Ecological Economics 193 (2022) 107311

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Green recovery in the mature manufacturing industry: The role of the green-circular premium and sustainability certification in innovative efforts

Andrea Appolloni [a], Charbel Jose Chiappetta Jabbour [b,*], Idiano D'Adamo [c], Massimo Gastaldi [d], Davide Settembre-Blundo [e]

[a] Department of Management and Law, University of Rome Tor Vergata, Via Columbia 2, 00133 Rome, Italy
[b] EMLYON Business School, 23 Av. Guy de Collongue, 69130, Lyon-Écully, France
[c] Department of Computer, Control and Management Engineering, Sapienza University of Rome, Via Ariosto 25, 00185 Rome, Italy
[d] Department of Industrial Engineering, Information and Economics, University of L'Aquila, Via G. Gronchi 18, 67100 L'Aquila, Italy
[e] Department of Business Administration (ADO), Applied Economics II and Fundamentals of Economic Analysis, Rey Juan Carlos University, 28032 Madrid, Spain

ARTICLE INFO

Keywords:
Green recovery
Circular premium
Green premium
Green manufacturing
Strategic innovation
Sustainability

ABSTRACT

Sustainability is an essential goal for companies to pursue alongside their efforts to cope with a period of economic crisis and uncertainty. Technologically mature manufacturing sectors need to preserve their competitiveness, and process and product innovation may no longer be sufficient to stimulate demand. Strategic innovation is one possible option to address this challenge. However, methods to implement this new paradigm are still underexplored. This paper analyzes the Italian and Spanish ceramic tile industries as a prime example of process digitalization and environmental practices in the European manufacturing context. Through the application of multi-criteria analysis, this study aims to investigate the possibilities provided by strategic innovation to companies in this sector, in order to be able to compete with producers in emerging countries who use price strategies as the only lever of their competitiveness. To this end, dimensions relating to operations, market, economy, society and the environment are considered herein. Our results show that the multidimensionality of industrial organizations should stimulate manufacturing firms not only to look at customer needs from a price point of view, but to commit to including social and environmental attributes in their products, such as the green-circular premium and sustainability certification. These two practices represent strategic innovation. This presents a complex challenge involving widespread change that concerns entrepreneurship, management and industrial policies.

1. Introduction

In today's climate, sustainable development goals (SDGs) are a crucial strategy for all governments. The theme of green recovery (Shaw and Nerlich, 2015) has been introduced in the field of ecological economics as an approach to remedy climate change. The circular economy, the bio-economy and the green economy provide important guidelines for post-Covid-19 sustainability-related transformations (D'Amato and Korhonen, 2021), while the theme of 'green growth' is increasingly a key concern of researchers (Savin et al., 2021). Policies put in place to counter not only the socio-economic crisis associated with the pandemic, but also climate change, are often termed 'green recovery' in order to highlight the strategic role of sustainability in moving towards the society of the future (Lahcen et al., 2020). The manufacturing sector is fully involved in this transformation process (Vrchota et al., 2020). Green innovation can provide new opportunities which have a strong focus on environmental issues (Rehman et al., 2021), and businesses are now being called upon to respond to new environment-related consumer demands (Waheed et al., 2020).

The development of the manufacturing industry is recognized as having the capacity to generate value (De Guimarães et al., 2020) because it promotes the growth of new job opportunities (Ndubisi et al., 2021), allowing for a rapid and widespread increase in people's standard of living (Ponce et al., 2019). In addition, rapid spread of new technologies makes it possible to combine growth with environmental protection (García-Muiña et al., 2021; Goto and Sueyoshi, 2020). It

* Corresponding author.
E-mail addresses: andrea.appolloni@uniroma2.it (A. Appolloni), chiappettajabbour@em-lyon.com (C.J. Chiappetta Jabbour), idiano.dadamo@uniroma1.it (I. D'Adamo), massimo.gastaldi@univaq.it (M. Gastaldi), davide.settembre@urjc.es (D. Settembre-Blundo).

https://doi.org/10.1016/j.ecolecon.2021.107311
Received 1 September 2021; Received in revised form 3 December 2021; Accepted 6 December 2021
Available online 15 December 2021

follows that without industrialization there can be no solid, long-term development; however, industrialization is itself not feasible without technology and innovation. In the industrial context, innovation and technology have proven to be indispensable requirements to ensure the competitiveness of enterprises, while also allowing industry to combine economic growth and environmental protection (D'Adamo et al., 2020b; Yin et al., 2020). The sustainable perspective can be used to assess how geographic contexts influence technology transfer, in terms of environmental patents underlining the relationship between sustainability and eco-innovation (Cheng et al., 2019; Fernando et al., 2019). Technological innovation makes it possible to sustainably re-engineer companies and manufacturing supply chains (Raj et al., 2020) and to increase efficiency in the use of natural and energy resources, reducing harmful emissions into the atmosphere and pollution of water and soil (Adebayo et al., 2021). Nevertheless, both from the business point of view and for public decision-makers, the conditions must be put in place so that this technology-enabled transition towards sustainability does not preclude but rather favors business productivity and profitability (Chiappetta Jabbour et al., 2020; Hristov et al., 2021).

In markets containing a diverse array of goods on offer, manufacturing companies gain market power by being able to influence consumer choices through price strategies, which are supported by process innovation that increases the efficiency of their factories, but also by implementing quality strategies based on product innovation, which provides the consumer with a new and improved perception of the product (Diaz Lopez et al., 2019; Song et al., 2021). On the other hand, in markets which are open to competition with emerging economies, where companies have already achieved high standards of operational efficiency thanks to the widespread implementation of advanced technologies, process innovation may not be sufficient to guide consumers to generate new demand (Kienzler and Kowalkowski, 2017). This is due to the ineffectiveness of pricing strategies, since the industrial costs of manufacturers in emerging countries are lower than in developed countries. This reduces the opportunity to establish a sustainable competitive advantage based only on cost advantage. Therefore, when product and process innovation lose importance, a new paradigm must be applied: strategic innovation (Gebauer et al., 2012). This paradigm is not directly related to technological advances, as in process/product innovation in emerging industries, but rather aims to convert standardized products into unique consumer experiences by providing new functions and ancillary services that enhance their utility. Strategic innovation using the experiential economy, through continuous experimentation and learning, becomes the basis of competitive advantage for mature industries (Varadarajan, 2018).

According to Onufrey and Bergek (2021), a mature industry is characterized by the presence of established technologies and intensive use of resources which, after long periods of relatively stable operations in consolidated markets, is under growing pressure to transform itself by implementing new strategies (Arasti et al., 2017) such as transitioning towards sustainability (Berggren et al., 2015). This push for innovation is demanded by the market, which has begun to seek new green and/or ethical product attributes and content over and above new products in the traditional sense (Serrano-García et al., 2021). In this context, companies in mature sectors mostly compete in terms of the ancillary services they offer and economies of scale (TenBrink and Gelb, 2017). Therefore, firms in mature sectors that are under external pressure to transform their organizational models (Lee et al., 2022) may seize the opportunity of green recovery more effectively than firms in other sectors, (Gusheva and de Gooyert, 2021) as a strategic option to innovate not in terms of proven products and processes, but business models (Sharma et al., 2021). Business model innovation allows companies in mature sectors to reformulate their value proposition from an environmental and socio-economic perspective, turning it into a powerful new competitive advantage (Shakeel et al., 2020).

