How Digital Technologies Enable Business Model Innovation in the Energy Sector: An Empirical Study of Italian Energy Service Companies

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***Abstract*—The evolution of digital technologies has been expanding the business opportunities that firms can tap by leveraging such technologies. Business model innovation triggered by digital technologies allows firms to extend the scope of products and services they offer and create new markets. This trend is particularly relevant in the energy sector. However, little is known about how actually energy firms' business models evolve because of the adoption of digital technologies. Therefore, this article aims at shedding light on the business model innovation process enabled by digital technologies in the energy sector. To this aim, eight Italian energy service companies that innovated their business model by adopting digital technologies are analyzed. The empirical analysis allows to spot an archetypal business models innovation process enabled by digital technologies in the energy sector. The study contributes to the literature on business model and business model innovation by highlighting how digital technologies may promote the evolution of business models and by spotting an archetypal business models innovation process that can be implemented accordingly. It also contributes to the emerging literature on digital transformation, by showing how digital technologies can be exploited by energy firms to improve their value creation, delivery, and appropriation mechanisms.**

***Index Terms*—Business model (BM), business model innovation (BMI), case study, digital technologies (DTs), energy service companies (ESCOs).**

I. Introduction

IN THE last years, the economic scenario has been dramatically reshaped by the progress and the growing diffusion of digital technologies (DTs) [1], [2], [3]. Indeed, the recent evolution of DTs has been expanding the potential business opportunities that firms can tap by adopting them; consequently, DTs are becoming increasingly pervasive to several industries [2], [4]. In particular, DTs allow firms to: 1) expand their offering and increase product and service flexibility, also supporting updates and the addition of new features after these reach the market, 2) favor the interconnection between different industries, thus enabling the development of new ecosystems, and 3) access timely and reliable data streams [5], [6], [7], [8]. Examples showing how the adoption of DTs is supporting firms in developing new and enhanced products and services that better satisfy customers' needs are more and more common. Moreover, through DTs, firms can sensitively change the design of the mechanisms they use to create value for customers and appropriate the same value, as well as their architecture, eventually innovating their business models (BMs) [9].

Business model innovation (BMI) triggered by DTs allows firms to extend the scope of products and services that they offer to their customers and also to create new markets [10], [11]. For instance, typical examples are those of the Nest thermostat, embedding DTs to offer further value-added services to customers [10], and the development of the eMaintenance platform by Canon, to get data on printer status on the basis of which provides additional services to customers [12]. As a matter of fact, BMI enabled by DTs may strengthen the commercial relationship between firms and their clients, generate new advantageous partnerships, as well as increase the appeal of current and new products and services to existing and potential customers [11], [13], [14]. Hence, firms may leverage DTs to keep or establish sustainable competitive advantage through BMI. Moreover, in an economic scenario characterized by the widespread digital transformation of businesses, firms failing to effectively innovate their BMs by leveraging DTs may risk being marginalized and to lose competitiveness (e.g., [13]).

The extant literature has been analyzing several aspects related with the role of DTs in BMI. For instance, previous studies investigated topics as how DTs change firms' value proposition and the way they create and capture value (e.g., [13]), how DTs allow firms to access untapped opportunities as those related to the sharing or circular economy (e.g., [15] and [16]), and those factors promoting DTs-enabled BMI (e.g., [17]). However, to the best of authors' knowledge, little is known about how actually BMs evolve because of the adoption of DTs. Indeed, the integration of DTs within an existing BM requires a deep and thorough revision of its main components [11], which eventually results in its innovation. Specifically, our study focuses on analyzing the transition from the BM before the integration of DTs to the one after. Accordingly, we aim at shedding light on the BMI process enabled by DTs.

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A sector that has been characterized by BMI enabled by DTs is the energy one [18]. In particular, energy service companies (ESCOs) could be noticeably affected by the adoption of DTs, being them focused on activities aiming at improving energy efficiency [19]. ESCOs are players that can provide a wide range of energy services [20], with different financing and remuneration schemes [21], [22]. DTs in this field allow to collect detailed data on energy usage, predict energy consumption behaviors, and provide consumers with timely suggestions providing opportunities to reduce energy consumption and favor energy cost savings [22].

Accordingly, the adoption of DTs is crucial to increase the value ESCOs create for customers. This may happen, for instance, by implementing smart monitoring of energy consumption, by tailoring the services provided to the specific customers' needs, and by the provision of novel services as the offering of advanced contracts such as energy performance contracts (EPCs) [23], [24]. However, the implementation of DTs may require ESCOs to completely rethink the way energy efficiency improvements are delivered to customers with respect to how the same process was performed before the digitalization, also requiring revising the relationships between the building blocks constituting their BM [25], [26]. Therefore, we ground our analysis in this sector, by analyzing the cases of eight Italian ESCOs that innovated their BM by adopting DTs. Italy is chosen as the empirical setting for this study since it is one of the most developed energy efficiency market worldwide [27], also with a long-lasting presence of ESCOs since the early '80s [28].

Our empirical analysis allows to shed light on the BMI process enabled by DTs in the energy sector, with specific reference to ESCOs. The results also display that all the investigated firms, even the ones with a limited adoption of DTs within their value architecture, show a significant impact of DTs on their BM, with particular reference to the infrastructure network.

From a theoretical perspective, our study contributes to the literature on BM and BMI, by highlighting how DTs promote the evolution of existing BMs, and by bringing into light an archetypal BMI process. Additionally, we also contribute to the novel and emerging literature on digital transformation in the energy sector, by showing how DTs can be exploited by firms as ESCOs to improve their value creation, delivery, and appropriation mechanisms.

Our findings also offer practical insights for managers by providing a detailed overview of the opportunities enabled by DTs for innovating an existing BM as well as the BMI process that may be enabled by DTs. Furthermore, being our analysis grounded in the energy sector, our findings can also support policymakers in the definition of provisions to favor the adoption of DTs by companies in the energy value chain (e.g., ESCOs), in order to foster energy transition.

II. Theoretical Background

The competitive advantage of firms is based on their capacity of creating value for customers, and delivering and appropriating the same value [9]. Therefore, increasing scholarly attention has been recently posed on these three concepts, which concurrently define a firm's BM. In fact, "a BM describes the design or architecture of the value creation, delivery, and capture mechanisms employed" ([9]: 191). Specifically, a BM may be conceived as made of different components [29]. For instance, the seminal work by Dubosson-Torbay et al. [30] already identified four BM pillars, i.e., 1) product, 2) customer interface, 3) infrastructure management, and 4) financial aspects. In particular, the product pillar is essentially built on the value proposition concept. Indeed, BMs are hinged on the firm's value proposition [9], [31], [32], i.e., the definition of the value that the firm generates for customers [33]. Hence, value proposition represents a paramount factor to support firms' in establishing and keeping their competitive advantage (e.g., [34]). Furthermore, the customer interface pillar allows to define the target customers as well as how actually the value created by the firm is delivered to target customers. Specifically, this refers to the definition of the target customers as well as the design of the distribution channels to reach the customers and the typology of relationships that the firm establishes with them [31]. Instead, the infrastructure management refers to the definition of relationship between resources, assets, activities, and networks leveraged by the firm to provide value to the customers [30]. Finally, financial aspects are related to the generation of revenue streams and the cost structure resulting from the creation, delivery, and appropriation of value [30], [31].

BMs are deemed as an element that can be innovated by managers to keep or establish a competitive advantage [35]. Indeed, the extant literature identified several drivers of BMI processes, such as the need to deal with stakeholders' expectations, regulatory forces, changes in business environment, and emergence of new technologies [36]. In particular, the last driver has been growing in relevance, along with the evolution and the broad diffusion of DTs. This is testified also by the fact that BMI enabled by DTs has been recently emerging as a novel line of investigation within the stream of literature dealing with BMI [37], [38].

A. DTs-Enabled BMI

Extant studies have been focusing on how firms' BMs change due to the adoption of DTs and the relationships between the building blocks that constitute the BMs [11], [13], while also analyzing the role of DTs in making BMI opportunities available to firms [39], [40]. In addition, more and more scholars are investigating the BMI process enabled by DTs and how this unravels through different phases [37], [41]. Nonetheless, the growing body of knowledge, more understanding about the role that DTs play during the BMI process is required to spot frameworks, common patterns, and even archetypes that could support a better understanding of the factors affecting that process [18], [41], [42], [43]. In particular, DTs can enable, enhance, or even modify specific activities that incur in the BMI process [44]. Moreover, the DTs-enabled BMI process may be performed by firms following different patterns [14], hence limiting the value of one-size-fits-all approaches. However, to the best of authors' knowledge, studies investigating the different paths through which DTs can promote BMI are scant in the literature.

