic production in the Sassuolo district. It is made up of a network of 79 companies that manufacture ceramic tiles, located in ten municipalities straddling the provinces of Modena and Reggio Emilia. During 2016, ceramic companies produced about 341m square meters, equal to 82 percent of Italian production, with a turnover of 5.4bn euros (Confindustria Ceramica, 2016a). Of the ceramic companies that make up the district, six have a turnover of more than 200m euros, nine have a turnover of between 200 and 100m euros and the rest are below 100m euros.

Four main types of product are manufactured in the Sassuolo district:

(1) Porous double-fired wall tiles – the tiles are obtained by a process divided into two distinct phases: a first phase of firing of the support which is then glazed and then fired again to obtain the fusion of the glaze. Two different kilns are used. The product, mainly intended for wall coverings, is characterized by high porosity (greater than 10 wt% water absorption), brilliance of the glazes and definition of colors. This typology corresponds to 6 percent of the total production.

(2) Porous single-fired wall tiles (or "monoporosa") – the tiles are obtained through a technique that involves single firing of the product: both bisque and glaze are fired in a single process, only one kiln is used. The product is porous (greater than 7 wt% water absorption) with aesthetic effects of smoothness and brightness on the surface and it is suitable for indoor wall covering. This typology corresponds to 3 percent of the total production.

(3) Glazed porcelain stoneware – the tiles are obtained by a single high-temperature firing cycle (1220°C) to obtain complete sintering of the ceramic body, which therefore has frost-hardy properties (water absorption less than 0.5 percent by weight). The glazing and surface decoration give the product valuable esthetic effects, as well as resistance to staining agents and chemical reagents, facilitating cleaning operations. For these properties glazed porcelain stoneware tiles are particularly suitable for indoor use. This typology corresponds to 60 percent of the total production.

(4) Unglazed porcelain stoneware – the tiles are obtained by a single firing process at a very high temperature (1220–1230°C) capable of reaching the complete greification of the product. For this reason, porcelain stoneware is the most performing type of ceramic from a technological point of view and is above all used in solutions for use where high mechanical resistance, absolute frost and chemical inertia are required. Porcelain stoneware is available in various surface finishes. This typology corresponds to 31 percent of the total production.

The production process of ceramic tiles is shown in Figure 2. The natural raw materials from the mines are stored in the warehouses of the factories waiting to be introduced into the mills for grinding in water. At the end of this phase a solid (66 percent)–liquid (33 percent) suspension is obtained, called slurry, which is dried in a spry drier to obtain a granular powder with a residual humidity of 6–8 percent. The spray-dried powder is pressed with hydraulic presses to shape the tiles, which after drying (to remove the last residual humidity) is glazed and digitally decorated. The glazed tiles are fired in roller kilns with cycles of 30–50 min and a maximum temperature of 1200–1230°C. The tiles are cut and squared to obtain the nominal sizes and then proceed with quality control, sorting, packaging and palletizing of the product.

For this study, the functional unit chosen is 1 m^2 of each of the selected product categories, in accordance with the method used to create the Sector EPD of Italian ceramic tiles (Confindustria Ceramica, 2016b). However, for the analysis of the sector, a change of functional unit was made using as reference the production volume of the district for each product category and the total district production.

The system boundaries include the whole life cycle of the product consistent with the LCA (cradle-to-grave) procedure: extraction, transport and grinding of raw materials; pressing, glazing, decoration, firing and packaging of tiles; in addition to the use, maintenance and disposal of equipment, emissions in to the air and water during manufacture and management of scrap and processing waste (Pini *et al.*, 2014). In this study, the spatialization of each phase

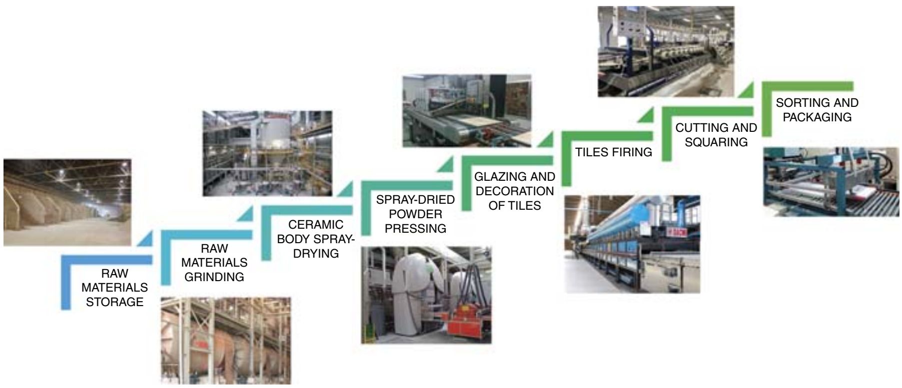


Figure 2. Manufacturing process phases for ceramic tiles

of the LCA was also adopted (Loiseau *et al.*, 2018), considering also the flows of raw materials and their impacts that come from other territories both in Italy (Tuscany, Piedmont, Sardinia) and abroad (Germany, Turkey and Ukraine).