Although this is the path indicated in the literature to ensure sustainable competitive advantage for companies in mature industries, one aspect that is under-researched both from a theoretical and managerial point of view is how strategic innovation can more successfully replace product and process innovation in companies with a higher degree of operational efficiency and technological maturity, both from the point of view of their competitive position in the market and of resource management (Onufrey and Bergek, 2021). Against this background, this paper aims to fill the gap highlighted in the literature by investigating companies that manufacture ceramic tiles for buildings in European countries, particularly in Italy and Spain. For both countries, this is a mature industrial sector (Molina-Morales et al., 2019a; Settembre Blundo et al., 2019), organized into industrial districts (Hervás-Oliver et al., 2018) and characterized by intensive use of resources (Dondi et al., 2021), a high level of digitalization of processes (Ferrari et al., 2021; Molina-Morales et al., 2019b), and attention paid by companies to environmental issues (Boschi et al., 2020; Ros-Dosdá et al., 2018). According to the research aim outlined above, the following research question was posed:

RQ. *In an efficient and technologically mature industry, how can sustainability-driven strategic innovation create competitive advantage?*

The paper is structured as follows: Section 2 presents the methodology used and the related input data in order to illustrate the main results, which are presented in Section 3. Finally, Section 4 presents a discussion of the main findings, while Section 5 concludes with some final remarks.

2. Materials and methodology

The use of quantitative methods (e.g. modeling, statistics, and surveys) is generally suited to testing hypotheses or quantifying relationships (correlation). These methodologies are widely used in the social sciences, but do require further definition of the field of analysis (Sovacool et al., 2020, 2018). This study adopts a forward approach.

2.1. Study context

The ceramic tile production industries in Italy and Spain together represent an important European manufacturing sector. Despite the pandemic crisis, in 2020 the production capacity of these two industries reached 344 million square meters of tiles in Italy, and 488 million square meters in Spain. Considering that around 20 kg of natural raw materials (e.g. clays, feldspars and sands) are needed to manufacture one square meter of tiles, these two industries in Italy and Spain consumed about 6.88 and 9.76 tons of mineral resources respectively. These numbers show that the ceramic industry is a resource-intensive sector.[1] The European ceramics industry is closely related to the construction industry, which is very important to the EU economy overall.[2] Therefore, in the European manufacturing landscape, the ceramic industry of Italy and Spain can boast several distinctive best practices. In accordance with the findings of the European Commission, ceramic companies have the ability to react quickly to changes in demand and new market opportunities, are able to develop just-in-time and just-to-market services in support of their products, and are characterized by a wide diffusion of digital technologies and virtuous environmental policies, despite the use of energy-intensive and resource-intensive processes.

2.2. Definition of scenarios

The MCDA methodology aims to define which project (scenario) is performing the best (Arbolino et al., 2021; D'Adamo et al., 2020a). It

[1] https://ec.europa.eu/growth/sectors/raw-materials/industries/non-metals/ceramics_nn

[2] https://ec.europa.eu/growth/sectors/construction_en

should be noted that our goal is competitive value, and six possible projects have been identified with the potential to translate a sustainable approach into added value for companies in the ceramic sector. The six scenarios considered are:

- "Reuse and Recycle materials", in which it is highlighted how the impact of adequate end-of-life procedures is able to make waste into an input for new processes. Reuse, recycling and recovery techniques promote the transition towards a circular economy. This cannot be seen only as an alternative to the use of landfill, but requires an analysis of the entire product life cycle and continuous improvements within environmentally friendly practices.
- "Green energy", in which renewable plants are installed instead of using energy from fossil fuel sources. In some cases, it is possible for companies to become a partial or full 'prosumer', while other companies can become part of an energy community. Such initiatives make companies a key part of the green transition. Several green energy sources should be compared, considering an approach based on the entire life cycle of the source used.
- "Artificial Intelligence", which represents a great opportunity for the evolution and better exploitation of Industry 4.0 and its potential. Ceramic companies have already started the digital transformation of their processes, but a new cultural approach is required. Artificial Intelligence should promote the development of a data economy and technology infrastructure that go hand in hand with skill development, as well as the training and development of appropriate policies and regulations.
- "Human skills", which explores how business strategies that enhance human resources are able to give a proactive boost to companies. Some aspects to study are the consideration of informal factors, the optimal compromise between personal satisfaction and organizational skills, training courses to make workers an active part of the change, opportunities for professional growth and enhancement of the human component.
- "Green-circular premium", in which companies implement a green and/or circular transition while the consumer accepts a higher price as renewable resources and/or reuse/recycle/recovery/bio-based materials are used. This scenario involves capturing "under-attended" market spaces and disrupting existing ones. Therefore, the consumer will not only experience an initial increased willingness to pay for these products, but will in fact proceed to purchase them.
- "Sustainable certification", which assumes that, while sustainability is a goal of many companies, not all of them succeed in achieving it. This scenario is seen as a transparency tool that rewards truly virtuous companies. Typically, this scenario includes an eco-label that certifies the consistency of products with respect to sustainability criteria and protects against self-referential actions and greenwashing. It is assumed that eco-labels are perceived and understood correctly by consumers. Sustainability certification can be divided into two main types: corporate and product certifications. Company certifications are based on recognized standards, issued by accredited bodies and have as their object the sustainability management system for which the company wants to offer a guarantee to the market (e.g. ISO 14001 for the environment, ISO 50001 for energy, SA 8000 for social responsibility). Product certifications are designed to help distributors and consumers understand how sustainable a given item is. Among these, the Environmental Product Declaration (EPD) is very popular. This is a voluntary declaration that describes the environmental impact of a given product or service in a transparent, objective and comparable way.

2.3. Identification of experts

The identification of experts plays a key role within the MCDA-AHP methodology. Four categories of stakeholders were considered in this analysis and potential experts among district managers and academic scholars were selected from European research projects (such as Horizon 2020, Life). Financial actors and policy makers were identified via common search engines using "ceramic sector" and "sustainability" as keywords. For each category, several messages were sent by email indicating that the first five in each group would be selected and that a period of 10 years' experience was required. A total number of 20 experts was considered, which equates to around half of the invitations sent out and, for this topic, is also consistent with the literature (D'Adamo et al., 2020a). There were more male respondents than female (13 vs. 7) and experts were selected from Europe, with a prevalence of certain countries, i.e., Italy, Spain, Portugal, Germany and Poland. Expert responses were collected through two survey rounds during January–March 2021. The first round was intended to assign weightings to certain criteria, while the second aimed to define values for the alternatives for each component associated with the criteria. The interview was conducted via a video call, in which the purpose and methodology of the research was explained, an example calculation was demonstrated in both surveys, and the experts' comments on the topic were recorded.

2.4. Definition of criteria

We selected nine criteria, considering the use of AHP in subsequent phases of the work. The choice of criteria was justified considering the parameters typically proposed by the two associations of ceramic producers in Italy and Spain – Confindustria Ceramica and ASCER (Spanish Ceramic Tile Manufacturers' Association) respectively. This choice was justified because these two countries represent a reference point for the sector on a global level. Furthermore, the economic-financial parameters were assessed according to reports published annually by KPMG, in which the performance of the two ceramic districts in Spain and Italy is compared. The nine criteria are intended to cover the broadest possible spectrum of analysis and are as follows: Companies, Production, Average Selling Price, Exports, Net Profit, ROI, Employees, Staff Costs and CO_2 Emissions.

2.5. Criteria weighting assignment

The AHP model assigns a priority level to each criterion examined through the eigenvalue method. The logic behind this model is to assign higher weights to the criteria that are more relevant (Appolloni et al., 2021). AHP weights were calculated following a nine-point judgment scale (Saaty, 2008) and a normalized approach was proposed to compare different values.