Accordingly, we aim at filling this gap by analyzing the transition from the BM before the integration of DTs to the one after to highlighting emerging BMI paths and commonalities.

B. DTs-Enabled BMI in the Energy Sector

As mentioned earlier, the recent rise of DTs has been supporting firms in the energy sector, as ESCOs, in innovating their BM. In fact, DTs can remarkably affect the four pillars of ESCOs' BM [30]. For instance, concerning the product (or service), DTs may add novel functionalities enhancing the range of needs that a product (or a service) satisfies or even modifying the scope of a product (or a service), even after it has been sold to the customer [10]. Considering that ESCOs offer energy efficiency services that are tailored on their customers, a continuous stream of data flowing from the customers through DTs may enable an accurate and timely control of energy consumption and generate novel energy savings opportunities. Emerging opportunities enabled by DTs may also affect the customer interface, i.e., by increasing the opportunities to deliver further value to existing or even new customers. In particular, the continuous data stream allowed by DTs provides product usage data to firms. In turn, ESCOs can leverage these data in their BMs to improve the customer relationship process, e.g., by exploiting technologies as artificial intelligence (AI) to be proactive in increasing the effectiveness of the value delivery [45]. This is a key point for ESCOs, since their value creation activities are strongly characterized by a regular interaction with customers, to fine tune their services on the customers' needs. Moreover, new customers may be targeted by ESCOs as well. Indeed, energy efficiency projects promoted by ESCOs have been mainly targeted the industrial and public sectors, while other sectors as the residential one started to be addressed more recently, being usually considered less attractive due to the high transaction costs and other barriers that nowadays could be managed through DTs exploitation [22], [46].

In terms of infrastructure management, the role of data as a crucial resource in digitally-enabled BMs is evident (e.g., [47]). In fact, DTs may totally reshape the way resources are used to support value creation activities [11], [48]. In addition, DTs allow for a radical revision of partnering networks, due to the novel and more efficient interaction opportunities offered [49]. The interaction with partnering firms is a relevant activity for ESCOs, since for example they do not typically manufacture energy efficiency technologies offered to their customers, rather they partner with technology providers. Such partnerships could be leveraged to being able to acquire and exploit DTs as well [22].

Finally, as far as the financial aspects are concerned, DTs may dramatically impact revenue streams and costs. Indeed, a more accurate tailoring of products and services on customers' needs is useful to be, on the one hand, more effective in sustaining costs and, on the other hand, allows to better appropriate the value created, hence increasing the revenues generated [10]. In the context of ESCOs, DTs may allow to understand in a more granular and accurate way how customers use energy, paving the way for not negligible energy and cost saving opportunities and, due to the ESCOs typical contracts, also providing related revenue growth.

TABLE I
OVERVIEW OF THE SAMPLED FIRMS AND INTERVIEWEE(S)' ROLE

Firm	Job position of the interviewee(s)
Firm A	Innovation Manager, Expert in Energy Management
Firm B	Co-founder & Chief Executive Officer, Business Intelligence Manager, Strategy & Innovation Manager
Firm C	Marketing Manager
Firm D	Innovation Manager, Customer Insight Manager
Firm E	General Manager, Chief Operating Officer
Firm F	Co-founder & Chief Executive Officer
Firm G	Co-founder & Managing Director
Firm H	General Manager & Head of Innovation

Therefore, these arguments suggest that DTs are endowed with characteristics that may support ESCOs in increasing the value generated for customers, improving its delivery, and facilitating its appropriation, in ways that are extremely peculiar. Accordingly, it is not surprising that ESCOs are increasingly leveraging DTs to innovate their BM. Hence, investigating the BMI in the energy sector, which is characterized, as discussed, by a high impact and pervasiveness of DTs may provide interesting insight to expand our understanding about how BMI enabled by DTs typically unravels in such contexts.

III. METHODOLOGY

The empirical research method adopted in this study refers to multiple case studies [50], [51]. In particular, the collection of rich qualitative data obtained through case study research has been leveraged, due to the novelty and complexity of the topic addressed, which are difficult to study with quantitative methodologies [52]. Furthermore, this method is consistent with our objective to provide an in-depth illustration of the phenomenon analyzed, particularly with reference to describing the evolution of the firm's BM due to the exploitation of DTs. Accordingly, a multiple case study analysis (rather than a single case study) provides a more robust and grounded foundation for the research activity [51].

As far as the selection of the case studies is concerned, it follows a convenience sampling criterion, which allows for easy accessibility and availability of information at a given time [53]. In particular, eight Italian ESCOs that innovated their BM by adopting DTs were selected. The number of selected companies adequately fits the exploratory nature of our research, as the number of participants in interpretive research is relatively small [54]. Table I shows the identified firms (whose names are blinded for confidentiality reasons), as well as the job position of the interviewees taking part in the following data collection phase.

As far as the following data collection is concerned, semistructured interviews with key informants were exploited as the main source. To this aim, a semistructured questionnaire consisting of open-ended questions was used as a guide for the collection of all the empirical data [55]. The questionnaire included two main parts, the first one investigating the firms' BMs before the exploitation of DTs, while the second one focuses on the outcome of the BMI process enabled by DTs. For each firm, we interviewed one to three key informants dealing with strategic

decisions within the firms, The interviews were conducted between September 2020 and March 2021 by a research team of three researchers, which allowed collecting different points of view during the interviews, thereby increasing the richness and reliability of the findings [50]. The interviews typically lasted between 60 and 90 min each and were tape-recorded. The first round of interviews was followed in some cases by follow-up interviews, as well as email exchanges to consolidate and further enrich the collected data. Furthermore, the analysis of secondary sources of information, such as annual reports and companies' websites was exploited to triangulate and integrate data gathered through the interviews. Data analysis followed these two steps [56]: i) each author first reviewed all the information of the transcribed interviews and secondary documents to verify their validity and avoid potential ambiguous and equivocal data. To this aim, a coding process and cross-comparison analysis of interviews' answers and data from secondary sources was performed to identify the recurrent patterns of useful information [57]; and ii) each author then contrasted or corroborated his own elaboration with the ones of other authors to reach a shared interpretation of the phenomenon under investigation.

IV. Empirical Analysis

Table II reports a short presentation of each investigated firm. A description of the "traditional" BM (i.e., the one before the adoption of DTs) characterizing each firm as well as the BMI process enabled by DTs is reported hereafter.

A. Firm A

1) Traditional BM Outline: Firm A offered energy efficiency solutions (EESs) and related services (e.g., energy audit, assets maintenance) to their customers, mainly belonging to the industrial and the tertiary sectors. EESs were mainly offered through turnkey contracts, where the firm typically received a lump-sum payment or a recurrent fee (e.g., on a monthly basis) that was not related to the performance level reached through the energy efficiency project (i.e., energy savings achieved). In a few cases, the firm leveraged guaranteed-savings EPCs, where the payment was linked to the energy savings achieved. The cost structure characterizing Firm A was mainly affected by the in-house development of the proprietary technologies (as energy meters or network analyzers), while the impact due to own investments at customers' premises to implement EPCs was rather negligible.

As far as the infrastructure management pillar is concerned, human resources represented the most relevant strategic asset for Firm A, as it exploited critical competencies and skills characterizing both managers and employees. Other key resources included financial resources and brand/image, being strongly linked to the recent acquisition of Firm A by a large Italian energy player active in the renewable energy production. Key activities were related to design of EESs and the energy efficiency projects delivery, with particular reference to the energy audit to identify energy saving opportunities. Finally, the firm developed several partnerships with other ESCOs offering ESSs developed by Firm A.

2) BMI Process Enabled by DTs: The main opportunities for Firm A, related to the exploitation of DTs, referred to the integration of the offered EESs with the information systems at customers' premises as well as the exploitation of mathematical models to optimize energy flows at customers premises.

To this aim, Firm A set up a novel working group that involved internal resources, called "Energy Intelligence." Accordingly, the infrastructure management pillar recorded the major changes to exploit DTs-related opportunities. Indeed, key activities reported significant changes, e.g., including those for the creation of mathematical models to optimize energy flows by leveraging data science competencies, which were carried out by the Energy Intelligence working group. As a result, Firm A started considering its energy management system as a strategic resource, alongside the optimization algorithms to decrease customers' energy consumption. Human resources were still strategic for the firm, due to their technical and IT competences. Beyond internal resources, partnerships with external parties started playing a role to exploit DTs, but less relevant compared with internal development. "*We started collaborating with external companies to integrate our offer that exploits DTs. Nevertheless, these relationships have not turned out to be fruitful so far. Moreover, as we perceive DTs as a source of competitive advantage, we decided to leverage our internal resources to increase their penetration within the company's value architecture*," Firm A's Innovation Manager said.