3.2 Inventory analysis

Primary data on raw material extraction processes have been provided directly by mining companies, as well as data on inks, glazes and pigments production processes have been provided by the chemical companies producing these materials. Instead, the Ecoinvent database (Weidema *et al.*, 2013) was used as a secondary data source.

For the quantification of average energy consumption, the data for 2016 were used. The source of the data is the processing of the data collected in the Integrated Environmental Authorizations collected by ceramic companies. For the calculation of emission factors of the main pollutants present in gaseous emissions deriving from production processes, reference was made to the data calculated based on the measurements made by ARPAE (Regional Agency for the Environment and Energy of Emilia-Romagna).

The production cost analysis is based on survey carried out recently by Confindustria Ceramica (Association of Italian Ceramic Producers) on the dynamics of costs that involved 60 production units concentrated for 89 percent in the district of Sassuolo and divided into the four types of this study. Employment in the sample companies accounts for 46 percent of the total number of employees in the sector, and accounts for just under 45 percent, the weight of production. It is therefore a representative sample and the results are shown in Table I.

The collection of social data was carried out through the adoption of the participatory process (Mathe, 2014) of social agents operating in the district. An adaptation of the tools contained in the AA1000 "Stakeholder Engagement Standard" (AA1000SES) guidelines was used for the operational identification of Stakeholders. These guidelines provide a framework for organizations to identify, respond and prioritize their sustainability challenges (Institute of Social and Ethical Accountability, 2015). In this way and in accordance with the SETAC/UNEP guidelines for S-LCA (Koellner *et al.*, 2013), stakeholders involved in ceramic production have been identified, adopting the principles of responsibility, influence, proximity, dependence and representation described in standard AA1000 (Table II).

4. Results and assessment discussion

4.1 LCA: impacts assessment

Table III shows the impact assessments, using as functional unit 1 m^2 of tiles (micro level), for the four types of ceramic products and the total corresponding weight factor (Pt).

Table I. Average production costs by product type in euro/m^2 and percentage on total incidence

Costs	Porous double-fired wall tiles		Porous single-fired wall tiles		Glazed porcelain stoneware		Unglazed porcelain stoneware	
Raw materials	0.96	15.6%	1.24	16.1%	1.35	19.7%	1.89	23.4%
Inks and glazes	0.85	13.8%	0.98	12.7%	0.65	9.5%	0.41	5.1%
Electrical energy	0.17	2.8%	0.29	3.8%	0.3	4.4%	0.44	5.5%
Thermal energy	0.38	6.2%	0.4	5.2%	0.58	8.5%	0.72	8.9%
Consumables	0.5	8.1%	0.7	9.1%	0.7	10.2%	0.84	10.4%
Packages	0.21	3.4%	0.23	3.0%	0.28	4.1%	0.34	4.2%
Production staff	1.61	26.2%	2.02	26.2%	1.64	23.9%	1.69	21.0%
Accessories	1.13	18.4%	1.38	17.9%	0.87	12.7%	1.02	12.7%
Amortizations	0.34	5.5%	0.48	6.2%	0.48	7.0%	0.71	8.8%
Total	6.15	100.0%	7.72	100.0%	6.85	100.0%	8.06	100.0%

Stakeholder categories	Stakeholder subcategories	Stakeholder details
1. Human resources	1.1 Staff personnel	1.1.1 Blue-collar workers
		1.1.2 Employees
		1.1.3 Managers
		1.1.4 Top management
	1.2 Trade unions	1.2.1 Confederal trade unions
		1.2.2 Independent trade unions
2. Local community	2.1 Local public institutions	2.1.1 Regional governments
		2.1.2 Provincial governments
		2.1.3 Municipalities
3. Society	3.1 Private business	3.1.1 Company's shareholders
		3.1.2 Association of manufacturing and service companies
		3.1.3 Chambers of commerce
	3.2 Public and private organization	3.2.1 Regulatory authorities
		3.2.2 Research community
		3.2.3 National and international public institutions
		3.2.4 Civil society organizations
	3.3 Environment	3.3.1 Natural environment
		3.3.2 Future generations
	3.4 Media	3.4.1 Newspapers
		3.4.2 Professional magazines
		3.4.3 TV and radio
		3.4.4 Internet
4. Consumers	4.1 Trade channel operators	4.1.1 Resellers
		4.1.2 Trading partners
		4.1.3 Business customers
	4.2 Final consumer	4.2.1 Private customers
		4.2.2 Consumers associations
5. Value chain actors	5.1 Suppliers	5.1.1 Large-scale suppliers
		5.1.2 Small-scale suppliers
	5.2 Partners	5.2.1 Practitioners and professionals
	5.3 Competitors	5.3.1 Direct competitors
		5.3.2 Indirect competitors