AHP was applied to compare the nine different criteria, and experts were provided with an Excel file in which they could independently assess whether their judgments were reliable as a function of the consistency ratio value. A value less than 0.10 indicates consistency in the pairwise comparison matrix (Saaty, 2008). Each interviewee provided 35 responses, which were used to define a 9×9 matrix.

2.6. Criteria value assignment

Building on the nine criteria reviewed above, it was agreed to consider five dimensions into which these criteria would fall, as follows:

- Companies and Production are aggregated into "Operations".
- Average Selling Price and Exports into "Market".
- Net Profit and ROI into "Economy".
- Employees and Staff Costs into "Society".
- CO_2 Emissions into "Environment".

This model was suggested during an informal meeting that took place with four of the 20 experts in a Skype video call, one representing each category of stakeholder. It was useful to consider the respective criteria in assigning weights, while in assigning values, the identification

of the five dimensions allowed the experts to identify which dimension was most likely to influence competitiveness. The fact that the environment dimension considers only one variable does not damage its validity since, according to the limited panel of experts, the variable considered was exhaustive. Experts were offered the weights obtained from the five dimensions in the first phase of the survey and the six scenarios to consider were explained. Scores varied from 1 (worst) to 10 (best) and each expert provided 30 responses.

3. Results

3.1. AHP results

As noted in Section 2.5, the first step in the forward analysis was to identify the weighting each criterion would take, based on the assumption that sustainability can generate competitive advantage. The experts each compiled their evaluations individually, and in all cases the consistency ratio was less than 0.10. Having established, therefore, that the pairwise comparison produced consistent results, we proceeded to aggregate the various expert judgments (Fig. 1). Each expert was assigned the same relevance, and an average value was calculated for the nine criteria. Fig. 2 shows the aggregation of criteria for each dimension according to Section 2.6.

The analysis of the weights (Fig. 1) shows that CO_2 emissions (17.1%) is the criterion with the greatest relevance. However, the experts pointed out that where two criteria were present, in particular in the economic dimension, their aggregate weight was more decisive. This sector has taken fundamental steps towards environmental compliance, and these issues are therefore not new within the sector; several actions have already been taken. At the same time, both Net Profit (15.4%) and Net ROI (11.7%) are relevant because they provide different results and are useful in framing company performance. It is therefore clear that economic conditions play a key role; sustainability is also relevant to social aspects, with employees having a weight of 13.3%.

As highlighted, the comparison between the five dimensions (Fig. 2) shows an important result: the economy, with 27.1%, is firmly in first place, ahead of both the market (21.9%) and society (20.3%). This is followed by the environment (17.1%) and operations (13.6%). This result, which may appear surprising, should be contextualized within the historical timeframe in which the analysis was conducted; i.e., the pandemic period. The experts' perception of reality was therefore influenced by a greater sensitivity to issues of human health and employment security, which are reflected in the economic and social dimensions. Our data also confirms that the pandemic has lowered attention to environmental issues (Helm, 2020).

Furthermore, these results highlight the relevance of a panel of experts belonging to different stakeholder categories, as the weighting of the dimensions changes significantly under each category: the weighting of the environment ranges from 14% to 21%, society from 16% to 29%, economy from 19% to 35%, market from 16% to 27% and operations from 10% to 18%. The economy appears to be the most relevant for three of the four groups, with the only exception being among policy makers, who assign the highest relevance to society. This may be because policy makers, in times of crisis, turn their attention to the concerns of citizens/voters and are careful to maintain social harmony, which may be compromised.

3.2. Assessment of scenarios

The second step in the forward analysis, according to Section 2.6, is to assign a value to each proposed scenario. In this phase, the experience of the experts is fundamental, as they can identify which actions can lead to the achievement of certain scenarios. There is a significant difference with respect to assigning weights. In this stage, experts identified the relevance of each criterion to indicate how sustainability can be a competitive advantage. However, this means remaining on a macro level of analysis. In assigning values, we move to a micro level in which the experts must indicate the performance of these values in a specific scenario. Their expertise is then called upon to evaluate two different perspectives. Fig. 3 presents the values assigned for each of the six scenarios examined.

In the reuse and recycle materials scenario the environment leads with 7.3, followed by society (6.65). However, this perception changes depending on the stakeholder category. Academic scholars gave greater value to the environment, while policy makers gave greater value to society. On the other hand, both district managers and financial actors assigned the highest value to the market. This scenario typically arises when turning waste into a resource, but it is a well-established practice in this sector, as attested by district managers.

The green energy scenario presents generally higher values than the previous one, a sign that this sector requires action in the wake of the major change in use of renewable energy that Europe is trying to achieve. This time society (8.0) is slightly ahead of the environment (7.9). This is a snapshot of the judgment of policy makers. On the other hand, both district managers and academic scholars see the environment as the most valuable component. This judgment is significantly different from that of financial actors, who assign a more significant weight to society.

In the Artificial Intelligence scenario, unlike the previous ones, another dimension excels: this time the highest value is assigned to operations, with 8.4, driven by the judgment of district managers and

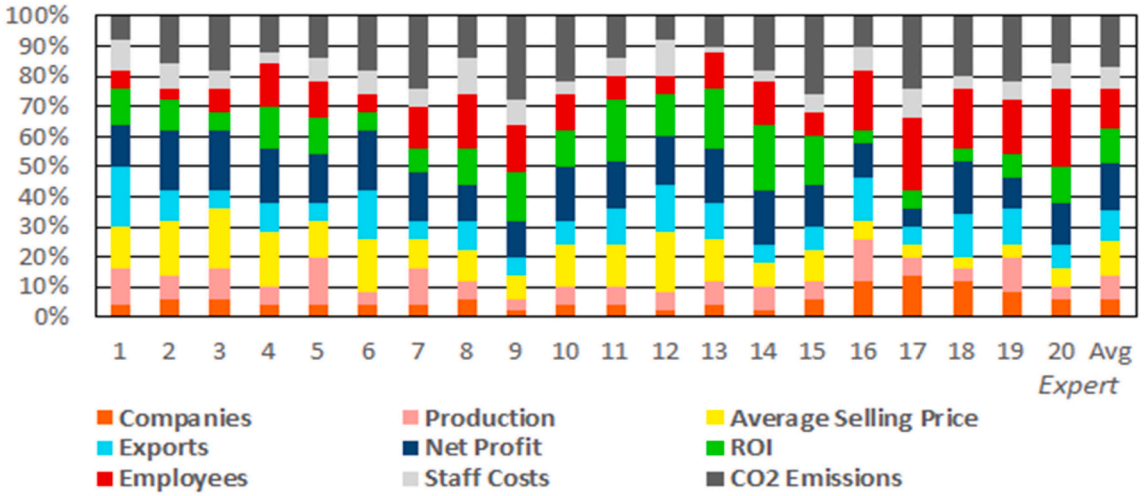

Fig. 1. Distribution of weights among the nine criteria.