The exploitation of DTs did not alter the product pillar (i.e., value proposition) of Firm A's BM, as its objective was still about offering integrated EESs to their customers, being the new digital nuance exploited to reach this objective. Neither target customer segments nor contract typologies (and related revenue streams) recorded any change as well. However, the cost structure registered some relevant changes, as training activities were introduced for both managers and engineers to properly exploit DTs.

B. Firm B

1) Traditional BM Outline: Firm B offered EESs and consultancy services to their customers (mainly industrial players). EESs were mainly offered through shared-savings EPCs, in which the revenues are calculated as a percentage of the achieved energy savings (in addition to a fixed success fee, which was subject to the achievement of a specific energy saving target). Therefore, the firm bore the performance risk characterizing the energy efficiency project, as well as the financial risks by providing financial resources to carry out the project itself. The main cost voices referred to EESs purchasing cost and related operating costs, as well as capital cost (including interest expenses). Regarding consultancy services, they were typically offered through turnkey contracts that included a one-shot payment.

Technology providers represented key partners for the Firm B, as it purchased almost all the offered EESs. Customers were considered as partners too, since they were tied to the firm through long-lasting relationships. Employees' technical competencies were considered a key resource to properly design EESs consistently with customers' needs and manage energy

TABLE II
DESCRIPTION OF THE SAMPLED FIRMS

Firm	Core Business	Turnover [mln € - FY 2020]	Number of employees [# - FY 2020]	Description
Firm A	Energy efficiency	13.7 (FY 2019)	82 (FY 2019)	Established in the late '90s, Firm A is a leading player in the Italian market of energy monitoring systems. Following the Italian energy market liberalisation process (in 2009), the company recorded a significant increase of its turnover (around € 5 mln) and started operating in the energy efficiency sector in 2010, also widening its geographical scope beyond Italy. In 2018, the company was acquired by a large energy player active in the renewable energy production, which has supported the Firm A's growth and the exploitation of DTs within its BM, e.g., by supporting the development of a brand new energy platform. As a result, the company recorded a significant increase of the turnover (around € 14 mln in 2019), by offering its products and services to more than 5,000 customers.
Firm B	Energy efficiency	32	51	Established in 2001, Firm B started operating as an ESCO in 2005. The main objective of Firm B is to design and develop innovative energy efficiency programs aimed at improving energy efficiency and reduce environmental impact of its customers. A distinctive feature of the company refers to the offer of EPCs (mainly shared-savings EPCs), whose related investments are typically funded through own financial resources or third parties (banks). In 2018, the majority of the Firm's B shares (i.e., 60%) was acquired by a multi-utility to support its growth.
Firm C	Utility	4,431	1,356	Established more than 100 years ago, Firm C is an energy utility that mainly operates in Italy and Europe, although it recently expanded its activities in South America and Africa, including more than five thousand employees and owning more than 6.5 GW of plants installed capacity. In 2012, Firm C was acquired by a large French utility. In the last years, Firm C widened the traditional utility scope by exploring new markets and redesigning its competitive strategy, e.g., with reference to renewable energy sources and the provision of energy efficiency and environmental services.
Firm D	Utility	64 (FY 2019)	272 (FY 2019)	Established in 2017, Firm D belongs to a large and well-established energy utility that was founded in 1962. Firm D offer new opportunities and solutions for their customers, ranging from companies to public administrations (due to the firm's interest towards the smart city domain). The scope is very broad, ranging from the electrification throughout cities, providing solutions to increase the smartness of houses, developing projects to increase the energy efficiency within the industrial world, alongside a smarter management of networks and grids, and implementing interventions to promote the diffusion of electric vehicles.
Firm E	Energy efficiency	3.2	18	Established in 2001, Firm E is a leading Italian ESCO that provides its services to energy-intensive players belonging to the industrial and tertiary sectors. Among the hundreds of energy efficiency projects carried out, the company has leveraged EPCs (mainly guaranteed-savings EPC) rather than turnkey contracts. In 2017, Firm E was acquired by the Italian transmission system operator (TSO). Following this acquisition, Firm E significantly increases and stresses the relevance of innovation and progress within its value architecture.
Firm F	Engineering services	6.4	59	Established in 2007, Firm F offers technologies and services in the engineering field. The firm leverages the technological competencies and skills of its human resources to offer technologies and services that can be grouped in three main clusters: (i) services aimed at designing and executing engineering projects; (ii) energy-related services, mainly to energy-intensive small-medium enterprises (SMEs), such as with energy audits and monitoring energy consumption, often acting as an ESCO; (iii) services to support the development of innovative projects, which are generally conducted by tackling both the environmental and the social spheres.
Firm G	Energy efficiency	8.1	16	Established in 2002, Firm G offers energy-related and environmental-related consultancy services mainly to companies in the industrial sector, where the company started to operate as an energy service company in 2006. Nevertheless, it also targets the service industry and Public Administrations. The main goal behind the energy efficiency interventions carried out by Firm G is about decreasing the energy bills borne by customers. To this aim, the company initially monitors the energy flows and, eventually, proposes the proper technological solutions to reduce waste and increase energy efficiency. The firm focuses its attention on both the energy and environmental spheres, trying to reduce greenhouse gas emissions through these programs.
Firm H	Energy efficiency	0.2	4	Established in 2018 within a broader company group operating in the architectural sector since 1914, Firm H presents peculiar traits within the energy efficiency sector, displaying the characteristics of both an ESCO and a real estate company. These peculiarities provide a competitive edge to the firm, that generally exploits EPCs when implementing energy efficiency projects (especially in the industrial sector). Firm H typically delivers innovative integrated solutions to its customers, taking care of all the efficiency programs' stages. Indeed, the company assists its clients from the design and the concept of the project, guaranteeing the achievement of prearranged performance levels.

efficiency projects. Furthermore, the firm highly valued legal competencies, as performance-based contracts were often risky and more complicated to be drafted than turnkey contracts.

2) BMI Process Enabled by DTs: The digitalization trends significantly reshaped the value architecture of Firm B. Indeed, the firm decided to develop and offer advanced control systems to achieve energy savings, were based on second-level automation and enabled the integration between predictive models and AI-based solutions. To this aim, internal competencies were exploited (also through the creation of a new business unit), also leveraging collaboration with external parties such as universities. For example, Firm B tightly collaborated with the Università Politecnica delle Marche to widen the scope of the internal R&D with reference to advanced control systems. Moreover, to exploit the developed DTs, the firm started considering its motherboard providers as strategic partners too, since they provided the hardware component that lies at the heart of the automation systems offered by the firm. The most

relevant activities became the development of the optimization algorithms and their integration with the end-users' pre-existing technologies. Furthermore, data analyses and data management represented further key activities, as they allowed the firm to offer value-added services to its customers, which were carried out through internal resources (including people hired from Università Politecnica delle Marche).

C. Firm C

1) Traditional BM Outline: Firm C offered a broad set of EESs and consultancy services to different target customers, belonging to the industrial and public and private tertiary sectors (while the main target customers refer to large energy-intensive players). The contract typology offered by Firm C, especially in the industrial sector, referred to the shared-savings EPC, where all the risks related to the investment were borne by the firm itself. For this reason, in addition to a fee based on the attained performance level, Firm C split the obtained energy savings with the customer for the whole contract duration (according to a predetermined quota). As the firm carried out the investment, its cost structure was widely affected by energy efficiency projects, considering both investment costs and interest expenses.

Technology providers were considered as strategic partners for Firm C, even though it preferred to have the possibility to choose among a broad set of providers to avoid a possible lock-in effect. In so doing, Firm C could select the most suitable providers based on the customer's peculiarities and requests. Customers played a critical role too, as the firm generally leveraged their resources during the implementation of EESs, especially with industrial customers. Although the firm did not internally produce EESs, human resources' technical competences were crucial within the Firm C's BM. For instance, engineers were in charge of handling the activities related to the design and implementation of EESs. Moreover, following the implementation of ESSs, activities related to energy consumption monitoring and analysis were considered as strategic too. All these activities were particularly relevant to assess and manage all the risks associated to each energy efficiency project, as the performance and financial risks were entirely borne by Firm C.

2) BMI Process Enabled by DTs: DTs were recently introduced within Firm's C portfolio to enrich its offer. In particular, the idea was related to the exploitation of machine learning and AI-based solutions to create digital twins of industrial plants in order to analyze their energy use patterns, foresee future behaviors, and implement corrective actions to save energy.

To develop these solutions, in addition to the exploitation of internal resources, a partnership with a French start-up was established. The advent of DTs increased the relevance of data analysis capabilities within the firm, which were critical to properly design interventions. Moreover, the optimization of customers' energy consumption was possible thanks to the algorithm's learning process, which automatically identified the best settings to optimize energy consumption. Within the new BM, human resources continued playing a strategic role within the firm, to favor the integration of these digital solutions. Nevertheless, they were complemented by new resources, such as optimization algorithms and simulators, which allowed the firm to deliver value-added services to its customers.