Table II.
Stakeholders mapping with correspondences between the categories defined by the SETAC/UNEP guidelines and subcategories

The processes produce an impact due to 19.7 percent to the porous double firing wall tiles, 22.2 percent to porous single firing wall tiles, 25.7 percent to glazed porcelain stoneware and 32.3 percent to unglazed porcelain stoneware. In order to estimate the environmental damage that ceramic production has on the district, a further calculation was made by weighting the impacts with the square meters produced for each type of product considered. In this way it has been passed from the level of microeconomic analysis (which refers only to the functional unit of 1 m^2 of ceramic tiles) to the level of meso-economic analysis which refers to the production of entire district as functional unit. The results are shown in Figure 3. The greatest impact for all products corresponds to the category of damage to human health. The detrimental effect on human health is mainly related to the NO_X (nitrogen oxide) emissions associated with transportation of raw materials from the extraction sites to the factory sites (41.9 percent overall). Clearly the same NO_X emissions affect climate changes (24.2 percent in total).

A rigorous LCA carried out at the micro level should be followed by a coherent action plan, with substantial changes to the current business model to transform it into a CBM. Based on environmental impact indices, it is possible to map the stages of the process that produce increases or decreases in impacts, so as to plan targeted solutions to minimize them. Such solutions can include both product and process innovation: changing suppliers, using

Table III.
Results of environmental damage for the four product categories expressed in Pt and obtained with the Impact 2002 model

Damage categories	Impact categories	LCA: Porous double firing wall tiles	Porous single firing wall tiles	Glazed porcelain stoneware	Unglazed porcelain stoneware	Total
Human health	Carcinogenic agents	1.45E−05	1.60E−05	2.60E−05	3.50E−05	3.22E−03
	Non-carcinogenic agents	3.80E−05	4.10E−05	4.90E−05	5.70E−05	
	Respiratory inorganic	6.10E−04	7.10E−04	7.10E−04	9.10E−04	
	Respiratory organic	1.00E−06	1.20E−06	1.40E−06	1.70E−06	
Ecosystem quality	Ozone depletion	2.40E−07	3.00E−07	3.60E−07	4.70E−07	4.07E−04
	Aquatic ecotoxicity	6.50E−06	1.00E−05	8.30E−06	1.10E−05	
	Terrestrial ecotoxicity	6.50E−05	8.20E−05	7.70E−05	8.00E−05	
	Aquatic acidification	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
	Soil acidification	9.80E−06	1.20E−05	1.20E−05	1.40E−05	
	Land occupation	3.60E−06	4.90E−06	4.20E−06	5.30E−06	
Climate change	Global warming	8.90E−04	9.50E−04	1.10E−03	1.40E−03	4.34E−03
Resources	Nonrenewable energy	8.10E−04	9.20E−04	1.20E−03	1.50E−03	4.44E−03
	Mineral extraction	3.20E−06	4.80E−06	2.70E−06	3.60E−06	
	Total	2.45E−03	2.75E−03	3.19E−03	4.02E−03	1.24E−02
		19.7%	22.2%	25.7%	32.3%	

LCA MICRO LEVEL	POROUS DOUBLE–FIRED WALL TILES		POROUS SINGLE–FIRED WALL TILES		GLAZED PORCELAIN STONEWARE		UNGLAZED PORCELAIN STONEWARE	
Human Health	2.34E−04	41.5%	2.31E−04	40.8%	2.92E−04	40.1%	3.94E−04	44.9%
Ecosystem Quality	4.35E−05	7.7%	4.19E−05	7.4%	5.24E−05	7.2%	5.69E−05	6.5%
Climate Change	1.36E−04	24.1%	1.39E−04	24.6%	1.82E−04	25.0%	2.02E−04	23.0%
Resources	1.50E−04	26.6%	1.54E−04	27.2%	2.02E−04	27.7%	2.25E−04	25.6%
TOTAL	5.64E−04	100.0%	5.66E−04	100.0%	7.28E−04	100.0%	8.78E−04	100.0%
	21%		21%		27%		32%	

LCA MESO LEVEL	POROUS DOUBLE–FIRED WALL TILES		POROUS SINGLE–FIRED WALL TILES		GLAZED PORCELAIN STONEWARE		UNGLAZED PORCELAIN STONEWARE	
Human Health	5.38E+03	41.5%	3.13E+03	40.8%	6.91E+04	40.1%	4.81E+04	44.9%
Ecosystem Quality	1.00E+03	7.7%	5.68E+02	7.4%	1.24E+04	7.2%	6.94E+03	6.5%
Climate Change	3.13E+03	24.1%	1.88E+03	24.6%	4.31E+04	25.0%	2.46E+04	23.0%
Resources	3.45E+03	26.6%	2.09E+03	27.2%	4.78E+04	27.7%	2.74E+04	25.6%
TOTAL	1.29E+04	100.0%	7.67E+03	100.0%	1.72E+05	100.0%	1.07E+05	100.0%
	4%		3%		57%		36%	