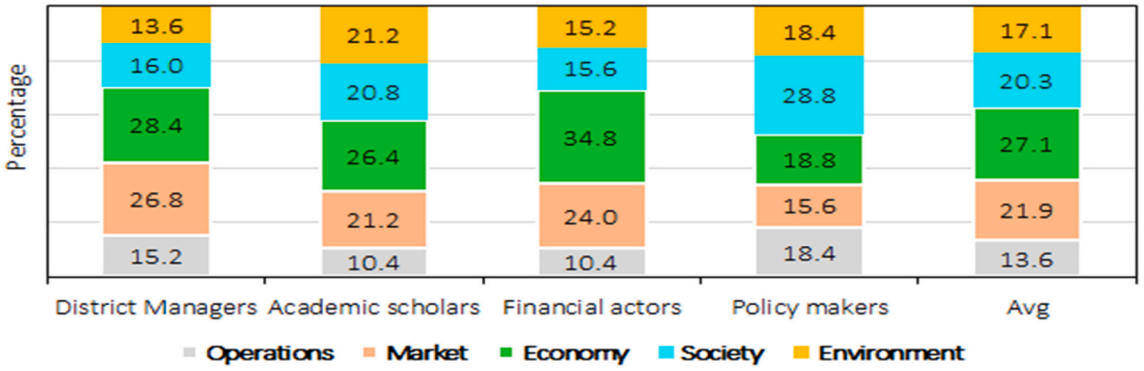

Fig. 2. Distribution of weights among the five criteria dimensions.

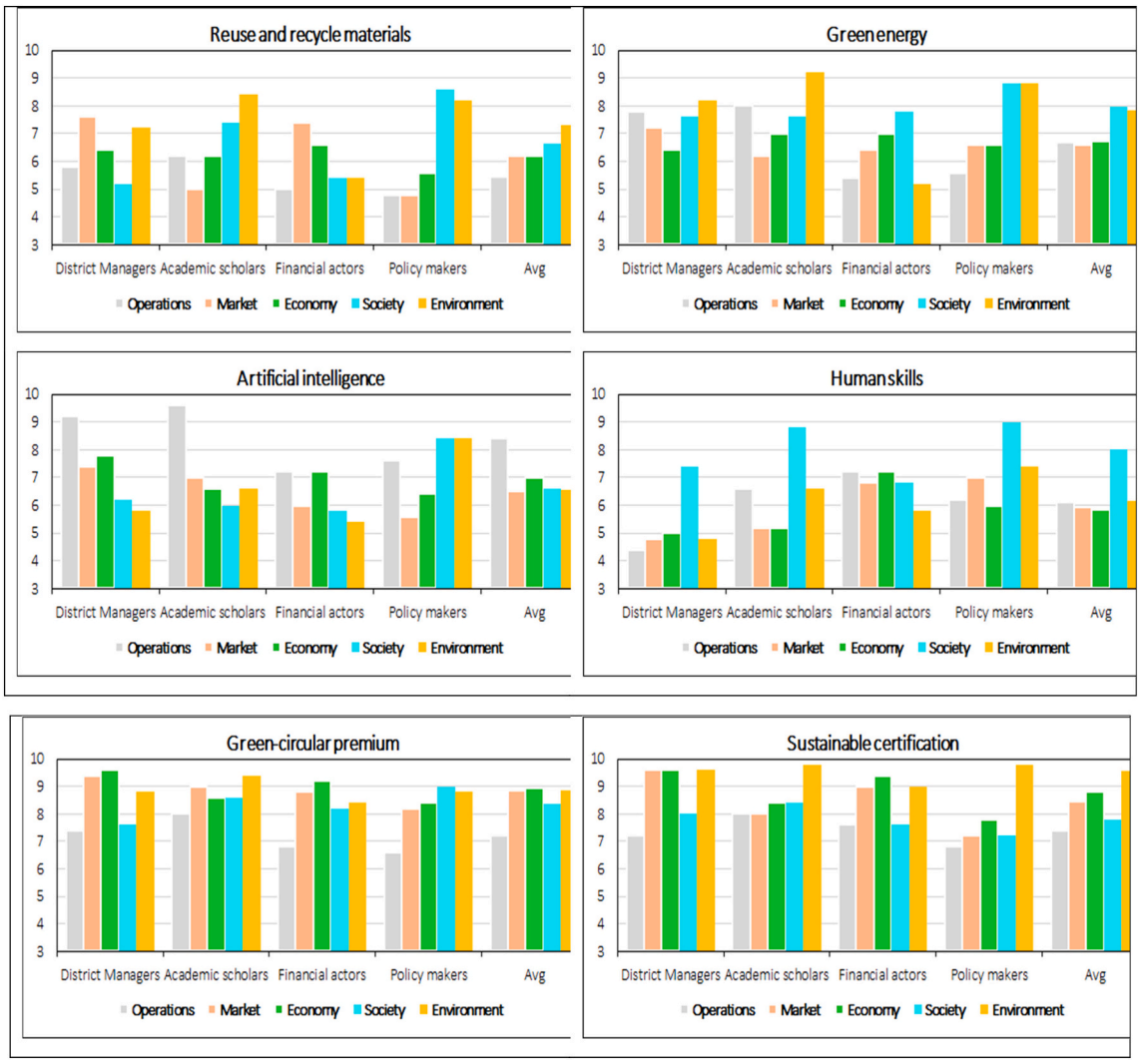

Fig. 3. Distribution of values among the five criteria dimensions.

academic scholars, outweighing the economy in particular, with its average value of 7. These two dimensions are those most identified by financial actors, while policy makers assign the highest value to society and the environment.

Continuing our analysis with the Human Skills scenario, society once again comes out on top with an average value of 8, significantly ahead of the environment, with 6.15. Even in this scenario, there is no uniformity in the experts' judgments, since the financial actors assign the highest value to operations, while all the other groups of stakeholders see society as the driving dimension.

The last two scenarios are those ones characterized by the highest overall ratings. As far as the Green-Circular Premium scenario is concerned, a dimension not found in the previous scenarios excels: economy, with 8.95, followed by market and environment with 8.85. District managers and financial actors drove this result, whereas academic scholars preferred to assign importance to the environment and policy

makers to society.

Finally, the Sustainable certification scenario sees the environment excel, with an average value of 9.55, followed by the economy with 8.8. This scenario confirms what was shown in all the other scenarios – there is no single vision among experts, as the different groups provide different values. The environment is considered fundamental to performance by academic scholars and policy makers. District managers assigned the highest value to two other dimensions – market and economy – while financial actors placed economy in first place.

3.3. MCDA-AHP results

The final step in the integrated MCDA-AHP analysis involves aggregating the weights and values obtained in the previous steps. Fig. 4 compares the six different scenarios analyzed in this work, varying from a potential minimum value of 1 to a maximum of 10, and representing one of the objectives of this work. On the other hand, Fig. 5 expresses the results as a function of size, meaning that no specific reference values can be identified. This comparison allows us to evaluate the impact of the values and of the different alternative scenarios (Fig. 3) with respect to the assignment of weights alone (Fig. 2).

The results show that two of our scenarios dominate, not only occupying the top two positions in the ranking but having a very significant value, such that sustainability is an enabler for competitive advantage. The Green-circular premium scenario presents a final value of 8.52, and this result derives mainly from the economic dimension (equal to 2.43), followed by the market. The experts consulted have, therefore, concluded that economic factors, compared to the others considered, are those with the greatest relevance from a macro perspective. However, when they then analyzed the individual scenarios, they assigned lower values. In fact, there may be some uncertainty here, in that the absence of supporting analysis does not allow a micro perspective to assign such relevance. However, the aggregation of the macro and micro perspectives confirms the economy as the dominant dimension in almost all the other scenarios. In the Green-circular premium scenario we find a difference of 0.51 with respect to the next ranked factor, with this figure being 0.56 in the Sustainable certification scenario. This scenario has a final value of 8.43, with an economic dimension value of 2.38, followed by the market aspect. The Green-circular premium scenario is therefore perceived as succeeding in applying as many green practices as circular ones, but emphasis is given to consumers (B2C market) or companies (B2B market) that are willing to recognize the economic value in the different inputs of resources used in management practices, the operational phase, and the end-of-life cycle. Competitive advantage could not be achieved if this was not perceived by the user. Similar perspectives can be found in Sustainable certification, but this scenario calls for additional effort (certification activities) in order to convey to the final consumer the procedures that have been adopted. In reality, the consumer remains relevant in this scenario, as it is assumed that he/she recognizes such certification as representing the actual implementation of certain procedures. The conjunction between these two scenarios therefore appears to be the strategy that firms in the sector are called upon to implement.