Following the development of DTs, the Firm C amended its value proposition to stress its enhanced ability to bring into light energy saving opportunities by exploiting a data-driven approach. The primary customer segments remained large energy-intensive players belonging to industrial and tertiary sectors. However, specific attention was more recently devoted to customers relationship management, since it emerged that making customers aware of the real benefits of digital solutions was a challenging task, due to limited customers' awareness on such topics. Moreover, despite contract typology offered by Firm C continued to refer to the shared-savings EPC, the exploitation of DTs unlocked additional revenue streams, through up-selling and cross-selling strategies. Finally, the cost structure was mainly affected by the investment costs (necessary to implement the energy efficiency program and digital solutions) and the interest expenses.

D. Firm D

1) Traditional BM Outline: EESs offered by Firm D targeted two main customer segments, belonging to the industrial and (public/private) service sectors. Firm D typically leveraged a shared-savings EPC, thus bearing all the risks associated to the energy efficiency project and obtaining a part of the achieved energy savings, as well as a fee based on the performance reached through the intervention. The cost structure included the investment costs needed to carry out the intervention and the interest expenses related to the loan supporting the project.

Firm D did not produce any EES in-house, rather it exploited several collaborations to acquire such solutions. In addition, Firm D highly valued its service providers (in charge for the installation, and in some cases the design, of EESs), allowing the firm to provide end-users with a high-quality service. One of the most strategic resources leveraged in these projects referred to the financial resources, which allowed the firm to bear the financial risk of an investment and propose performance-based contracts. Moreover, Firm D considered as highly strategic the human resources' know-how, together with the EESs themselves, which were continuously updated by selecting innovative suppliers. Within energy efficiency projects, a key activity referred to the monitoring and analysis of energy consumption to identify energy efficiency opportunities. Moreover, the firm carefully carried out creditworthiness assessments to evaluate customers' solvency requirements.

2) BMI Process Enabled by DTs: The digitalization trends heavily affected Firm D's BM, through the development of two main initiatives. On the one hand, the firm developed a platform allowing the real-time monitoring of energy consumption that can be leveraged to optimize customers' energy consumptions and identifying energy efficiency opportunities. On the other hand, the firm developed a comfort management solution, which can manage assets such as the heating ventilation and air conditioning systems to offer the highest comfort level at the minimum energy costs.

To develop these DTs, different approaches were pursued. Firm's D Customer Insights Manager explains: "Once recognized the strategic relevance of DTs within our BM, we faced a challenge in developing the different opportunities internally. Then we decided to develop internally the ones that fit well with our core competencies, while acquiring from external parties the ones that are too costly or risky against our existing competence base." In particular, the platform for energy monitoring and management was acquired by an external provider, while the comfort management solution was internally developed by exploiting the competence of a subsidiary company.

To exploit both DTs, Firm D embarked on several partnerships to complement its internal know-how, such as those with software houses and platform developers. In this context, technological scouting activities to spot and identify innovative suppliers that may enhance its offer assumed an increasing relevance. Moreover, the firm focused on developing and updating the optimization algorithms, which became more and more central to the firm's BM. These aspects affected the cost structure, e.g., the costs borne to develop and continuously update the optimization algorithms or acquire technologies.

To exploit emerging opportunities related to DTs, the firm then decided to revise its value proposition, toward a more effective and tailor-made offer of customized EESs by leveraging a deep knowledge of its customers (based on data *c*ollected and analyzed). Contractual models offered did not record a significant change.

E. Firm E

1) Traditional BM Outline: Firm E offered EES targeting large energy-intensive players in the industrial and tertiary sectors.

On the one hand, EESs offered to the industrial sector are mainly focused on the production process and ancillary services layout, which were usually proposed through guaranteed-savings EPC. Although Firm E might finance energy efficiency projects, customers usually provided the financial resources needed; therefore, the impact on the firm's cost structure was quite limited. Revenues enjoyed by the company correspond to a fee based on the level of energy savings achieved through the energy efficiency intervention, while the energy savings were entirely enjoyed by the end-user (who supported the investment's financial risk) till a specific energy saving target was reached (while the eventual extra-savings were shared between the firm and the customer). On the other hand, EESs offered to the tertiary sector were mainly focused on plants installed within buildings through turnkey contracts.

Customers represented strategic partners, especially in the industrial sector, as long-lasting relationships were typically set up, in which customers supported the firm in designing EESs and reaching other customers through word of mouth. Moreover, Firm E took on other partnerships with technology providers. As far as internal resources are concerned, Firm E leveraged its technical capabilities to carry out EPCs, by managing related risks. Internal competences were also exploited to carry out energy audits to identify energy efficiency opportunities and to create a network of technology providers to identify the best EES that fit with customers' needs.

2) BMI Process Enabled by DTs: The digitalization trend considerably affected Firm E's BM. In particular, Firm E developed an energy monitoring and diagnostic platform that can be integrated within customers' information systems. The platform suggests corrective actions to reduce energy consumption, by leveraging Big Data analysis through which predictive hypotheses on energy consumption patterns are formulated.

The digital platform was internally developed by Firm E. In such an endeavor, the firm involved external parties, such as research centers and universities, to complement internal know-how. In particular, hackathons and start-up challenges were organized to gather insightful external inputs to inform the internal development of the platform. As a result, the cost structure was affected by the platform development of as well as training activities for human resources to exploit such platform. Moreover, the continuous improvement of the energy platform was reckoned to be a strategic activity to exploit the developed DT, together with the Big Data analysis and the related predictive models based on these analyses. Moreover, Firm E strove to integrate its systems and technologies with the ones at the customers' premises, facilitating the interaction between these systems and, in turn, reducing the costs of these interventions.

The exploitation of the DTs then pushed Firm E to enrich its value proposition, by stressing the data-driven approach to bring into light and evaluate energy efficiency opportunities. Instead, customer segments did not record any major change, as Firm E continued targeting large energy-intensive players in both the industrial and the service sectors. Contractual agreements did not record a significant change too; the same applies for revenues streams, though they were positively affected by a stronger firm's brand reputation linked to the exploitation of the DT.

F. Firm F

1) Traditional BM Outline: Firm F offered traditional EESs targeting small to medium-sized customers belonging to the industrial sector. Energy efficiency projects were carried out through both turnkey contracts and EPCs. Regarding the latter, the firm typically offered guaranteed-savings EPC, enjoying a fee based on the performance achieved through the energy efficiency interventions. The impact on the cost structure was relatively low, as customers were typically in charge for the related investment. The firm then started proposing shared-savings EPCs, in which it obtained a prearranged quota of the achieved energy savings, while bearing the investment costs. When offering shared-savings EPCs, financial institutions and banks played a strategic role by providing the required financial resources.

Focusing on key resources, the firm highly valued its financial resources and the possibility to gather them from financial institutions. Among key activities, energy audits were crucial to spot energy efficiency opportunities and increase energy efficiency projects effectiveness. Furthermore, key activities referred to EESs design. Lastly, when EPCs were carried out, monitoring

and analyzing the energy consumption patterns were considered as key activities, thus carried out through internal resources.

2) BMI Process Enabled by DTs: To leverage the digitalization trend, Firm F decided to extend its offer with smart metering systems to monitor energy consumptions and identify timely corrective actions.

These systems were internally developed by the firm, through the establishment of a small, dedicated team. To support the design and development of such systems, Firm F also collaborated with external partners. Accordingly, the development and subsequent exploitation of DTs increased the number of suppliers and partners leveraged by Firm F, as both hardware suppliers and software developers started to be considered as crucial within the firm's value architecture. In this scenario, activities related to the analysis and monitoring of consumption patterns were considered as strategic, as they allowed the optimization of energy consumption through algorithms and technologies based on the Internet of Things. The firm's strategic resources continued to include the technical competences of its human resources (which are critical to design the technological solutions offered), as well as financial resources. Moreover, partnerships with third-party companies for the commercialization of the developed systems were put in place.

Smart metering systems were then integrated within a web platform, which was acquired by a technology provider. Firm F chose not to internally develop this platform, to have the chance to select different suppliers over time to continuously update it.

The exploitation of DTs did not significantly affect the firm's value proposition, but it allowed the firm to strengthen its offer, with a positive impact on revenues. For example, exploiting DTs led to reducing the performance risk, especially when implementing guaranteed-savings EPCs, which typically led to higher energy savings. Regarding the cost structure, the expenses borne for the staff and the personnel increased, as well as those for the design, development, and update of the smart metering systems.