Figure 3.
Impact of production in absolute value and expressed in percent for each category of damage at micro and meso level

different raw materials and changing production processes with the adoption of new technologies. The incorporation of LCA analyses into the CBM has a potential for defining new business strategies for resource use and allocating environmental impacts. In fact, if at the micro level the only LCA analysis refers to a process and a specific product. On the contrary, in a CBM context, life cycles of different products and processes, within the same company can be related to each other in a holistic perspective: the outputs of a life cycle analysis of one product can become the inputs of the life cycle of another. Similarly, at the meso level, the LCA of each single actor in the supply chain, in a systemic perspective, can correlate the LCA of suppliers and distributors and customers, shifting the focus of the strategic analysis from the business level to the corporate level.

4.2 LCC: Costs assessment

In an integrated process for the manufacturing of a product, the life cycle of costs is the sum of the costs attributable to the individual life cycle stages (Sell *et al.*, 2014):

$$LCC_{TOT} = \text{Development costs} + \text{Utilization costs} + \text{Disposal costs}. \quad (2)$$

To adapt the above conceptual formula (2) to the specific case under study, we propose this new empirical formula:

$$LCC_{TOT} = \text{Production costs} + \text{Utilization costs} + \text{Externalities}. \quad (3)$$

The calculation of production and utilization (distribution, installation and use phases) costs of the end product were determined per m^2 and then projected on a "meso" scale on the basis of production volumes by category and total for the entire district (Table IV). The economic impact assessment (LCC), which is carried out in parallel with the environmental impact assessment (LCA), makes it possible to quantify environmental damage economically. The production of ceramic tiles, as well as other economic activities, uses resources that come from the environment without, however, considering the economic value of the environmental damage caused using these factors of production. Costs incurred by some parts of society because of activities that affect the environmental balance of a territory are referred to as negative environmental externalities or external costs (Chava, 2014). The EPS 2000 model has been used to estimate externalities. It estimates the economic cost of pollutant emissions based on the willingness to pay of the entity responsible, in order to avoid a worsening of the situation created or to remedy a damage caused, attributing an economic value to the damage. Each impact category in the EPS 2000 model attributes a specific weight to the severity of the impact in environmental and social terms. This weight is defined as the Environmental Load Unit (ELU), whose value is 1 ELU = €1. Table IV shows

Life cycle costing	Porous double-fired wall tiles	Porous single-fired wall tiles	Glazed porcelain stoneware	Unglazed porcelain stoneware
Production cost				
Production (m^2)	22,978,356	13,545,628	236,734,900	121,954,343
Production costs (€/m^2)	6.15	7.72	6.85	8.06
Total production costs	141,316,889	104,572,248	1,621,634,065	982,952,005
		2,850,475,207		
Utilization cost				
Utilization costs (€/m^2)	6.56	6.85	8.99	10.01
Total utilization costs	150,738,015	92,787,552	2,128,010,016	1,220,762,973
		3,592,298,557		
Externalities				
Human health	0.11	0.13	0.15	0.17
Ecosystem production capacity	0.11	0.14	0.14	0.19
Abiotic stock resource	0.54	0.83	0.41	0.50
Biodiversity	0.0014	0.0015	0.0018	0.0023
Total	0.76	1.10	0.71	0.86
Total externalities	17,443,293	14,896,295	168,293,988	104,824,295
		305,457,871		
Total product cost (€/m^2)	13.47	15.67	16.55	18.93
Total costs by category	309,498,197.60	212,256,095.04	3,917,938,069.26	2,308,539,272.52
Total		6,748,231,634		

Note: Externalities are expressed in euro/m^2

Table IV. LCC calculation scheme based on inventory data and applying the empirical formula (3) the costs of environmental externalities relating to the damage category for each type of ceramic product considered.

LCC allows us to quantify both the production costs (internal) and the social costs due to the use of the product and the costs corresponding to the environmental damage caused by the manufacturing process (externalities). In a traditional business model, at the micro level, a company invests in an innovation (product, process or organizational) when the expected revenues are higher than the investment costs. In a CBM, on the other hand, decision makers can also take into account the external (process) costs and social benefits that they could generate. This is therefore a way to include economic sustainability within the company's strategy.

The adoption of the external costs approach allowed us to monetize the environmental impact of different ceramic tiles production. The LCC analysis assimilates the directional accounting because it introduces into it not only the industrial costs and those of use, but also those that the environment and the company must pay in order to maintain the manufacturing conditions of the ceramic product. The transformation of environmental externalities into internal costs makes it possible to go beyond the individual production units and to consider the territory, switching from micro to the meso level.