The other four scenarios present a more significant difference in terms of overall value but are still interesting for achieving the goal of sustainability. We can therefore examine the significant potential of each scenario. The Green energy scenario has a final value of 7.12, with the economic dimension equal to 1.83, and this time it is followed by society, with 1.61. Renewable energy therefore requires a new social approach, in which all stakeholders are called to be part of this change. This transition requires a change of gear in the approach towards decentralized models of energy. Next, we find the Artificial Intelligence scenario, with an overall value of 6.90, with the largest factor being the economic component with 1.90, followed, as in the first two scenarios, by the market, with 0.49. Industry 4.0 innovation characterizes this sector, as well as sustainable good practices. The key strength that emerges from the analysis is the dynamic approach that, unlike a static approach, prompts the sector to be sensitive to changes coming from the outside world, and to transform challenges into opportunities. Artificial Intelligence requires additional effort, as well as the ability to harmonize the use of data, keep cyber risks low and be more efficient (Ameen et al., 2021).

The last two positions in the ranking are occupied by the Human skills scenario and the Reuse and recycle materials scenario, with overall values of 6.38 and 6.36 respectively. The first of these two scenarios is the only one in which it is not the economic component that excels (1.59), but rather society (1.62). The field of human relations has placed importance on informal factors, and the process of change to face the new global challenges requires personnel who are qualified and motivated to perform their crucial tasks. The Reuse and recycle materials scenario prioritizes the economic component, with a value of 1.68, and this rating should not be read as implying a lack of attention to circular practices. In fact, this sector already utilizes these among its good practices, and this is therefore not the strategy identified to make a qualitative leap. This set of values is useful to us in a forward analysis in order to identify strategies to implement. Competitive advantage requires the contribution of all components and these results identify that both operations and the environment have a perception of being already known in the industry, while extreme emphasis is given to the economic perspective, which is called on to highlight the advantages, opportunities, and new frontiers to be explored. Following this pattern, social change, as well as the market, must also be investigated, because new

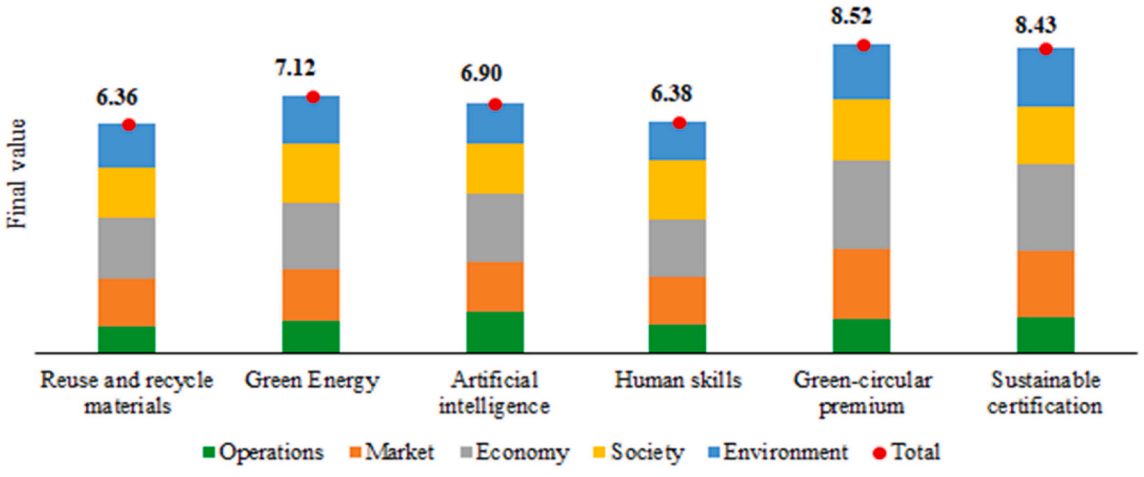

Fig. 4. Assessment of competitiveness as a function of the final value of the six scenarios.

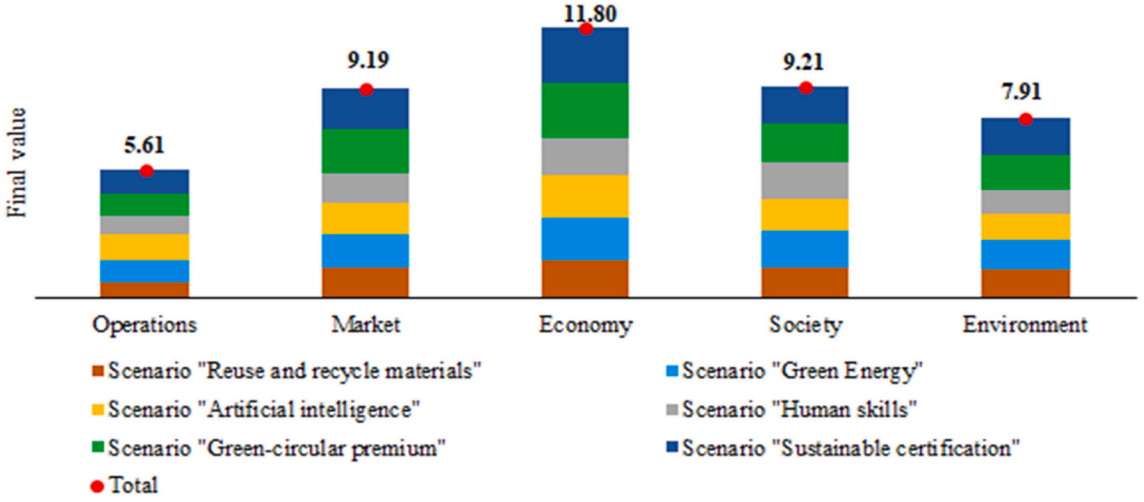

Fig. 5. Assessment of competitiveness as a function of the final value of the five dimensions.

messages must be conveyed to the public, and new needs must be understood. Even in sectors such as the ceramics industry, where the most innovative technology is readily available to all regional operators, the strategic options for defending and increasing competitiveness can be diverse. A sector that is already performing at a high level operationally, and has already achieved an excellent level of eco-efficiency, should focus its resources on projects that are truly eco-effectiveness-oriented (Borrello et al., 2020); hence the recommendation of circular economy actions as strategies to differentiate from competitors in emerging countries that are less sensitive to sustainability issues.

This work, in accordance with the prior literature (Colasante and D'Adamo, 2021), proposes the concept of the green-circular premium. The value of the circular premium is an essential component of the green premium, and may even coincide in value. The difference between these terms is similar to the difference between the terms circular economy and green economy: the circular economy includes the benefits associated with waste management, waste prevention and resource efficiency, while the green economy also includes human well-being and ecosystem resilience.

