

Twin Green and Digital Innovation by SMEs in the Construction Sector

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Abstract: The Twin green and digital innovation is a fundamental element of the European SME Strategy and European Green Deal. While larger corporations have initiated a transition towards more sustainable and data-driven business, only a limited part of SMEs in Europe are actively investing in Twin innovation. Most SMEs presume elevated costs of Twin innovation and are unaware of the potential impact on their business performance. The study describes a usable generic framework to analyse the Twin innovation options, the impact on business performance and a roadmap for implementation by SMEs in the construction sector. The paper offers practical tools for SME owners and directors seeking to engage in Twin innovation. The findings are also relevant for other researchers in this field interested to gain a better understanding of twin innovation, as well as policy makers who seek to steer support programs towards innovation in SMEs.

Keywords: twin green and digital innovation, twin innovation, SMEs, construction sector

1. General introduction

Green and digital innovation represent two leading but still separated trends that are shaping the transformation of business and hitherto mainly adopted by larger corporations as an answer to the pressure from internal and external stakeholders (Martins *et al.*, 2022). The combination of digital and green innovation of business is a more recent approach to achieve long term transformation of business and the society at large towards a more competitive and sustainable future. The twin green and digital innovation (hereafter indicated as Twin innovation) has recently been marked as a priority for European business (Muench *et al.*, 2022). The twin seeks to achieve a climate-neutral, resource-efficient, and agile digital economy at the level of European SMEs across industrial sectors (European Union, 2022).

SMEs will have to catch up with Twin innovation due to a combination of increasing pressure from different stakeholders including government, corporate clients and increasingly customers. Where larger companies invest in Twin innovation, SMEs are lagging behind as it is seen as complicated and sometimes considered as competing transitions (Muench *et al.*, 2022). SMEs are facing a number of challenges to invest in Twin innovations including a lack of general knowledge about relevant Twin innovation options, high costs and a perceived lack of impact on business performance (George, Merrill and Schillebeeckx, 2021). It is indicated that research focuses on Twin innovation in public sectors and larger companies, research on SMEs is very limited. Similarly, there is limited literature on the impact of digital technologies on green innovation by SMEs (George, *et al.*, 2022). In this context, this article seeks to identify a framework to identify relevant Twin innovation options for SMEs, to analyse their impact on business performance and to define a roadmap for its implementation in the construction sector.

2. Literature review

2.1 SMEs and green and digital innovation

Small and Medium Business (SMEs) play a central part in the challenges Europe is facing given their overall contribution to European production and employment. SMEs represent over 99% of all companies in the European Union, generate 57% of value added and generate 67% of employment. SMEs account for 99.8% of the total number of enterprises and 66.6% of total EU employment (European Commission, 2020). SMEs play a large role in their region at community level and can thereby have an important contribution to a greener production pattern in Europe. As key actors SMEs are essential to build a more sustainable economy (Martins *et*

al., 2022). However, SMEs have limited knowledge and resources for structural innovation (PWC, 2022; Szewieczek *et al.*, 2022).

From an environmental perspective, SMEs are to embark on green innovation to diminish their environmental impact. SMEs have a significant share in the deteriorating environment in most environmental processes including the combat in climate change and environmental degradation caused by higher concentrations of carbon dioxide, methane and nitrous oxide, biodiversity loss, and ocean acidification, changes in freshwater consumption and land use for commercial exploitation and chemical pollution (Muench *et al.*, 2022). The emission of carbon dioxide by SMEs alone represents 63% of all emissions by companies in Europe (European Union, 2022). Although data are scarce, a study indicates that SMEs represent around 36% of energy use in the UK, most of which is based on fossil energy sources (Blundel, 2022). SMEs are main actors in the European road transport sector and still dependent on fossil fuels. Related to the green transition, Blundel has stated that SMEs are central, but widely-neglected actors in the Net Zero transition (Blundel, 2022).

Digital innovation, referring to the adoption of digital technologies and data by companies to improve business performance is also highly relevant to SMEs (Muller *et al.*, 2021). Research indicates that they can provide broad benefits for SMEs in terms of better access to skills and talent, productivity and competitiveness, finance, product development and markets (Ramdani, Raja and Kayumova, 2021). These tools are perceived as of strategic value to market expansion and internationalisation (Coronel, 2020; Falco, 2020). Emerging digital technologies or Industry 4.0 can have a large impact on products, processes, customer experience and the overall business model (Bär, Lee Hansen and Khalid, 2018; European Commission, 2021). Scuotto (2017) has shown that digitalisation is highly instrumental in new product development. Others have shown the most impact of digital transformation on customer satisfaction (Balan and Feng, 2019).