4.3 S-LCA: social assessment

The three impact assessment systems S-LCA, LCA and LCC all refer to the guidelines set out in ISO 14040 which provides for four phases Therefore, for the determination of the social impact, implementing the same objective and scope of LCA and LCC, using the participatory approach (Mathe, 2014) already used for the engagement of stakeholders involved in the management of cultural heritage (Settembre Blundo *et al.*, 2018). In the case under consideration in this study, the expectations of the stakeholders involved in the value chain of the Sassuolo district were adopted as an indicator of social impact. To determine the expectations of the main stakeholders, the qualitative analysis has required the use of various data collection techniques, such as structured online interviews and focus groups. Subsequently, in order to define the degree of influence that the expectations of the stakeholders have on the producers of ceramic tiles, it was necessary to assign to each stakeholder a prioritization index, constructed with the criteria of power, urgency and proximity already described in the AA1000 standard. The social research applied to this case study raised relevant methodological questions. It has been verified that the analyst's position is not neutral, when he/she observes social events to infer conclusions, he/she "interprets" social phenomena based on his/her background: experience, knowledge and conscience (Berger, 2015). Therefore, the research team was confronted with the intrinsic partiality of each member when collecting, processing and analyzing social data (Robinson and Kerr, 2015). The construction of knowledge is therefore done through a continuous exchange of points of view, including not only those of the research team. The interpretative process and the construction of reality are also influenced by the context in which the social event occurs. Converging multiple points of view, such as stakeholder expectations, is a way to build and describe reality. Through the interpretation of these different points of view, the background of the researcher/analysts merges with those of other social agents, creating a new and more complete understanding of the reality under examination (Gerrard, 2017).

For this reason, the importance of stakeholders was declined into three sets characterized by three different perspectives of observation of reality. Scenario 1, entrepreneurial perspective (Figure 4); Scenario 2, worker's perspective (Figure 5) and Scenario 3 public institutions' perspective (Figure 6). Part "a" of each scenario considered (Figures 4–6) indicates that for each main stakeholder category and each criterion, a priority index has been assigned (from 1 to 10). The total index is obtained from their sum. Assuming the value 30 (10 + 10 + 10) as the maximum prioritization index, the percentage deviation for

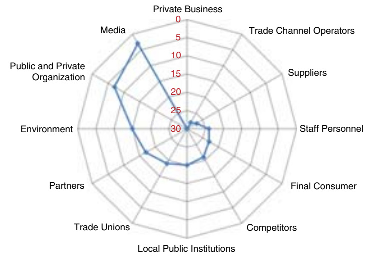
(a)

STAKEHOLDERS	Power Criterion	Urgency Criteria	Proximity Criteria	Total Prioritization Index	Deviation %
Staff Personnel	7	7	10	24	20
Trade Unions	6	6	7	19	37
Local Public Institutions	10	5	5	20	33
Private Business	10	10	10	30	0
Public and Private Organization	2	2	3	7	77
Environment	5	6	4	15	50
Media	1	1	1	3	90
Trade Channel Operators	9	10	9	28	7
Final Consumer	8	8	7	23	23
Suppliers	9	8	10	27	10
Partners	6	4	7	17	43
Competitors	9	5	7	21	30
MAXIMUM PRIORITIZATION	10	10	10	30	0

(b)

Priority	STAKEHOLDERS	Total Prioritization Index	Weighting Factor	Priority Group
1	Private Business	30	1.0	Priority Group 1 WF ⩾ 0.9
2	Trade Channel Operators	28	0.9	
3	Suppliers	27	0.9	
4	Staff Personnel	24	0.8	Priority Group 2 WF ⩾ 0.7
5	Final Consumer	23	0.8	
6	Competitors	21	0.7	
7	Local Public Institutions	20	0.7	
8	Trade Unions	19	0.6	Priority Group 3 WF ⩾ 0.5
9	Partners	17	0.6	
10	Environment	15	0.5	
11	Public and Private Organization	7	0.2	Priority Group 4 WF ⩽ 0.2
12	Media	3	0.1	

(c)



Notes: (a) Mapping; (b) prioritization; (c) graphic representation of the significance of stakeholders

Figure 4. Scenario 1: entrepreneurial perspective

each stakeholder indicates the "distance" of this value from the maximum possible index. In Part "b" (Figures 4–5), stakeholder groups are ordered by total index of decreasing prioritization and by weighting factor obtained by dividing this index with the maximum index of prioritization (30). In this way, it was possible to aggravate the stakeholders in four priority groups. Finally, radial diagram "c" (Figures 4–6) graphically traces the relative relevance of the stakeholders with respect to the index of maximum prioritization.