4. Discussion

The EU's most recent policies aim to make European industry and businesses more competitive and to promote job creation and economic growth by creating an environment favorable to economic activity, particularly for the manufacturing industry. In addition, the EU recognizes that the keys to Europe's economic recovery are competitiveness, innovation and entrepreneurship, and that Europe's long-term economic prosperity will depend on the strength of its industrial base, not just its financial and service sectors.[3]

The manufacturing sector contains a variety of different sectors within it, and this study aimed to focus on a mature sector from a technological point of view. In particular, our considerations relate to European manufacturers, which are characterized by particularly stringent regulations, as opposed to non-European manufacturers. It emerges that Italian and Spanish industrial districts, foremost among European markets, have effectively combined factory digitalization with environmental sustainability practices. However, in order for sustainability to become a competitive advantage, market recognition in terms of premium price is necessary.

In this regard, the results obtained from the mixed MCDA are highly significant and suggestive. All the proposed scenarios are considered interesting, but among them there are two in particular that stand out. Green-circular premium and Sustainability certification are seen as enabling approaches to leverage sustainability as an effective factor of competitive advantage. In fact, these two approaches have common characteristics, as both start from the already consolidated sustainable practices that some European (in particular Italian and Spanish) companies have implemented. Another aspect that emerges from this study is that such processes are already strongly characterized by elements of circularity and that potential improvements are identified in terms of the use of renewable energy. However, the effort that needs to be made by companies is to understand if and how much the consumer is willing to recognize this commitment of producers, both for the circular and green dimensions. One option could be to find appropriate solutions to create greater consumer awareness, so that consumers' sensitivity to sustainability issues also translates into consistent purchasing behavior. This result can only be achieved through the design and implementation of targeted marketing strategies to enhance the sustainability attributes associated with ceramic products. To this end, strong cooperation with the distribution channel is necessary, given the distance, not only physical but also cognitive, between manufacturer and consumer. This step should not be underestimated, because it requires a real social change. In fact, for the marketing strategy to be successful, it is necessary to break down the competitive boundaries between manufacturing companies, suppliers and distributors, to define new business models in which methods of creating and sharing environmental, economic and social value are defined. Within this shift, attention must then be paid to the different markets and potential new customers that can be acquired in emerging economies.

The experts consulted pointed out that a further step of analysis is to propose not only the concept of a Green-circular premium but that of a Green-social-circular premium, because it is thanks to social change that sustainability will be seen not only as a brand or as a lifeline in the face of climate change, but as an effective development of civil society.

Certification also represents a system of traceability and transparency, based on objective and quantitative data verified by independent authorities. The current system of environmental and social certification is not exploited to its full potential. The complexity of these documents makes information difficult to use, especially for consumers. As a direct consequence, producers and distributors limit themselves to certifying the existence (or lack thereof) of product and process certifications, without investigating or exploiting the information content they provide. A solution to address the criticality of accessibility to

[3] Szczepański, M., & Zachariadis, I. (2019). EU industrial policy at the crossroads. Current state of affairs, challenges and way forward. European Parliamentary Research Service, doi:https://doi.org/10.2861/801636QA-03-19-905-EN-N

environmental and social data could be to assign a scale of performance divided into classes, such as already happens in the energy rating of household appliances. In addition, the path towards greater competitiveness of companies could be strengthened by taking advantage of Artificial Intelligence to reduce cyber risks associated with the digitization of processes. In fact, Industry 4.0 technologies, while offering undeniable advantages, also carry the risk of sharing sensitive industrial data with technology providers that remotely control equipment. Finally, the ceramics sector devotes great attention and sensitivity to human capital and human skills. This result was not unexpected given how much widely this is known, as the districts in which these business operate are small social communities with much cohesion between them.

The results of this research show how, even in a sector that is technologically mature but still open to innovation, social change has always been one of the components of sustainability, as it is an innate characteristic of the social dimension of these districts, which characterizes both Italian and Spanish companies. This demonstrates that this dimension, similarly to the technological and environmental dimensions, can also contribute to the creation of an effective competitive advantage. This will play a key role in the transformation of industrial organization towards sustainable goals.

The pandemic period has caused an extraordinary socio-economic shock, and the European Union (EU), by means of the Next Generation EU, aims not only to mitigate its negative effects, but also to outline future scenarios in which companies can be globally competitive while ensuring the welfare of the societies in which they operate. In fact, it is undeniable that some economies, especially emerging ones, do not leverage the social factors of sustainability by operating under poor working conditions. In addition, European and/or local regulations should take greater account of the globalism of markets in order to ensure that those production systems that comply with strict environmental and social safety protocols are not penalized as a result of regulations. Where this is not ensured, it leads to higher costs for companies, loss of competitiveness, and market distortions. Currently, several countries provide subsidies for the implementation of circular, green and digital policies, and a further effort could be made to differentiate taxation according to the class of sustainability certification achieved. This incentive could be distributed along the value chain both to producers and consumers, for example by acting on the VAT rate. In this way, the cost of the green-circular premium would be partly financed by states.

5. Conclusions

This MCDA-based work is able to provide a forward-looking approach applied to a mature industry characterized by both technological and environmental evolution. It is therefore not surprising that among the dimensions considered, these are ranked lower. It is the economic dimension that prevails, a result perhaps associated with the pandemic period in which the analysis was conducted, but also the consideration that sustainability is a broader concept than an exclusively environmental approach. It is also worth highlighting that the market and social dimensions were found to be highly significant. Another advantage of our framework is that it involved different categories of stakeholders, who provided several weights and values for the alternatives analyzed.

Originally, our results show that the Green-circular premium and Sustainability certification scenarios, with final values of 8.52 and 8.43 respectively, are able to promote sustainability as a competitive advantage. In addition, the other scenarios are also relevant: Green energy (7.12), Artificial Intelligence (6.90), Human skills (6.38) and Reuse and recycle materials (6.36). Starting from these assessments, we have identified policies capable of implementing these strategies, strengthening the competitiveness of the two districts without jeopardizing their consolidated social cohesion and the economic wellbeing of the territories.

The competitiveness of the sector, the challenges of globalization and the economic crisis generated by the pandemic period have all forced companies to address new challenges. The evaluation of the link between technology and industrial organization can be viewed as being oriented to meet the needs of customers or to the protection of ecosystems. In this framework, stakeholders' assessment becomes crucial. The results of this work have shown that social change consists in an understanding of the efforts that a company makes, and this effort cannot be limited only to the consumer. Both the Green-circular premium and Sustainability certification complement the concept of sustainability by extending the two environmental and economic dimensions into the social dimension.

These two practices represent strategic innovation in order to make companies in this sector more competitive, as they cannot rely solely on product and process innovation. This challenge is complex because it requires a transversal change that concerns entrepreneurship, management and industrial policies. In this transformation, consumers, if they adopt responsible behavior towards the purchase of sustainable products, contribute to the creation of shared value between producers, consumers and society.

This framework has the potential to be applicable to other districts and other sectoral analyses. However, this work also has some limitations, such as the lack of comparison of the scenarios analyzed in different markets where less stringent regulation is observed. Moreover, it is appropriate to measure the propensity of consumers to accept the Green-circular premium. Finally, the value given to the certification of a product in consumers' choices should be ascertained.