2.2 Current status of Twin innovation in SMEs

The Twin green and digital innovation was adopted as a new concept by the European Union as part of its European SME Strategy and the European Green Deal (European Commission, 2021). Next to the need for digitalisation in general, SMEs are required to embrace the adoption of digital technologies and data to be able to demonstrate and measure the environmental footprint of their business activities. Twin innovation creates important opportunities to create additional value to SMEs. Green innovation combined with digital tools to analyse emission levels can generate competitive advantages in material usage and production processes and create new markets for green products and services (George *et al.*, 2021).

However, a recent survey (European Union, 2022) indicates that most SMEs in Europe take limited and isolated actions to reduce resource usage, some with support of basic digital tools. Only 25% of SMEs in Europe have a strategy to reduce their carbon dioxide emissions and 4% indicate that they are carbon neutral. Next to green innovation, digital technologies and capabilities can act as a catalyst and create synergies for green innovation processes and products through optimization of processes, monitoring and tracking of resources and virtualisation of green products and services (Muench *et al.*, 2021). Despite the overall potential impact of digitalisation, there is still a clear gap between the level of digitalisation of both basic and emerging digital technologies among SMEs and larger companies. A recent study of PWC shows that SMEs have a significant gap in digital transformation even in basic technologies such as E-commerce, cloud computing, ERP or big data analysis (PWC, 2022).

Despite the increased attention for resource efficiency, investment by SMEs in green measures and technology is still limited (European Union, 2022). SMEs face important barriers to Twin innovation including a perceived lack of benefits and the impact of both green and digital solutions on business performance (Szewieczek *et al.*, 2022). Earlier studies indicate that SME business owners are mostly reactive as they see environmental measures as costly and affecting competitiveness without providing tangible benefits (Studer, Welford and Hill, 2006). Another obstacle is found in the lack of internal environmental and digital expertise, with only 15% of small companies and 42% of mid-sized companies compared with 75% of larger companies (Muller *et al.*, 2021). SME capabilities are insufficient to identify a roadmap for planning and implementation Twin innovation (Martins, *et al.*, 2022).

2.3 Twin innovation in the construction sector

In this paper it is chosen for the construction sector because it has a large need for twin innovation due its high pollution levels and low adoption rate. The sector has a 35% share in greenhouse emissions in the European Union. It uses half of all raw materials, one third of water usage and waste in Europe and only 1% of all materials are reused in new buildings. The sector consumes 40% of European energy use related to energy intensive construction methods and low energy efficiency of the larger part of building stock in Europe (Muench *et al.*, 2021). As part of the carbon emission objectives in Europe, emission intensities of the sector need to be reduced by an additional 50% (Li, Wiedmann and Hadjikakou, 2020). Therefore, the sector provides important opportunities to become more sustainable and resource efficient in materials, energy, water and waste (European Union, 2022). There is also scope for green products and services including circular design, low-carbon material choices and reuse of construction material, renewable energy use in construction and building usage, renovation and retrofitting, reduced demand for buildings by rethinking home and co-working and virtualisation of products and services (European Commission, 2021).

While the challenges of SMEs hitherto described apply to most economic sectors, the type and adoption levels of Twin innovations and the sectoral contribution to European environmental pollution vary widely among sectors. In general manufacturing, infrastructure and service industries are much ahead in Twin innovations (European Commission, 2022). In the construction sector, only 40% of companies are using emerging digital technologies in support of green innovation and an even lower percentage of companies engaged in organisation-wide green innovation (Muller, P., et al., 2021). The construction sector is slow to implement Twin innovations as a result of its highly decentralised, a lack of collaboration in the value chain and a lack of expertise (Goh, 2020). SMEs are key actors in the sector representing 99.9% of all companies, 90% of employment and 83% of value added in the European Union (European Commission, 2021). SMEs in the sector have limited capacity to implement and use digital technologies to support the green transition (Muench *et al.*, 2022). Similar to SMEs in other sectors, SMEs in the construction sector will only be able and interested to engage in a twin transition process if they gain better insights in the twin options and their impact of twin innovations on business performance.