Figure 7 represents the logic of stakeholder prioritization for each scenario. Entrepreneurs, workers and public institutions have a different construction of reality depending on the specificity of their expectations. After collecting these different visions, the research team, through a hermeneutical process (Gantt *et al.*, 2017), carried out the fusion of the three different interpretative horizons to arrive at a new construction of reality that is represented in the table in Figure 7 (Stenner *et al.*, 2017). It represents a new prioritization of the stakeholders of the Sassuolo district on the basis of the perspectives of the three scenarios that have been considered. The new stakeholder list was built by combining scenarios (in columns) with priority groups (in line) across them and listing them in descending order of priority, switching from micro to meso level. The new list of stakeholders can be the basis for defining the most appropriate strategies for engagement. In fact, the list shows a new mapping that allows to focus on the priority areas of environmental and socio-economic intervention (for stakeholders) and on those that can allow strategic innovations from the technological and organizational point of view (for firms). The S-LCA analysis proves to be the suitable tool to make the synthesis between growth and development, because it raises the question of how technological choices can exert positive (or negative) effects on the business of companies, on the territory and the environment and more generally on the well-being and satisfaction of stakeholders' expectations. This synthesis can take place in the CBM in which it is possible to bring

(a)

STAKEHOLDERS	Power Criterion	Urgency Criteria	Proximity Criteria	Total Prioritization Index	Deviation %
Staff Personnel	10	10	10	30	0
Trade Unions	9	9	10	28	7
Local Public Institutions	8	4	4	16	47
Private Business	9	8	9	26	13
Public and Private Organization	1	1	1	3	90
Environment	4	5	2	11	63
Media	1	1	2	4	87
Trade Channel Operators	1	4	5	10	67
Final Consumer	1	1	1	3	90
Suppliers	2	1	5	8	73
Partners	1	1	1	3	90
Competitors	4	1	1	6	80
MAXIMUM PRIORITIZATION	10	10	10	30	0

(b)

Priority	STAKEHOLDERS	Total Prioritization Index	Weighting Factor	Priority Group
1	Staff Personnel	30	1.0	Priority Group 1 WF ⩾ 0.9
2	Trade Unions	28	0.9	
3	Private Business	26	0.9	
4	Local Public Institutions	16	0.5	Priority Group 2 WF ⩾ 0.3
5	Environment	11	0.4	
6	Trade Channel Operators	10	0.3	Priority Group 3 WF ⩽ 0.2
7	Suppliers	8	0.3	
8	Competitors	6	0.2	
9	Media	4	0.1	Priority Group 4 WF ⩽ 0.1
10	Public and Private Organization	3	0.1	
11	Final Consumer	3	0.1	
12	Partners	3	0.1	

(c)

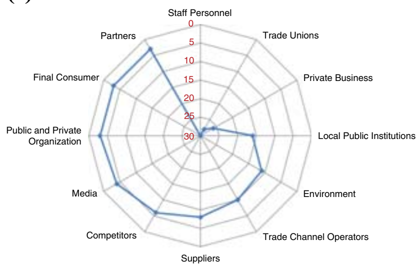


Figure 5.
Scenario 2: worker's perspective

Notes: (a) Mapping; (b) prioritization; (c) graphic representation of the significance of stakeholders

together these three flows of information relating to environmental and socio-economic impacts: the corporate vision coming from the top, from the entrepreneurs and from the company management; the business vision coming from the bottom coming from the workers and from the collaborators; and the vision of the territories expressed by the requests of the public authorities.

5. Discussion and conclusions

This section presents the main results and conclusions arising from this research.

5.1 Overview and discussion of results

In this paper, adopting the holistic perspective of the life cycle and the LCSA tools, the environmental and economic impact of the main types of production in the Italian ceramic sector has been determined. Empirically, the study showed that the transport of raw materials constitutes about 20–25 percent of the environmental damage produced by the entire life cycle, for all the production categories of the Sassuolo ceramic district. However, there are no great differences between the different processes of the product categories considered, in terms of environmental impact, demonstrating the standardization of the production phases. The process of technological standardization has also made less relevant the reduction costs related to the territorial proximity and the outsourcing of production phases and the efficiency of learning processes that are at the basis of innovation. The LCSA, by LCC method, helped to incorporate the full social cost of an economic transaction with environmental effects into the price of products, avoiding attributing the

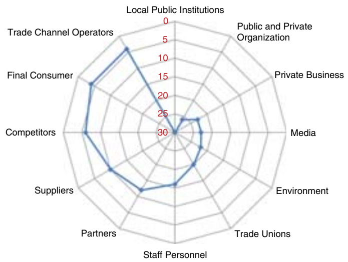
(a)

STAKEHOLDERS	Power Criterion	Urgency Criteria	Proximity Criteria	Total Prioritization Index	Deviation %
Staff Personnel	2	6	8	16	47
Trade Unions	6	8	6	20	33
Local Public Institutions	10	10	10	30	0
Private Business	7	8	8	23	23
Public and Private Organization	9	8	9	26	13
Environment	7	9	6	22	27
Media	9	6	8	23	23
Trade Channel Operators	1	1	2	4	87
Final Consumer	1	2	1	4	87
Suppliers	4	2	4	10	67
Partners	4	5	3	12	60
Competitors	3	2	1	6	80
MAXIMUM PRIORITIZATION	10	10	10	30	0

(b)