G. Firm G

1) Traditional BM Outline: Firm G offered a large array of EESs, which mainly targeted customers within the industrial sector, especially through turnkey contracts.

In addition to collaborations with the technology providers, which allowed the firm to select the most suitable EESs based on customers' needs, Firm G embarked on several partnerships with other firms to jointly design and implement projects. Energy audits and technical evaluations represented the most relevant activities carried out by the firm. When shared-savings EPCs were offered, the assessment of customers' solvency and creditworthiness assumed a huge relevance. Accordingly, human resources played a critical role, as they represented the main value-added asset of Firm G thanks to their technical competences.

2) BMI Process Enabled by DTs: The exploitation of DTs only marginally affected Firm G's BM. The only initiative carried out by the firm referred to the development of a web platform to monitor customers' energy consumptions over time, in order to bring into light energy savings opportunities (without advanced capabilities such as Big Data analysis).

The web platform was developed by exploiting internal competences, also with the support of an academic spin-off. Once understood the potential benefits of this collaboration, even beyond the development of the platform (i.e., to exploit it), Firm G decided to hire the spin-off employees and involve them within a brand-new internal business unit, with an impact on the firm's cost structure.

This initiative did not significantly affect the revenue streams and the cost structure characterizing the firm. On the one hand, it just represented an additional tool to better satisfy customers' needs. The opportunities unlocked by the platform referred to the analysis of energy consumption and, hence, the energy savings obtained through an energy efficiency intervention, eventually simplifying the procedure to require and obtain white certificates.

H. Firm H

1) Traditional BM Outline: The main customer segments targeted by Firm H while carrying out energy efficiency projects referred to large energy-consuming players in the industrial sector as well as players in the tertiary sector.

The firm's value proposition included enabling energy efficiency and comfort improvement within a building or an industrial plant. In the tertiary sector, the firm offered several EESs to make buildings more efficient, including advanced monitoring systems, mainly through turnkey contracts. In the industrial sector, Firm H provided customers with traditional EESs as well as more advanced monitoring systems (the latter being associated to a very limited number of initiatives, mainly through shared-savings EPC). The cost structure was strongly affected by the investment cost borne to carry out the investment through EPCs and the related financial expenses.

Firm H took on a strategic partnership with its mother company that produced facades and, hence, provided the firm with some of the key technologies for the promoted energy efficiency projects. Other strategic collaborations were in place with other technology providers, which provided the firm with both hardware and, particularly, software. Among key resources, human resources were the most value-added ones, as each manager or engineer's competencies represented a critical resource in Firm H's value architecture. Human resources also played a critical role in pushing innovation, which was typically managed internally. In the industrial sector, the firm reckoned energy audits as a core activity, as they represented a fundamental step to identify the energy efficiency opportunities. In the building sector, instead, comfort checks were characterized by higher importance than energy audits. Indeed, through comfort checks, Firm H could evaluate the current comfort level within a building in a quick and nonintrusive manner and identify rooms for improvement.

2) BMI Process Enabled by DTs: The firm started offering (basic) digital-based solutions to its customers since its establishment; however, a deep exploitation of DTs started in the last years by increasingly integrating DTs within its offer. This

mainly happened through the development of a software based on AI algorithms to improve the indoor air quality and another software to optimize energy consumption patterns.

Firm H internally developed such DTs, also exploiting external collaborations to complement its internal competences. Such collaborations involved universities, research centers, firms belonging to the energy efficiency sector, and software houses. Software and optimization algorithms are considered strategic resources by Firm H to convey its offer, which in turn nurtured the firm's brand image. Accordingly, the design and development of the optimization algorithms were key activities, in addition to data analysis to increase the effectiveness of energy efficiency projects, which implied a substantial spike in the R&D expenses borne by Firm H, particularly related to software development and update.

The exploitation of DTs pushed the firm to change its value proposition, to properly emphasize (and share with customers) the opportunities associated to DTs exploitation. Indeed, DT exploitation led to higher energy savings, while reducing both the costs associated to design and consultancy activities (which became more effective and efficient, thus implying significant benefits that could be partially shared with customers).

Following the revision of the value proposition, the firm decided to change customer relationships too. Indeed, while before the exploitation of DTs the firm needed to contact end-users and propose its services, the stronger brand image due to DTs exploitation increased the number of customers' requests. Nevertheless, to tackle the lack of awareness on these solutions by many potential customers, the firm promoted some initiatives to increase such awareness. As a result, Firm H succeeded in unlocking further revenue streams by exploiting new contractual forms (i.e., EPCs), as DTs positively affected the performance and service levels offered by the firm.

V. Discussion

An overview of the BMI process characterizing each investigated firm is reported in Table III, with reference to the four BM pillars identified by Dubosson-Torbay et al. [30], i.e., product, customer interface, infrastructure management, and financial aspects. In particular, numbers (from 1 to 4) refer to the chronological order of the different phases of the BMI process carried out by each firm; letters ("a" and "b") refer to subphases characterizing some phases, while the apostrophe indicates that a specific subphase (e.g., 1a') is the result of another one (e.g., 1a).

First, the empirical analysis shows that the exploitation of DTs affects the different BM pillars of investigated firms, even those with a rather limited exploitation of such technologies. Among such pillars, the infrastructure management is the mostly affected one, since all the analyzed firms showed its evolution to effectively exploit opportunities associated to DTs.

Interestingly, such pillar is the first one that is addressed by firms while innovating their BM to exploit DTs. In particular, two main activities carried out by firms can be identified, i.e., the acquisition of DTs and the following exploitation of such technologies.

To acquire DTs, two different recurrent approaches emerge: i) internal development, in which a firm mainly exploits internal competences and resources to develop DTs, even with the support of external parties such as universities, technology providers, and software houses; ii) acquisition, in which a firm acquires DTs developed by external parties. This choice is mainly affected by the availability of internal resources to internally develop DTs. For example, Firm D implemented the first approach for the comfort-related DTs and the second one for the energy-related DTs. It is worth highlighting that, even though ESCOs have not typically been in charge for the development of traditional EESs, the interest toward DTs' internal development stems from the fact that they are perceived as a potential source of competitive advantage. In this vein, some firms (e.g., Firms B and G) decided to internalize external competences to develop DTs by hiring university researchers, consequently to a positive interaction with them. Furthermore, the cases show that firms reckon DTs to be a strategic asset to offer enhanced services to end-users. In fact, digitalization increased the relevance of data analyses and data science activities to achieve energy savings. Therefore, crucial importance is given to integrating DTs with the systems already in place at customers premises, especially when long-lasting relationships with customers are established. Finally, algorithms and energy platforms undergo continuous development and updates to increase their effectiveness over time.

Then, the following exploitation of DTs, such as smart energy management systems and digital (energy) platforms, typically require further changes to the infrastructure management pillar, in terms of key resources, activities, and partners. This occurs as internal resources are typically not enough to successfully exploit DTs. Therefore, firms are required to take on partnerships and collaborations to expand its pool of available resources and capabilities, as well as to create an internal unit aimed at integrating internal and external resources and capabilities. Such initiatives in turn affect the cost structure characterizing the firms' BM, regarding R&D costs (which refers, for example, to the costs incurred to establish and nurture the interaction with external parties), costs for human resources to be hired (as further and skilled employees are needed to favor the exploitation of DTs), and costs for the development and update of energy management software, platforms, and algorithms, which represent novel (digital) key resources.