2.4 A framework for Twin innovation in the construction sector

To be able to understand options and the potential benefits and impact of Twin innovation on business performance a framework can assist in the methodological analysis of the Twin and its impact at the level of different business activities in the value chain. The first element of the framework are the three key business processes of a traditional value chain including supply chain management, operations and products and markets (table 1). These three business processes are aligned with the standard greenhouse gas emissions or carbon footprint of business activities, including scope 1 emissions of direct emissions in operations, scope 2 emissions from energy usage by the company and scope 3 level indirect emissions of suppliers and clients' products and services (Li, 2020).

Secondly, the framework covers a set of economic, social and environmental indicators (table 1) based on the Triple Bottom Line and adjusted to the realities of the construction sector that supports a better integration of sustainable development practices (Goh, 2020). Basic economic impact indicators include revenues, price, costs and productivity, customer satisfaction and compliance with government regulations (Ramdani *et al.*, 2021; Martins *et al.*, 2022). As for social impact indicators companies can expect an impact on their access to new talent, employment numbers and employee satisfaction and impacts on the community (Martins *et al.*, 2022). Environmental impact indicators include greenhouse emissions, materials, energy and water efficiency levels and the impact on sustainability of cities (Muench *et al.*, 2021; Rockstrom *et al.*, 2009). To optimise the framework, for each business activity level, the most relevant impact indicators are selected.

To be relevant, the framework is to identify as a third element of a set of Twin innovations that are **salient** to the construction sector (table 1). Within the supply chain of the construction sector, key green and digital innovations include the use and local sourcing of low carbon and nature-based materials and digital tools to compare materials and transport costs (European Union, 2022; Muench *et al.*, 2022). At business operations level, construction companies are to seek greener, less use and recycling of materials, energy, water and waste products with support of data analytics, smart metres and enterprise resource planning tools (European Commission, 2021). When looking at product and service development, the construction sector can benefit from

green innovations in efficient building processes, maintenance and energy sourcing and renovation and service based real estate services empowered by product digital tracking and tracing technologies, big data analysis and machine learning (Blundel, 2021; Muench *et al.*, 2022).

Table 1: A framework for Twin innovation in the construction sector

Business process	Twin green and digital innovation options in the construction sector		Key impact indicators on business performance
Supply chain management level (Scope 3)	<ol style="list-style-type: none"> 1. Use of low carbon materials (low grey energy, lifetime, energy efficiency, potential for repair and recyclability) 2. Use of nature-based materials 3. Local sourcing of materials 	<ol style="list-style-type: none"> 1. Digital tracking and data analytics to measure carbon intensity & cost analysis of materials (sensors, databases & dashboards and product passport) 	<p>Economic</p> <ol style="list-style-type: none"> 1.1 Purchasing costs 1.2 Customer compliance 1.3 Government compliance <p>Social</p> <ol style="list-style-type: none"> 2.1 Access to new talent 2.2 Employee satisfaction <p>Environmental</p> <ol style="list-style-type: none"> 3.1 Greenhouse gas emissions 3.2 Materials efficiency 3.3 Recycling of materials
Business operations level (Scope 1 and 2)	<ol style="list-style-type: none"> 1. Improved efficiency of materials 2. Technologies to enhance waste reduction, reuse & recycling 3. Technologies to reduce and clear water 4. Electrification 5. Use of renewable energy 	<ol style="list-style-type: none"> 1. Enterprise Resource Planning (ERP) 2. Smart digital metres & data analytics (databases, dashboards, AI) 3. Smart production methods (robotica en 3d printen) 	<p>Economic</p> <ol style="list-style-type: none"> 1.1 Production costs 1.2 Productivity 1.3 Competitiveness 1.4 Customer compliance 1.5 Government compliance <p>Social</p> <ol style="list-style-type: none"> 2.1 Access to new talent 2.2 Employee satisfaction <p>Environmental</p> <ol style="list-style-type: none"> 3.1 Greenhouse gas emissions 3.2 Materials efficiency 3.3 Recycling materials 3.4 Water efficiency 3.5 Energy efficiency
Products and markets level (Scope 3)	<ol style="list-style-type: none"> 1. Integrated building design and planning based on sustainable, resilient and recyclable materials 2. Improved efficiency of materials 3. Building retrofitting through energy renovation (shading, solar & geothermal energy) 4. Low carbon heating & cooling systems 5. Development of business service models for living and office buildings 	<ol style="list-style-type: none"> 1. Integrated digital building modelling 2. Life cycle analysis, simulation and forecasting models for buildings 3. Digital building management systems 4. Digital platforms for living and office space sharing 	<p>Economic</p> <ol style="list-style-type: none"> 1.1 Product costs 1.2 Revenues 1.3 Customer compliance 1.4 Government compliance 1.5 Local competitiveness 1.6 International competitiveness <p>Social</p> <ol style="list-style-type: none"> 2.1 Access to new talent 2.2 Employee satisfaction <p>Environmental</p> <ol style="list-style-type: none"> 3.1 Greenhouse gas emissions 3.2 Recycling materials 3.3 Materials efficiency 3.4 Recycling materials