Priority	STAKEHOLDERS	Total Prioritization Index	Weighting Factor	Priority Group
1	Local Public Institutions	30	1.0	Priority Group 1 WF ⩾ 0.9
2	Public and Private Organization	26	0.9	
3	Private Business	23	0.8	Priority Group 2 WF ⩾ 0.7
4	Media	23	0.8	
5	Environment	22	0.7	
6	Trade Unions	20	0.7	
7	Staff Personnel	16	0.5	Priority Group 3 WF ⩾ 0.3
8	Partners	12	0.4	
9	Suppliers	10	0.3	
10	Competitors	6	0.2	Priority Group 4 WF ⩽ 0.2
11	Final Consumer	4	0.1	
12	Trade Channel Operators	4	0.1	

(c)



Notes: (a) Mapping; (b) prioritization; (c) graphic representation of the significance of stakeholders

Figure 6.
Scenario 3: public institutions' perspective

Priority Group	SCENARIO 1 Entrepreneurial Perspective		SCENARIO 2 Worker's Perspective		SCENARIO 3 Public Institutions' Perspective	
	STAKEHOLDER	INDEX	STAKEHOLDER	INDEX	STAKEHOLDER	INDEX
1	Private Business	1.0	Staff Personnel	1.0	Local Public Institutions	1.0
	Trade Channel Operators	0.9	Trade Unions	0.9	Public and Private Organization	0.9
	Suppliers	0.9	Private Business	0.9		
2	Staff Personnel	0.8	Local Public Institutions	0.5	Private Business	0.8
	Final Consumer	0.8	Environment	0.4	Media	0.8
	Competitors	0.7			Environment	0.7
	Local Public Institutions	0.7			Trade Unions	0.7
3	Trade Unions	0.6	Trade Channel Operators	0.3	Staff Personnel	0.5
	Partners	0.6	Suppliers	0.3	Partners	0.4
	Environment	0.5	Competitors	0.2	Suppliers	0.3
4	Public and Private Organization	0.2	Media	0.1	Competitors	0.2
	Media	0.1	Public and Private Organization	0.1	Final Consumer	0.1
			Final Consumer	0.1	Trade Channel Operators	0.1
			Partners	0.1		

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1	Private Business	1.0
2	Staff Personnel	1.0
3	Local Public Institutions	1.0
4	Trade Channel Operators	0.9
5	Suppliers	0.9
6	Trade Unions	0.9
7	Public and Private Organization	0.9
8	Final Consumer	0.8
9	Media	0.8
10	Competitors	0.7
11	Environment	0.7
12	Partners	0.6

Figure 7.
Interpretative process of fusion of the different perspectives of entrepreneurs, workers and public institutions and construction of a new prioritization of the stakeholders of Sassuolo district

external costs to the community and responding to market failures. Through the S-LCA, the main stakeholders within the supply chain have been identified and each of them has been assigned a different index of prioritization according to the different perspectives of analysis: entrepreneurs, workers and public institutions. The assessment of the pillars of sustainability was carried out at two levels: meso-economic, considering the production data of the entire district as a functional unit, and microeconomic, at the level of the business, considering a m^2 of tiles produced for each type manufactured as a functional unit. The study also highlighted how, at the micro level, environmental (LCA), economic (LCC) and social (S-LCA) impact assessment tools can help companies in the sector to evolve their traditional business models from linear to circular, through the integration of sustainability principles into their business strategies. At the meso (district) level, on the other hand, it was seen that production factors and emissions are partially shared with upstream and downstream agents in the supply chain, and therefore from a sectorial perspective, this allows the integration of sustainability in corporate strategies or in public policies. Therefore, this research bridges the gap between scholars and practitioners in the field of integrating sustainability principles into business models and economic and industrial policies for the governance of territories.

In a theoretical perspective, the change of the analysis unit, from the enterprise (at micro level) to the district (at meso level), allows one to take into account those externalities that would otherwise remain outside the "gates" of the economic actors and allows one to transform them into sector internalities. The LCSA model also highlighted that the transport of raw materials is one of the most impacting factors, but above all it showed that it is not only a physical operation cost (the transport from the mine to the factories), but also an environmental cost not exclusively attributable to the individual company, but to the entire sector. The determination of the monetary value of externalities has questioned the hypothesis of the "isotropicity" of space considered in terms of "pure distance," that is, that spatial element that must be filled in order to transport people with raw materials and finished products. Distance is not only an operations cost, but also an environmental cost. Externalities have the consequence of creating situations of interdependence between subjects who are not among themselves in contractual relations. This vision raises the question of managing interactions between economic agents and internalizing externalities that cannot be left exclusively to market coordination. This is a problem of governance of the system and the implementation of appropriate economic policies aimed at attributing the cost of externalities to those who have been able to use public assets for the exercise of their economic activity. The economic quantification of external costs in aggregate terms broadens the knowledge of the factors of pressure offering private decision makers and public administrators, useful information to prepare responses and targeted interventions of economic policies. This could be done by moving from the coercive logic of "prohibiting" to the positive logic of "doing better," in which the environment is no longer perceived as an externality, a threat and an obstacle to business development, but as an opportunity to stimulate product and process innovation.