Sustainability can be seen as the integrative factor between technological innovation and social equity. This final message highlights that this work does not only aim to assist the achievement of SDG 12 "Sustainable Production and Consumption", as it embraces several spheres. Sustainability itself is a broad concept, which involves the interaction of a number of indicators that are associated with several different SDGs. This work presents a framework in which different aspects interact, placing sustainability not as a single goal to be achieved, but as the business approach that represents the greenest means for a future society based on shared social values. In addition to this, the results of this study also provide managerial implications for companies not belonging to mature sectors. Companies currently relying on proven technologies may be unlikely to implement radical process and product innovation strategies. They may, however, design and adopt organizational innovation strategies to steer the firm increasingly towards good sustainability practices. This means identifying new ways of creating and capturing the value generated in the supply chain or, expressed in another way, innovatively transforming their business models from traditional to sustainable.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The authors declare no conflict of interest.

References

Adebayo, T.S., Coelho, M.F., Onbaşıoğlu, D.Ç., Rjoub, H., Mata, M.N., Carvalho, P.V., Rita, J.X., Adeshola, I., 2021. Modeling the dynamic linkage between renewable energy consumption, globalization, and environmental degradation in South Korea: does technological innovation matter? Energies 14, 4265. https://doi.org/10.3390/en14144265.

Ameen, N., Tarhini, A., Shah, M.H., Madichie, N., Paul, J., Choudrie, J., 2021. Keeping customers' data secure: a cross-cultural study of cybersecurity compliance among the Gen-Mobile workforce. Comput. Hum. Behav. 114, 106531 https://doi.org/10.1016/j.chb.2020.106531.

Appolloni, A., D'Adamo, I., Gastaldi, M., Santibanez-Gonzalez, E.D.R., Settembre-Blundo, D., 2021. Growing e-waste management risk awareness points towards new recycling scenarios: the view of the Big Four's youngest consultants. Environ. Technol. Innov. 23, 101716 https://doi.org/10.1016/j.eti.2021.101716.

Arasti, M., Khaleghi, M., Noori, J., 2017. Corporate-level technology strategy and its linkage with corporate strategy in multi-business companies: IKCO case study. Technol. Forecast. Soc. Chang. 122, 243–252. https://doi.org/10.1016/j.techfore.2016.02.013.

Arbolino, R., Boffardi, R., De Simone, L., Ioppolo, G., 2021. Multi-objective optimization technique: a novel approach in tourism sustainability planning. J. Environ. Manag. 285, 112016 https://doi.org/10.1016/j.jenvman.2021.112016.

Berggren, C., Magnusson, T., Sushandoyo, D., 2015. Transition pathways revisited: established firms as multi-level actors in the heavy vehicle industry. Res. Policy 44, 1017–1028. https://doi.org/10.1016/j.respol.2014.11.009.

Borrello, M., Pascucci, S., Cembalo, L., 2020. Three propositions to unify circular economy research: a review. Sustainability 12, 4069. https://doi.org/10.3390/su12104069.

Boschi, G., Masi, G., Bonvicini, G., Bignozzi, M.C., 2020. Sustainability in Italian ceramic tile production: evaluation of the environmental impact. Appl. Sci. 10, 9063. https://doi.org/10.3390/app10249063.

Cheng, C., Ren, X., Wang, Z., Yan, C., 2019. Heterogeneous impacts of renewable energy and environmental patents on CO2 emission - evidence from the BRIICS. Sci. Total Environ. 668, 1328–1338. https://doi.org/10.1016/j.scitotenv.2019.02.063.

Chiappetta Jabbour, C.J., Seuring, S., de Sousa, Lopes, Jabbour, A.B., Jugend, D., De Camargo Fiorini, P., Latan, H., Izeppi, W.C., 2020. Stakeholders, innovative business models for the circular economy and sustainable performance of firms in an emerging economy facing institutional voids. J. Environ. Manag. 264, 110416 https://doi.org/10.1016/j.jenvman.2020.110416.

Colasante, A., D'Adamo, I., 2021. The circular economy and bioeconomy in the fashion sector: emergence of a "sustainability bias". J. Clean. Prod. 329, 129774 https://doi.org/10.1016/j.jclepro.2021.129774.

D'Adamo, I., Falcone, P.M., Imbert, E., Morone, P., 2020a. A socio-economic indicator for EoL strategies for bio-based products. Ecol. Econ. 178, 106794 https://doi.org/10.1016/j.ecolecon.2020.106794.

D'Adamo, I., Gastaldi, M., Rosa, P., 2020b. Recycling of end-of-life vehicles: assessing trends and performances in Europe. Technol. Forecast. Soc. Chang. 152, 1–14. https://doi.org/10.1016/j.techfore.2019.119887.

D'Amato, D., Korhonen, J., 2021. Integrating the green economy, circular economy and bioeconomy in a strategic sustainability framework. Ecol. Econ. 188, 107143 https://doi.org/10.1016/j.ecolecon.2021.107143.

De Guimarães, J.C.F., Dorion, E.C.H., Severo, E.A., 2020. Antecedents, mediators and consequences of sustainable operations. Benchmarking An Int. J. 27, 2189–2212. https://doi.org/10.1108/BIJ-09-2018-0296.

Diaz Lopez, F.J., Bastein, T., Tukker, A., 2019. Business model innovation for resource-efficiency, circularity and cleaner production: what 143 cases tell us. Ecol. Econ. 155, 20–35. https://doi.org/10.1016/j.ecolecon.2018.03.009.

Dondi, M., García-Ten, J., Rambaldi, E., Zanelli, C., Vicent-Cabedo, M., 2021. Resource efficiency versus market trends in the ceramic tile industry: effect on the supply chain in Italy and Spain. Resour. Conserv. Recycl. 168, 105271 https://doi.org/10.1016/j.resconrec.2020.105271.

Fernando, Y., Chiappetta Jabbour, C.J., Wah, W.-X., 2019. Pursuing green growth in technology firms through the connections between environmental innovation and sustainable business performance: does service capability matter? Resour. Conserv. Recycl. 141, 8–20. https://doi.org/10.1016/j.resconrec.2018.09.031.

Ferrari, A.M., Volpi, L., Settembre-Blundo, D., García-Muiña, F.E., 2021. Dynamic life cycle assessment (LCA) integrating life cycle inventory (LCI) and Enterprise resource planning (ERP) in an industry 4.0 environment. J. Clean. Prod. 286, 125314 https://doi.org/10.1016/j.jclepro.2020.125314.

García-Muiña, F., Medina-Salgado, M.S., González-Sánchez, R., Huertas-Valdivia, I., Ferrari, A.M., Settembre-Blundo, D., 2021. Industry 4.0-based dynamic social organizational life cycle assessment to target the social circular economy in manufacturing. J. Clean. Prod. 327, 129439 https://doi.org/10.1016/j.jclepro.2021.129439.

Gebauer, H., Worch, H., Truffer, B., 2012. Absorptive capacity, learning processes and combinative capabilities as determinants of strategic innovation. Eur. Manag. J. 30, 57–73. https://doi.org/10.1016/j.emj.2011.10.004.

Goto, M., Sueyoshi, T., 2020. Sustainable development and corporate social responsibility in Japanese manufacturing companies. Sustain. Dev. 28, 844–856. https://doi.org/10.1002/sd.2035.

Gusheva, E., de Gooyert, V., 2021. Can we have our cake and eat it? A review of the debate on green recovery from the COVID-19 crisis. Sustainability 13, 874. https://doi.org/10.3390/su13020874.

Helm, D., 2020. The environmental impacts of the coronavirus. Environ. Resour. Econ. 76, 21–38. https://doi.org/10.1007/s10640-020-00426-z.