Sources: Based on inputs from Blundel, 2021; European Commission 2021; European Union, 2022; Goh, 2020; Goh, 2020; Li, 2020; Martins *et al.*, 2022; Muench *et al.*, 2021; Ramdani *et al.*, 2021; Rockstrom *et al.*, 2009 and Authors.

3. Research questions and methodology

The key research questions of this study are:

1. What are relevant Twin innovations in the construction sector?
2. What is the expected impact of Twin innovations on SMEs in the construction sector?
3. What can be a roadmap for the implementation of the Twin innovations by SMEs in the construction sector?

The choice of research method is based on the purpose of this study. This study uses a qualitative case-study research design to answer the explanatory research questions (Yin, 2016). In contrast to an experimental design or a survey, a case study method presents more flexibility, allowing an in-depth analysis of a complex research problem within a highly-contextualised environment (Yin, 2016). This research design helps answer the research questions because it allows the use of the replication logic as a possibility to obtain external and internal validities as well as to analyse pattern-matching properties between the theoretical framework and the case (Yin, 2016).

This method is apt to develop new insights and develop emerging concepts such as the Twin and enables the creation of new frameworks (Snyder, 2019). This method also enables us to integrate interdisciplinary - economic, social, environmental and technological- conditions that companies need to consider when making decisions on innovation. To enhance the practical relevance of the framework it is chosen to develop a framework for a specific sector, in this the construction sector.

The framework is validated by semi-structured interviews with five subject matter experts in the construction sector in the Netherlands about Twins and their impact on business performance. The experts included two decision makers with experience in sustainability and digitalisation, two sustainability experts and one digitalisation expert. The experts all have vast experience in the application of Twin innovations in the construction sector. This way the framework will lay a basis for future empirical case studies among SMEs in the construction sector which can further validate the practical relevance of the framework.

4. Findings on Twin innovations in the construction sector

4.1 Relevant Twin innovations in the construction sector

The relevance of the Twin innovation options identified in the framework is confirmed by the subject matter experts interviewed. To enhance sustainability in the supply chain, the local sourcing of materials has since long been considered as an option to achieve lower emissions and low carbon materials are increasingly chosen as an alternative in building projects (Vreese, 2023). The use of nature-based materials is less common due to elevated costs and limited to pilot projects in the construction sector (Van Doorn, 2023). Larger construction companies combine the green innovation with data analytics to measure material cost and emissions. Eventually, these will be developed into product passports and life-cycle models at product and construction project levels (Spierings, 2023; Van der Mark, 2023). There are also initial experiments with using sensors integrated into infrastructure and buildings to optimise the maintenance activities, e.g. in bridges. In line with other studies earlier mentioned, the adoption of Twin innovation by SMEs is still limited due to higher costs and a lack of knowledge (Kor, 2023; Spierings, 2023).

Whereas business operations are concerned, the interviewees indicate that construction companies seek efficiencies in the use of materials, technologies supporting waste and water reduction, reuse and recycling. Larger construction companies are also experimenting with the electrification of construction and transport equipment, even though this implies additional investment costs and a period of adaptation by staff. They are also investing in renewable energy solutions. In most cases smart metres and some level of data analytics are used to monitor resource usage (Kort, 2023; Spierings, 2023). In a smaller number of cases, the sector experiments novel technologies such as 3D concrete printing (Vreese, 2023; Van Doorn, 2023). However, due to the complexity of integration of environmental data, there is limited integration of related data in ERP systems (Vreese, 2023).