Among the analyzed firms, Firms A, F, and G are the only three that are at this stage. Instead, the other cases show that the redesign of the infrastructure management pillar is followed by (at least) the redesign of the product pillar. Indeed, following an initial phase when DTs are perceived as complementary technologies (rather than a key factor for sustaining the firms' competitive advantage), the other firms decided to display and integrate DTs within their value proposition, to make customers more and more aware of the opportunities unlocked by DTs exploitation. In some cases, such initiative determined an increase of the revenues. However, on the one hand, additional revenues are not comparable to the main streams; on the other hand, such revenue streams did not typically require an amendment of the revenue models exploited by firms (e.g., moving from turnkey

TABLE III
OVERVIEW OF THE BMI PROCESS ENABLED BY DTS FOR THE SAMPLED FIRMS

Firm	Product	Customer interface	Infrastructure management	Financial aspects
Firm A	*Unchanged*	*Unchanged*	**1a) DTs acquisition**: internal development (establishment of a working group to enable the integration of the offered EESs with the information systems at customers' premises) **1b) DTs exploitation**: new key resources, activities, and partnerships	**1b') Related new costs:** costs for training activities
Firm B	**2) New value proposition**: to stress the opportunities for customers associated to DTs exploitation	**3) New target customer segments** (i.e., tertiary and residential sectors)	**1a) DTs acquisition**: internal development (creation of a new internal unit; support by external parties) **1b) DTs exploitation**: new key resources (including hiring new employees), activities, and partnerships	**1a', 1b') Related new costs:** costs for external support and related to new key resources, activities, and partnerships **3') Related new revenues** (enabled by new target customers)
Firm C	**2) New value proposition**: to stress the opportunities for customers associated to DTs exploitation	**3) Higher focus on customers relationship management** to make customers aware of the benefits provided by DTs	**1a) DTs acquisition**: internal development (with the support of an external party) **1b) DTs exploitation:** new key resources and activities	**1b') Related new costs:** costs for external support **3') Related new revenues** (up-selling / cross-selling)
Firm D	**2) New value proposition**: to stress the opportunities for customers associated to DTs exploitation	*Unchanged*	**1a) DTs acquisition**: internal development (comfort-related DT); acquisition (energy monitoring and management-related DT) **1b) DTs exploitation**: new key resources, activities, and partnerships	**1a' – 1b') Related new costs:** costs for DT acquisition (energy monitoring and management-related DT) and related to new key resources, activities, and partnerships
Firm E	**2) New value proposition**: to stress the opportunities for customers associated to DTs exploitation	*Unchanged*	**1a) DTs acquisition**: internal development (with the support of external parties) **1b) DTs exploitation**: new key resources and activities	**1b') Related new costs:** costs for external support
Firm F	*Unchanged*	*Unchanged*	**1a) DTs acquisition:** internal development (with the support of external parties) (smart metering systems); acquisition (digital platform) **1b) DTs exploitation**: new key resources, activities, and partnerships	**1a' – 1b') Related new costs:** costs for DT acquisition (platform) and related to new key resources, activities, and partnerships
Firm G	*Unchanged*	*Unchanged*	**1a) DTs acquisition**: internal development (with the support of external parties) **1b) DTs exploitation:** new key resources and activities	**1a' – 1b') Related new costs**: costs for external support and hiring
Firm H	**2) New value proposition**: to stress the opportunities for customers associated to DTs exploitation	**3) Higher focus on customers relationship management** to make customers aware of the benefits provided by DTs	**1a) DTs acquisition**: internal development (with the support of external parties) **1b) DTs exploitation**: new key resources and activities	**1a' – 1b') Related new costs:** costs for DTs internal development and external support **3') Related new revenues** (up-selling / cross-selling) **4) New revenue streams** (EPCs)

contracts to EPCs). Among the analyzed firms, Firms D and E are the only two that are at this stage.

Then, in two cases (i.e., Firms B and C) the redesign of customer interface pillar follows, with reference to the targeted customer segments (through which a firm starts to target new market segments) as well as the customers relationship management. For example, Firm B, which originally targeted players in the industrial sector, leveraged DTs to target other sectors, i.e., buildings owners (belonging to both the residential and tertiary sectors). Instead, Firm C (being a utility as its core business) started to target segments that it traditionally never reached as a utility, and even modified the relationships with its customers. Utilities, indeed, generally never interacts with clients after delivering its offer. Vice versa, the presence of DTs strengthened the relationship between the firm and its customers, as a mutual effort is critical to deliver the DTs-enabled value proposition. The consequent impacts on revenue streams typically refer to additional revenues realized through up-selling

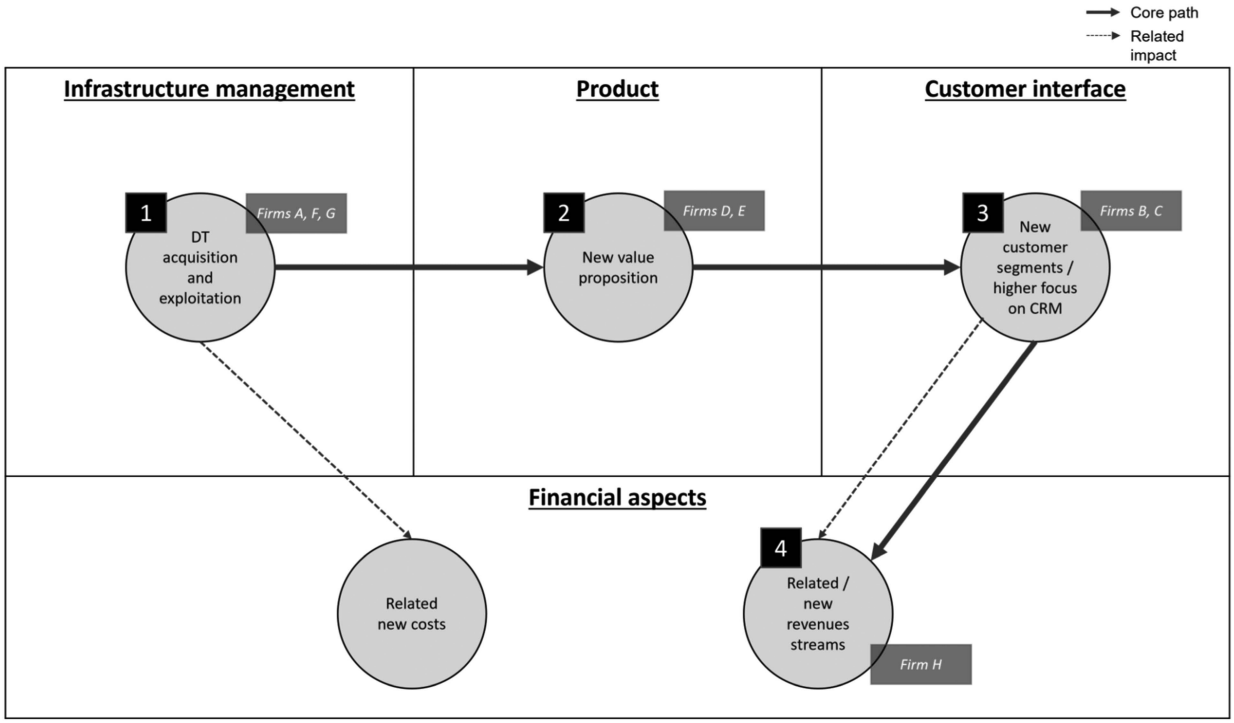

Fig. 1. BMI process enabled by DTs.

and cross-selling strategies, e.g., by allowing a firm to offer more technologies.

Finally, in only one case (i.e., Firm H), the new customer segments addressed as well as the better customer relationship management enabled an amendment of the revenue models exploited by firms. Indeed, the increased service and performance levels achieved through DTs enabled the firm to offer EPCs.

All in all, from the empirical analysis a common path followed by the investigated firms in innovating their BM to exploit DTs does emerge. In particular, the BMI process includes four stages, as depicted in Fig. 1:

1) Redesign of the infrastructure management pillar (and related impact on the financial aspects – with reference to the cost structure).
2) Redesign of the product pillar.
3) Redesign of the customer interface pillar (and related impact on the financial aspects – with reference to the revenue streams).
4) Redesign of the financial aspects (with reference to new revenue streams).

VI. Conclusion

A. Theoretical, Practical, and Policy Implications

Our study provides several theoretical and practical implications. From a theoretical perspective, we contribute to the BMI literature [35], [36], [49] by showing how a specific typology of technology, as DTs, may trigger BMI in the energy sector and how this process unravels through different phases. In particular, we show that DTs may push firms as ESCOs to transform their BM starting with the development or acquisition of the needed DT, on the basis of which the firm changes its value proposition and, consequently, may address new customers or tighten the relationship with existing one. This process also affects the financial aspects, since costs and revenues are influenced by the adoption and implementation of DTs and by the earnings from new and existing customers. Accordingly, we identify an archetype of DTs-enabled BMI in the energy sector that may become the basis for further research on BMI in this peculiar industry. Furthermore, by looking at the different stages of the process through which firms as ESCOs can innovate their BM, we also contribute to the extant studies that have been focusing on the transformation of the BMs (e.g., [37] and [41]). In addition, our findings also contribute to the emerging digital transformation literature (e.g., [7] and [58]). In fact, we clarify and provide evidence of the paramount role that DTs assume nowadays in supporting firms in the energy sector improving value creation, delivery, and appropriation, and how they can actually trigger BMI. Indeed, the digital transformation process is not straightforward and many difficulties could emerge (e.g., [11]). Accordingly, the findings of our study highlight how ESCOs can effectively leverage DTs to enhance their business activities. From a practical perspective, our analysis shows that the DTs-enabled BMI by ESCOs follows a specific path that may serve as an inspiration to firms transforming their BMs by leveraging the adoption of DTs. Indeed, this path may represent, for other firms in the energy sector, an ideal and effective process to reconfigure their BM, hence these firms may use the spotted archetype as a roadmap to effectively drive their BMI process. In this way, firms can reduce frictions and inefficiencies that could emerge during the BMI process. In addition, we recommend firms to use these results as ideal inspiration, being prompt

to adapt and revise them to match extant internal and external conditions. Finally, our study is grounded in the energy sector, being inferred from case studies of ESCOs. Therefore, the results of this research could be leveraged by policymakers to define supporting policies to facilitate the adoption of DTs by ESCOs and ease their BMI, consequently increasing the effectiveness and efficiency of their businesses to foster energy transition.