Hervás-Oliver, J.-L., Albors-Garrigos, J., Estelles-Miguel, S., Boronat-Moll, C., 2018. Radical innovation in Marshallian industrial districts. Reg. Stud. 52, 1388–1397. https://doi.org/10.1080/00343404.2017.1390311.

Hristov, I., Appolloni, A., Chirico, A., Cheng, W., 2021. The role of the environmental dimension in the performance management system: a systematic review and conceptual framework. J. Clean. Prod. 293, 126075 https://doi.org/10.1016/j.jclepro.2021.126075.

Kienzler, M., Kowalkowski, C., 2017. Pricing strategy: a review of 22years of marketing research. J. Bus. Res. 78, 101–110. https://doi.org/10.1016/j.jbusres.2017.05.005.

Lahcen, B., Brusselaers, J., Vrancken, K., Dams, Y., Da Silva Paes, C., Eyckmans, J., Rousseau, S., 2020. Green recovery policies for the COVID-19 crisis: modelling the impact on the economy and greenhouse gas emissions. Environ. Resour. Econ. 76, 731–750. https://doi.org/10.1007/s10640-020-00454-9.

Lee, J., Hwang, J., Kim, H., 2022. Different government support effects on emerging and mature ICT sectors. Technol. Forecast. Soc. Chang. 174, 121253 https://doi.org/10.1016/j.techfore.2021.121253.

Molina-Morales, F.X., Martínez-Cháfer, L., Valiente-Bordanova, D., 2019a. Different paths to achieve high technological innovation in clustered firms: an analysis of the Spanish ceramic tile industry. Appl. Sci. 9, 3710. https://doi.org/10.3390/app9183710.

Molina-Morales, F.X., Martínez-Cháfer, L., Valiente-Bordanova, D., 2019b. Disruptive technology adoption, particularities of clustered firms. Entrep. Reg. Dev. 31, 62–81. https://doi.org/10.1080/08985626.2018.1537147.

Ndubisi, N.O., Zhai, X. (Amy), Lai, K., 2021. Small and medium manufacturing enterprises and Asia's sustainable economic development. Int. J. Prod. Econ. 233, 107971 https://doi.org/10.1016/j.ijpe.2020.107971.

Onufrey, K., Bergek, A., 2021. Transformation in a mature industry: the role of business and innovation strategies. Technovation 105, 102190. https://doi.org/10.1016/j.technovation.2020.102190.

Ponce, P., Alvarado, Rafael, Ponce, K., Alvarado, Raquel, Granda, D., Yaguana, K., 2019. Green returns of labor income and human capital: empirical evidence of the environmental behavior of households in developing countries. Ecol. Econ. 160, 105–113. https://doi.org/10.1016/j.ecolecon.2019.02.012.

Raj, A., Dwivedi, G., Sharma, A., de Sousa, Lopes, Jabbour, A.B., Rajak, S., 2020. Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: an inter-country comparative perspective. Int. J. Prod. Econ. 224, 107546 https://doi.org/10.1016/j.ijpe.2019.107546.

Rehman, S.U., Kraus, S., Shah, S.A., Khanin, D., Mahto, R.V., 2021. Analyzing the relationship between green innovation and environmental performance in large manufacturing firms. Technol. Forecast. Soc. Chang. 163, 120481 https://doi.org/10.1016/j.techfore.2020.120481.

Ros-Dosdá, T., Celades, I., Monfort, E., Fullana-i-Palmer, P., 2018. Environmental profile of Spanish porcelain stoneware tiles. Int. J. Life Cycle Assess. 23, 1562–1580. https://doi.org/10.1007/s11367-017-1377-9.

Saaty, T.L., 2008. Decision making with the analytic hierarchy process. Int. J. Serv. Sci. 1, 83–98. https://doi.org/10.1504/IJSSCI.2008.017590.

Savin, I., Drews, S., van den Bergh, J., 2021. Free associations of citizens and scientists with economic and green growth: a computational-linguistics analysis. Ecol. Econ. 180, 106878 https://doi.org/10.1016/j.ecolecon.2020.106878.

Serrano-García, J., Bikfalvi, A., Llach, J., Arbeláez-Toro, J.J., 2021. Orchestrating capabilities, organizational dimensions and determinants in the pursuit of green product innovation. J. Clean. Prod. 313, 127873 https://doi.org/10.1016/j.jclepro.2021.127873.

Settembre Blundo, D., García-Muiña, F.E., Pini, M., Volpi, L., Siligardi, C., Ferrari, A.M., 2019. Sustainability as source of competitive advantages in mature sectors. Smart Sustain. Built Environ. 8, 53–79. https://doi.org/10.1108/sasbe-07-2018-0038.

Shakeel, J., Mardani, A., Chofreh, A.G., Goni, F.A., Klemeš, J.J., 2020. Anatomy of sustainable business model innovation. J. Clean. Prod. 261, 121201 https://doi.org/10.1016/j.jclepro.2020.121201.

Sharma, H.B., Vanapalli, K.R., Samal, B., Cheela, V.R.S., Dubey, B.K., Bhattacharya, J., 2021. Circular economy approach in solid waste management system to achieve UN-SDGs: solutions for post-COVID recovery. Sci. Total Environ. 800, 149605 https://doi.org/10.1016/j.scitotenv.2021.149605.

Shaw, C., Nerlich, B., 2015. Metaphor as a mechanism of global climate change governance: a study of international policies, 1992–2012. Ecol. Econ. 109, 34–40. https://doi.org/10.1016/j.ecolecon.2014.11.001.

Song, J., Chutani, A., Dolgui, A., Liang, L., 2021. Dynamic innovation and pricing decisions in a supply-chain. Omega 103, 102423. https://doi.org/10.1016/j.omega.2021.102423.

Sovacool, B.K., Axsen, J., Sorrell, S., 2018. Promoting novelty, rigor, and style in energy social science: towards codes of practice for appropriate methods and research design. Energy Res. Soc. Sci. 45, 12–42. https://doi.org/10.1016/j.erss.2018.07.007.

Sovacool, B.K., Martiskainen, M., Hook, A., Baker, L., 2020. Beyond cost and carbon: the multidimensional co-benefits of low carbon transitions in Europe. Ecol. Econ. 169, 106529 https://doi.org/10.1016/j.ecolecon.2019.106529.

TenBrink, C., Gelb, B., 2017. When firms mature: keeping the ho-hum at bay and embracing change. J. Bus. Strateg. 38, 12–17. https://doi.org/10.1108/JBS-07-2016-0079.

Varadarajan, R., 2018. Innovation, innovation strategy, and strategic innovation. In: Innovation and Strategy, Review of Marketing Research. Emerald Publishing Limited, pp. 143–166. https://doi.org/10.1108/S1548-643520180000015007.

Vrchota, J., Pech, M., Rolínek, L., Bednář, J., 2020. Sustainability outcomes of green processes in relation to industry 4.0 in manufacturing. Syst. Rev. Sustain. https://doi.org/10.3390/su12155968.

Waheed, A., Zhang, Q., Rashid, Y., Tahir, M.S., Zafar, M.W., 2020. Impact of green manufacturing on consumer ecological behavior: stakeholder engagement through green production and innovation. Sustain. Dev. 28, 1395–1403. https://doi.org/10.1002/sd.2093.

Yin, S., Zhang, N., Li, B., 2020. Enhancing the competitiveness of multi-agent cooperation for green manufacturing in China: an empirical study of the measure of green technology innovation capabilities and their influencing factors. Sustain. Prod. Consum. 23, 63–76. https://doi.org/10.1016/j.spc.2020.05.003.