From a managerial perspective, this experimental research has shown how the use of an appropriate scientific tool (the LCSA model) allows one to quantify the economic, environmental and social impact, using process data normally available to economic agents and otherwise not always used profitably. The information provided by LCSA's tool can provide companies in a mature sector, such as the ceramic one, with incentives to innovate their competitive strategy in order to create value along the entire supply chain. For example, by repositioning the product to place it in a premium market segment that is more sensitive to sustainability attributes. The effects of the industrial activities of the Sassuolo district extend beyond the traditional concept of local territory to reach beyond national borders, to the countries from which the raw materials necessary to produce ceramic tiles are sourced. The social dimension of industrial activity in the district and the related costs has led us to ask ourselves about the ways in which economic actors interact and about the model of "government" of the territory.

The interpretative study of the expectations of the various stakeholders, divided into three different scenarios, would evoke the creation of a district governance that guides the efforts and investments of all companies toward cost efficiency, value innovation, market presence with an adequate policy of brand, the ability to develop and integrate into international markets. In mature markets technologies and operations are notably standardized. Therefore, traditional sources of competitive advantages will not take place in theses contexts, like the case of the European tiles ceramic industry. Coherently, sustainability can be considered an alternative way to differentiate products, companies or even countries, giving it a significant role in value creation. LCSA let firms or the whole industry identify new opportunities for competitive advantages along the value chain directly related to sustainability.

5.2 Conclusion and final remarks

This research has shown, through the analysis of the life cycle, that the environmental impact of the manufacture of ceramic tiles is mainly due to the transport of raw materials from mines to factories and the finished product to distributors to customers. The economic cost of this impact represents an externality of the manufacturing system, which can be considered and can be internalized by integrating it into the industrial cost structure. Environmental impact and related externalities are relevant especially for three main categories of stakeholders: private business, staff personnel and local public institutions. Internalizing externalities, however, leads to an increase in industrial costs and could potentially make the Italian ceramic manufacturing system less competitive compared to competitors from other countries that do not consider the socio-economic impact of their industrial activities.

Therefore, in order to improve the competitiveness of the system, it is necessary to include sustainability principles within the traditional business models, moving from a linear to a circular paradigm. In practice, LCSA's operational tools (LCA+LCC+S-LCA) can provide adequate sustainability KPIs to design the CBM based on clear business plans that can highlight cash flows, the investments needed to support sustainability strategies and their return. In addition, the LCSA can be useful to highlight and exploit certain returns on investments such as, for example, the ethical profile, reputation or degree of innovation, not easily identifiable, quantifiable and monetized with traditional accounting methods. It is therefore clear that, thanks to LCSA and CBM, it is possible to close the life cycle of the ceramic product, taking the appropriate actions that lead to the achievement of sustainability goals both at business and corporate level and the quantification of its effects, expressed in terms directly correlated to the KPIs defined in the previous planning phase.

In this way it is possible to take advantage of the "recursiveness" of the LCSA methodology, checking if there are significant differences between what is planned and what has been achieved. Consequently, it is necessary to retrace the cycle by modifying the objectives according to the causes that, during the first iteration, prevented them from being achieved (e.g. over-ambitious objectives, insufficient resources, etc.). By also investigating whether, on the contrary, the objectives initially set have been achieved, it is possible to set more ambitious objectives for subsequent iterations by updating the KPIs and/or adding new ones that will describe the objectives set for development in terms of sustainability. The circularity inherent in the recursiveness of the LCSA methodology can allow the economic agents of an industrial chain, such as the ceramic one covered by this study, to highlight the points of creation and transfer of value in the chain. The finished product (output) of a supplier (e.g. raw materials or glazes) becomes a production factor for the tile manufacturer and the waste from the manufacturing process is often part of the same process or can be returned to the supplier for reuse. Thus, the same material has generated value twice. This mechanism can be fully highlighted with the LCSA's systemic approach.

Finally, this paper has developed a first step into the integration of the three tools dealing with sustainability: LCA, LCC and S-LCA. The integration between the environment and economy took place through the transformation of environmental damage into externalities, thanks to the guidelines common to the two assessment models (LCA and LCC) defined in the ISO standards. Integration with the social dimension was achieved by assessing the expectations of the main stakeholders with respect to the environmental and economic impact data obtained. Our approach to integration has shown some critical points:

(1) the transformation of environmental damage into externalities does not cover the entire economic dimension of an activity; in a strategic dimension, it would also be appropriate to determine the economic-financial sustainability of alternative scenarios; and

(2) there is still no link, even an indirect one, between the social and economic dimensions, so as to be able to address socio-economic sustainability in a broader sense, and not just the assessment of the social effects of environmental damage.

Both these critical issues provide a natural guide to future research.

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