B. Limitations and Further Research

Our study is not exempt from limitations that can spur further research. First, our analysis is based on Italian ESCOs. Hence, to increase the generalizability of our analysis, further research may investigate different institutional contexts. This may be relevant to perform cross-industry and cross-national analyses that may allow to spot the existence of context-specific factors affecting DTs-enabled BMI. Second, nonetheless the study is based on multiple case study, it would be interesting to validate our result on an extensive sample. Further research could adopt quantitative analysis based on a larger sample, to confirm the theory we build in this research. Analyzing the effectiveness and the efficiency of the archetypal path to BMI in different conditions could be helpful, both from a theoretical and practical perspective, to dig deeper into the different characteristics that make firms more or less mature to innovate their BMs by integrating DTs. Finally, more and more studies are analyzing the micro-level factors that affect firms' macro processes [59]. Considering the role of dynamic capabilities in BMI (e.g., [17]), further analyses may assume this perspective and investigate how factors at individual level may affect the firms' dynamic capabilities and, consequently, the DTs-enabled BMI. This would provide a clearer picture on the factors driving the effectiveness of the BMI process.

References

[1] B. K. AlNuaimi, S. K. Singh, S. Ren, P. Budhwar, and D. Vorobyev, "Mastering digital transformation: The nexus between leadership, agility, and digital strategy," *J. Bus. Res.*, vol. 145, pp. 636–648, Jun. 2022, doi: 10.1016/j.jbusres.2022.03.038.

[2] European Institute of Innovation & Technology, "Digital transformation of European industry, a policy perspective. Full report," Sep. 2021. Accessed: Dec. 20, 2022. [Online]. Available: https://eit.europa.eu/library/digital-transformation-European-industry-policy-perspective-full-report

[3] S. Ghosh, M. Hughes, I. Hodgkinson, and P. Hughes, "Digital transformation of industrial businesses: A dynamic capability approach," *Technovation*, vol. 113, May 2022, Art. no. 102414, doi: 10.1016/j.technovation.2021.102414.

[4] F. P. Appio, F. Frattini, A. M. Petruzzelli, and P. Neirotti, "Digital transformation and innovation management: A synthesis of existing research and an agenda for future studies," *J. Prod. Innov. Manage.*, vol. 38, no. 1, pp. 4–20, 2021, doi: 10.1111/jpim.12562.

[5] F. Pigni, G. Piccoli, and R. Watson, "Digital data streams: Creating value from the real-time flow of big data," *California Manage. Rev.*, vol. 58, no. 3, pp. 5–25, May 2016, doi: 10.1525/cmr.2016.58.3.5.

[6] S. Nambisan, "Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship," *Entrepreneurship Theory Pract.*, vol. 41, no. 2, pp. 1029–2055, 2017, doi: 10.1111/etap.12254.

[7] G. Lanzolla and J. Anderson, "The digital revolution is over. Long live the digital revolution!," *Bus. Strategy Rev.*, vol. 21, no. 1, pp. 74–77, 2010, doi: 10.1111/j.1467-8616.2010.00650.x.

[8] F. Sussan and Z. J. Acs, "The digital entrepreneurial ecosystem," *Small Bus. Econ.*, vol. 49, no. 1, pp. 55–73, Jun. 2017, doi: 10.1007/s11187-017-9867-5.

[9] D. J. Teece, "Business models, business strategy and innovation," *Long Range Plan.*, vol. 43, no. 2–3, pp. 172–194, Apr. 2010, doi: 10.1016/j.lrp.2009.07.003.

[10] M. Iansiti and K. R. Lakhani, "Digital ubiquity: How connections, sensors, and data are revolutionizing business," *Harvard Bus. Rev.*, vol. 92, no. 11, pp. 90–99, 2014.

[11] A. Correani, A. De Massis, F. Frattini, A. M. Petruzzelli, and A. Natalicchio, "Implementing a digital strategy: Learning from the experience of three digital transformation projects," *California Manage. Rev.*, vol. 62, no. 4, pp. 37–56, Aug. 2020, doi: 10.1177/0008125620934864.

[12] M. Ardolino, M. Rapaccini, N. Saccani, P. Gaiardelli, G. Crespi, and C. Ruggeri, "The role of digital technologies for the service transformation of industrial companies," *Int. J. Prod. Res.*, vol. 56, no. 6, pp. 2116–2132, Mar. 2018, doi: 10.1080/00207543.2017.1324224.

[13] C. Klos, P. Spieth, T. Clauss, and C. Klusmann, "Digital transformation of incumbent firms: A business model innovation perspective," *IEEE Trans. Eng. Manage.*, vol. 70, no. 6, pp. 2017–2033, Jun. 2023, doi: 10.1109/TEM.2021.3075502.

[14] F. Rummel, S. Hüsig, and S. Steinhauser, "Two archetypes of business model innovation processes for manufacturing firms in the context of digital transformation," *R&D Manage.*, vol. 52, no. 4, pp. 685–703, 2022, doi: 10.1111/radm.12514.

[15] C. Richter, S. Kraus, A. Brem, S. Durst, and C. Giselbrecht, "Digital entrepreneurship: Innovative business models for the sharing economy," *Creativity Innov. Manage.*, vol. 26, no. 3, pp. 300–310, 2017, doi: 10.1111/caim.12227.

[16] V. Ranta, L. Aarikka-Stenroos, and J.-M. Väisänen, "Digital technologies catalyzing business model innovation for circular economy—Multiple case study," *Resour., Conservation, Recycling*, vol. 164, Jan. 2021, Art. no. 105155, doi: 10.1016/j.resconrec.2020.105155.

[17] J. Soluk, I. Miroshnychenko, N. Kammerlander, and A. De Massis, "Family influence and digital business model innovation: The enabling role of dynamic capabilities," *Entrepreneurship Theory Pract.*, vol. 45, no. 4, pp. 867–905, Jul. 2021, doi: 10.1177/1042258721998946.

[18] V. M. M. Latilla, A. Urbinati, A. Cavallo, S. Franzò, and A. Ghezzi, "Organizational re-design for business model innovation while exploiting digital technologies: A single case study of an energy company," *Int. J. Innov. Technol. Manage.*, vol. 18, no. 02, Apr. 2021, Art. no. 2040002, doi: 10.1142/S0219877020400027.

[19] W. S. Fang, S. M. Miller, and C.-C. Yeh, "The effect of ESCOs on energy use," *Energy Policy*, vol. 51, pp. 558–568, Dec. 2012, doi: 10.1016/j.enpol.2012.08.068.

[20] G. Kalt, D. Wiedenhofer, C. Görg, and H. Haberl, "Conceptualizing energy services: A review of energy and well-being along the energy service cascade," *Energy Res. Soc. Sci.*, vol. 53, pp. 47–58, Jul. 2019, doi: 10.1016/j.erss.2019.02.026.

[21] P. Bertoldi, S. Rezessy, and E. Vine, "Energy service companies in European countries: Current status and a strategy to foster their development," *Energy Policy*, vol. 34, no. 14, pp. 1818–1832, Sep. 2006, doi: 10.1016/j.enpol.2005.01.010.

[22] E. Cagno, S. Franzò, E. Storoni, and A. Trianni, "A characterisation framework of energy services offered by energy service companies," *Appl. Energy*, vol. 324, Oct. 2022, Art. no. 119674, doi: 10.1016/j.apenergy.2022.119674.

[23] J. Nieto-Martin and D. W. Bunn, "Enabling automated transparency for the market participation of ESCOs with blockchain," in *Proc. IEEE Power Energy Soc. Gen. Meeting*, 2018, pp. 1–5. doi: 10.1109/PESGM.2018.8586109.

[24] S. Pätäri and K. Sinkkonen, "Energy service companies and energy performance contracting: Is there a need to renew the business model? Insights from a Delphi study," *J. Cleaner Prod.*, vol. 66, pp. 264–271, Mar. 2014, doi: 10.1016/j.jclepro.2013.10.017.

[25] J. Aranda, T. Tsitsanis, G. Georgopoulos, and J. M. Longares, "Innovative data-driven energy services and business models in the domestic building sector," *Sustainability*, vol. 15, no. 4, Jan. 2023, Art. no. 3742, doi: 10.3390/su15043742.