When considering new Twin products and services, the experts interviewed indicate that there is important scope for sustainable construction projects if clients collaborate with constructors to develop a more sustainable and integrated design, planning of infrastructure and buildings, supported by digital modelling. In this area, companies have also started with basic life-cycle analysis (Spierings, 2023; Van der Mark, 2023). This also applies to retrofitting and efficient heating and cooling systems. Due to complex ownership issues, the experts indicate that shared digital building management systems and 'construction as a service' is not yet a viable option in the sector (Vreese, 2023, Van Doorn, 2023; Kor, 2023).

4.2 The impact of Twin innovation in the construction sector

The analysis of the impact of Twin innovation in the construction sector provides a mixed outcome. At the supplier level, the innovation towards the use of low carbon materials supported by data analytics does come with an increase in material costs of construction projects but will strongly contribute to the reduction of scope 3 emissions and positively impact the compliance of customer and government requirements. The use of natural materials and locally acquired materials is seen as less relevant as it will not lead to improved material efficiency or compliance with client or government regulations (Kor, 2023; Freeze, 2023).

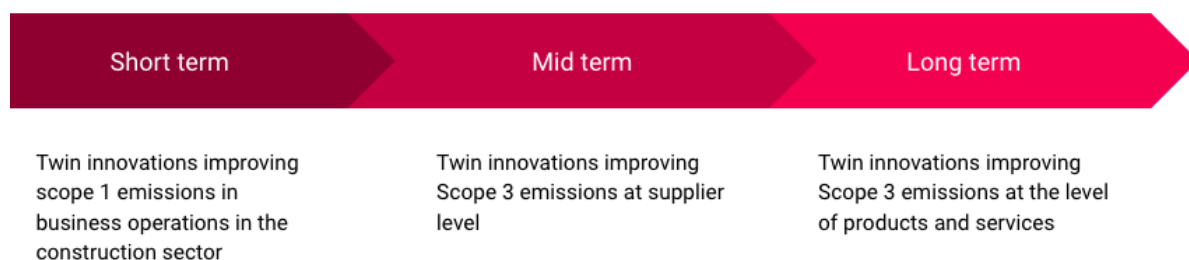
The impact of more efficient and low-carbon material use in combination with digital tools such as smart metres and data analytics is high in terms of scope 1 emission levels, competitiveness and compliance with client demands. Twin innovation in low-carbon building materials and data analytics, where possible supported by smart metres and robotics, is seen as an important longer-term differentiator in which companies are to invest now to secure both competitiveness and compliance with future regulations. It also enhances the satisfaction of employees and attractiveness to new talent. The impact of twin innovations in waste and water reduction and recycling on scope 1 emissions is high and will contribute to more efficient resource usage but has limited impact on other business indicators (Kor, 2023; Vreese, 2023). Electrification of construction equipment and renewable energy solutions can encounter resistance and require additional investments but do gain support from employees once implemented (Kor, 2023; Vreese, 2023; Van Doorn, 2023).

Twin innovations in new products and services are important to diminish scope 3 emissions but will generate additional product costs which cannot be compensated with higher product and service price levels but do strengthen competitiveness and differentiation in the market (Van der Mark, 2023; Van Doorn, 2023). The use of more sustainable construction by using integrated digital planning and life-cycle models for building projects will help in reuse and recycling of building materials and prepare constructors for expected future demands by customers and governments and attract new talent. The companies have gained some experience with advanced business model innovation such as Construction as a Service but this approach is still seen as highly complicated due to its complex legal implications for ownership (Kor, 2023; Van der Mark, 2023).

4.3 A roadmap for twin innovation in the construction sector

The research also enables us to understand at what activity level in the value chain SMEs are best to start with Twin innovation. The timelines applied are based on the necessary adoption rates as a consequence of European current and expected environmental regulatory standards, related customer demands and market opportunities. The short-term time frame covers the next two years and the mid-term period a three to five-year period. The long-term timeline for twin transition refers in the period up to 2030, where major emission and waste targets are set in the construction sector (European Commission, 2021).