[26] P. Makris et al., "Digitization era for electric utilities: A novel business model through an inter-disciplinary S/W platform and open research challenges," *IEEE Access*, vol. 6, pp. 22452–22463, 2018, doi: 10.1109/ACCESS.2018.2828323.

[27] S. Subramanian et al., "International energy efficiency scorecard," Washington, DC, USA, American Council for an Energy-Efficient Economy, 2022. Accessed: Dec. 23, 2022. [Online]. Available: https://www.aceee.org/research-report/i2201

[28] A. Pantaleo, C. Candelise, A. Bauen, and N. Shah, "ESCO business models for biomass heating and CHP: Profitability of ESCO operations in Italy and key factors assessment," *Renewable Sustain. Energy Rev.*, vol. 30, pp. 237–253, Feb. 2014, doi: 10.1016/j.rser.2013.10.001.
[29] M. Morris, M. Schindehutte, and J. Allen, "The entrepreneur's business model: Toward a unified perspective," *J. Bus. Res.*, vol. 58, no. 6, pp. 726–735, Jun. 2005, doi: 10.1016/j.jbusres.2003.11.001.
[30] M. Dubosson-Torbay, A. Osterwalder, and Y. Pigneur, "E-business model design, classification, and measurements," *Thunderbird Int. Bus. Rev.*, vol. 44, no. 1, pp. 5–23, 2002, doi: 10.1002/tie.1036.
[31] A. Osterwalder, Y. Pigneur, and C. L. Tucci, "Clarifying business models: Origins, present, and future of the concept," *Commun. Assoc. Inf. Syst.*, vol. 16, pp. 1–25, 2005.
[32] R. Casadesus-Masanell and J. E. Ricart, "From strategy to business models and onto tactics," *Long Range Plan.*, vol. 43, no. 2–3, pp. 195–215, Apr. 2010, doi: 10.1016/j.lrp.2010.01.004.
[33] K. Antonopoulou and C. Begkos, "Strategizing for digital innovations: Value propositions for transcending market boundaries," *Technol. Forecasting Social Change*, vol. 156, Jul. 2020, Art. no. 120042, doi: 10.1016/j.techfore.2020.120042.
[34] A. Annarelli, C. Battistella, and F. Nonino, "Competitive advantage implication of different product service system business models: Consequences of 'not-replicable' capabilities," *J. Cleaner Prod.*, vol. 247, Feb. 2020, Art. no. 119121, doi: 10.1016/j.jclepro.2019.119121.
[35] N. J. Foss and T. Saebi, "Fifteen years of research on business model innovation: How far have we come, and where should we go?," *J. Manage.*, vol. 43, no. 1, pp. 200–227, Jan. 2017, doi: 10.1177/0149206316675927.
[36] T. Saebi, L. Lien, and N. J. Foss, "What drives business model adaptation? The impact of opportunities, threats and strategic orientation," *Long Range Plan.*, vol. 50, no. 5, pp. 567–581, Oct. 2017, doi: 10.1016/j.lrp.2016.06.006.
[37] M. Paiola, L. Agostini, R. Grandinetti, and A. Nosella, "The process of business model innovation driven by IoT: Exploring the case of incumbent SMEs," *Ind. Marketing Manage.*, vol. 103, pp. 30–46, May 2022, doi: 10.1016/j.indmarman.2022.03.006.
[38] S. Leminen, M. Rajahonka, R. Wendelin, and M. Westerlund, "Industrial Internet of Things business models in the machine-to-machine context," *Ind. Marketing Manage.*, vol. 84, pp. 298–311, Jan. 2020, doi: 10.1016/j.indmarman.2019.08.008.
[39] C. Cheng and L. Wang, "How companies configure digital innovation attributes for business model innovation? A configurational view," *Technovation*, vol. 112, Apr. 2022, Art. no. 102398, doi: 10.1016/j.technovation.2021.102398.
[40] D. Sjödin, V. Parida, M. Palmié, and J. Wincent, "How AI capabilities enable business model innovation: Scaling AI through co-evolutionary processes and feedback loops," *J. Bus. Res.*, vol. 134, pp. 574–587, Sep. 2021, doi: 10.1016/j.jbusres.2021.05.009.
[41] M. Karami, W. W. Baber, and A. Ojala, "The effectual process of business model innovation for seizing opportunities in frontier markets," *Technovation*, vol. 117, pp. 102595, Sep. 2022, doi: 10.1016/j.technovation.2022.102595.
[42] T. C. K. Andersen, A. Aagaard, and M. Magnusson, "Exploring business model innovation in SMEs in a digital context: Organizing search behaviours, experimentation and decision-making," *Creativity Innov. Manage.*, vol. 31, no. 1, pp. 19–34, Mar. 2022, doi: 10.1111/caim.12474.
[43] M. Palmié, L. Miehé, P. Oghazi, V. Parida, and J. Wincent, "The evolution of the digital service ecosystem and digital business model innovation in retail: The emergence of meta-ecosystems and the value of physical interactions," *Technological Forecasting Social Change*, vol. 177, Apr. 2022, Art. no. 121496, doi: 10.1016/j.techfore.2022.121496.
[44] D. Sjödin, V. Parida, and I. Visnjic, "How can large manufacturers digitalize their business models? A framework for orchestrating industrial ecosystems," *California Manage. Rev.*, vol. 64, no. 3, pp. 49–77, May 2022, doi: 10.1177/00081256211059140.
[45] T. Burström, V. Parida, T. Lahti, and J. Wincent, "AI-enabled business-model innovation and transformation in industrial ecosystems: A framework, model and outline for further research," *J. Bus. Res.*, vol. 127, pp. 85–95, Apr. 2021, doi: 10.1016/j.jbusres.2021.01.016.
[46] W. Irrek, N. Labanca, P. Bertoldi, and F. Suerkemper, "ESCOs for residential buildings: Market situation in the European Union and policy recommendations," *JRC Pub. Repository*, Jan. 23, 2014. Accessed: Mar. 27, 2023. [Online]. Available: https://publications.jrc.ec.europa.eu/repository/handle/JRC79856
[47] C. Loebbecke and A. Picot, "Reflections on societal and business model transformation arising from digitization and big data analytics: A research agenda," *J. Strategic Inf. Syst.*, vol. 24, no. 3, pp. 149–157, Sep. 2015, doi: 10.1016/j.jsis.2015.08.002.
[48] A. Sorescu, "Data-driven business model innovation," *J. Prod. Innov. Manage.*, vol. 34, no. 5, pp. 691–696, Sep. 2017, doi: 10.1111/jpim.12398.
[49] R. Amit and C. Zott, "Value creation in E-business," *Strategic Manage. J.*, vol. 22, no. 6–7, pp. 493–520, Jun. 2001, doi: 10.1002/smj.187.
[50] K. M. Eisenhardt, "Building theories from case study research," *Acad. Manage. Rev.*, vol. 14, no. 4, Oct. 1989, Art. no. 532, doi: 10.2307/258557.
[51] R. K. Yin, *Case Study Research: Design and Methods*, 3rd ed. Thousand Oaks, CA, USA: SAGE, 2003.
[52] P. Ghauri, K. Grønhaug, and R. Strange, *Research Methods in Business Studies*, 5th ed. Cambridge, U.K.: Cambridge Univ. Press, 2020.
[53] C. Voss, N. Tsikriktsis, and M. Frohlich, "Case research in operations management," *Int. J. Oper. Prod. Manage.*, vol. 22, no. 2, pp. 195–219, Feb. 2002, doi: 10.1108/01443570210414329.
[54] I. Holloway, *Basic Concepts for Qualitative Research*. London, U.K.: Wiley, 1997.
[55] P. Eriksson and A. Kovalainen, *Qualitative Methods in Business Research: A Practical Guide to Social Research*. Croydon, U.K.: SAGE, 2015.
[56] W. M. Tellis, "Application of a case study methodology," *Qualitative Rep.*, vol. 3, no. 3, pp. 1–19, 1997.
[57] R. P. Weber, *Basic Content Analysis*. Newbury Park, CA, USA: SAGE, 1990.
[58] G. Lanzolla and J. Anderson, "Digital transformation," *Bus. Strategy Rev.*, vol. 19, no. 2, pp. 72–76, Jun. 2008, doi: 10.1111/j.1467-8616.2008.00539.x.
[59] T. Felin, N. J. Foss, K. H. Heimeriks, and T. L. Madsen, "Microfoundations of routines and capabilities: Individuals, processes, and structure: Microfoundations of routines and capabilities," *J. Manage. Stud.*, vol. 49, no. 8, pp. 1351–1374, Dec. 2012, doi: 10.1111/j.1467-6486.2012.01052.x.

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