Table 2: A roadmap for implementation of the twin innovation in the construction sector



Sources: Authors

The subject matter experts suggest that in the short term companies are to start with Twin innovation at the level of their business operations (Van Doorn, 2023; Vreese, 2023). The first argument is that construction companies are already legally bound to comply with European Climate Law and national government regulations that focus on emission levels scope 1 which are directly related to business operations (European Commission, 2021). Furthermore, companies have more control over their own processes than over suppliers or customers and they can exploit the presence of basic digital infrastructure (Muller *et al.*, 2021). Construction companies can also benefit from the more proven green innovations available. Finally, despite the negative impact on

production costs, twin innovations are expected to have a positive impact on the companies' competitiveness as a result of resource efficiency gains can reduce resource costs and even generate new sources of revenues from the sales of waste and energy (Goh, 2020).

In the middle-long term, companies are to further integrate Twin innovation in their supply chain. This is firstly related to the expected increase in EU and national regulations regarding resource efficiency in the next 3 to 5 years which will oblige suppliers to source more carbon efficient materials (European Commission, 2021). Without the Twin innovation, smaller construction suppliers may not be able to comply with increased standards for green building materials set by contracting construction companies and thereby lose market access and competitiveness. The interviewed experts indicate that improving the sustainability of the supply chain is complicated as some of the larger suppliers of construction materials are reluctant to provide the necessary data and smaller providers do not yet have the required knowledge and resources of digital tools to provide the necessary data (Spierings, 2023; Van der Mark, 2023).

In the longer term from five to ten years, construction companies are to look out for Twin innovation in products and services delivered to customers in the construction sector. This includes multiple innovations to increase material efficiency and reduce emissions by developing digital life-cycle and simulation models and introducing service-based construction (Muench, *et al.*, 2022). These innovations will be needed to respond to fast developing EU and national regulations for buildings in Europe to reduce Scope 3 emissions (European Commission, 2021). They also stress the importance of new forms of collaboration and contracting between construction companies and their clients such as real estate investors or governments where partners seek shared ownership of the innovation process and the necessary additional costs, time and efforts (Van der Mark, 2023; Van Doorn, 2023)).

5. Discussion

Although the literature clearly supports the need for Twin innovation in general and in the construction sector in particular, the study has found limited academic sources that assist in defining a framework to analyse the impact on business performance of SMEs active in the construction sector. While the framework present in this study provides a starting point, the validation of the framework with subject matter experts indicates that there is still a need for a better systematic overview of possible and relevant Twin innovations at each level of the value chain in the construction sector.

Where it concerns the expected impact of Twin innovation, the empirical findings based on the opinions of subject matter experts coincide with the expected social and environmental impact of twin innovation. However, the expert opinions do considerably divert from the literature where the economic impact of twin innovations is concerned. While twin innovation will support competitiveness in the longer term, the innovations are associated with cost increases that will not be compensated by higher market prices. Therefore, successful twin innovations will only be realised if suppliers, contractors and clients work together and share knowledge and investments to identify effective twin innovation in the sector.

Finally, the literature suggests a clear priority to the adoption of twin innovation in internal business operations. Yet, the experts suggest to compensate associated internal investment with the promotion of twin innovation with customers that are prepared to share pilot investment and benefit from reduced scope 3 emission levels in the construction sector. Similarly, different from what was expected, despite the high potential of environmental gains at supplier levels, the experts indicate most difficulties are to achieve twin innovation at the level of both larger and smaller suppliers in the construction sector.

6. Conclusions and research agenda

This paper confirms the urgent need and opportunities for SMEs active in the European construction sector to engage in Twin innovation. For this, the framework in this paper presents a set of Twin innovation options for SMEs in the construction sector and discusses their impact on business performance. In the short term, SMEs can expect the most positive impact from integrated implementation of Twin innovations at the level of their business operations. In the mid-term, SMEs are to invest in Twin innovation in construction materials to secure their competitiveness in the market. In the longer term, construction companies are to explore Twin innovation

to achieve more sustainable building methods and building management services which will enhance their long-term competitiveness in the market.

Next to direct relevance for SME company owners and directors, these findings are relevant for other researchers in this field interested in deepening research on the twin innovation, as well as policy makers who seek to steer and speed up support programs towards successful Twin innovation among European SMEs.

Where future research is concerned, it is important to conduct further research among SMEs in the construction sector to validate the proposed framework and deepen initial findings. To enhance the relevance of the framework it is recommended to expand the research to case studies in other European countries. Subsequently, the framework can be used to conduct comparative research on the twin transition among SMEs in other economic sectors.

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