Problemy Zarządzania – Management Issues, vol. 17, no. 2(82): 32–52
ISSN 1644-9584, © Wydział Zarządzania UW
DOI 10.7172/1644-9584.82.2

Technology, Business Models and Competitive Advantage in the Age of Industry 4.0

Submitted: 07.01.19 | Accepted: 29.03.19

Lesław Pietrewicz*

Industry 4.0 is a concept which sets out a way of understanding the observed revolutionary changes in the organization of manufacturing processes and their impact on businesses and societies. The scale and scope of changes already underway are seen as so large as to mark the advent of a new industrial age. While technology innovation is widely recognized as a key determinant of firm success in this new age, the role of business models (BMs) and business model innovation (BMI) remains understudied, and therefore potentially underestimated in this setting. Thus, the aim of this paper is to analyze how BMs and BMI relate to technology innovation in shaping the competitive advantage of firms in the age of Industry 4.0. As the topic is far too broad for any single empirical analysis, the author's ambition is to lay theoretical groundwork for future empirical studies. To achieve that, integration and reinterpretation of several separate streams of managerial literature is required, for which interpretative literature review has been selected as the most appropriate research method.

The study shows that BMs (and thus BMI) mediate in the commercialization of new technologies, build on and leverage technology innovation, elicit and foster such innovation, and cause disruption, changing rules of the game and triggering new waves of technology innovation. As a separate type of innovation, BMI can be a source of competitive advantage superior to technology innovation. These findings suggest that focusing on technology innovation while downplaying BMI would result in only partial understanding of the sources of competitive advantage in the age of Industry 4.0.

Keywords: business model, business model innovation, Industry 4.0, technology innovation.

Technologia, modele biznesowe i przewaga konkurencyjna w erze Przemysłu 4.0

Nadesłany: 07.01.19 | Zaakceptowany do druku: 29.03.19

Przemysł 4.0 to koncepcja, która określa sposób rozumienia obserwowanych rewolucyjnych zmian w organizacji procesów produkcyjnych i ich wpływu na przedsiębiorstwa i społeczeństwa. Skala i zakres tych zmian są tak wielkie, że postrzegane są jako wyznaczające nadejście nowej ery przemysłowej. Podczas gdy innowacje technologiczne są powszechnie uznawane za kluczowy czynnik decydujący o sukcesie przedsiębiorstw w tej nowej erze, rola modeli biznesowych i innowacji modelu biznesowego pozostaje niedostatecznie zbadana, a zatem potencjalnie niedoszacowana w tym kontekście. Dlatego celem tego artykułu jest analiza, w jaki sposób modele biznesowe i innowacje modelu biznesowego odnoszą się do innowacji technologicznych w kształtowaniu przewagi konkurencyjnej firm w dobie Przemysłu 4.0.

* **Lesław Pietrewicz** – dr, Instytut Nauk Ekonomicznych PAN. https://orcid.org/0000-0002-6784-0771.

Correspondence address: Instytut Nauk Ekonomicznych PAN, 72 Nowy Świat Street, 00-330 Warsaw; e-mail: pietrewi@inepan.waw.pl.

Ministry of Science and Higher Education
Republic of Poland

The creation of the English-language version of these publications is financed in the framework of contract No. 607/P-DUN/2018 by the Ministry of Science and Higher Education committed to activities aimed at the promotion of education.

Ponieważ temat jest zbyt szeroki dla pojedynczej analizy empirycznej, ambicją autora jest położenie teoretycznych podstaw dla przyszłych badań empirycznych. Aby to osiągnąć, wymagana jest integracja i reinterpretacja kilku oddzielnych strumieni literatury menedżerskiej, dla których jako najbardziej odpowiednią metodę badawczą wybrano interpretatywny przegląd literatury.
Badanie pokazało, że modele biznesowe i (a tym samym innowacje modeli biznesowych) pośredniczą w komercjalizacji nowych technologii, wykorzystują je i rozwijają się dzięki nim, wywołują i wspierają takie innowacje, zmieniają reguły gry i wywołują nowe fale innowacji technologicznych. Jako oddzielny typ innowacje modeli biznesowych mogą być źródłem przewagi konkurencyjnej nad innowacjami technologicznymi. Wyniki te sugerują, że skupienie się na innowacjach technologicznych przy jednoczesnym bagatelizowaniu lub umniejszaniu roli innowacyjnych modeli biznesowych prowadzić może do silnie ograniczonego zrozumienia źródeł przewagi konkurencyjnej w dobie Przemysłu 4.0.

Słowa kluczowe: innowacje technologiczne, model biznesowy, Przemysł 4.0.

JEL: L23, M11, M15

1. Introduction

The unprecedented pace of technological advancement (e.g. Liu & Vasarhelyi, 2014), progressing digitalization and "datafication" (Lycett, 2013) of the business world, confluence and fusing of digital and physical technologies (e.g. Baheti & Gill, 2011; Poovendran, 2010; Schwab, 2016) and growing interconnectivity of tools and machines (e.g. Lee, Bagheri & Kao, 2015; Strange & Zucchella, 2017) that feature the present business landscape have created a broad range of challenges and opportunities that are transforming firms, business processes and the very nature of competition (Kagermann, Wahlster & Helbig, 2013; McKinsey, 2015). The scale, scope, depth and speed of changes are viewed as revolutionary (Schwab, 2016) and have been labeled the fourth industrial revolution, or Industry 4.0.

Technology and technology innovation are central to the current revolution (e.g. European Commission, 2017; European Patent Office, 2017; Kagermann et al., 2013; Liao, Deschamps, Lourdes & Ramos, 2017; Paprocki, 2016) and have long been recognized as a key determinant of firm performance (e.g. Porter, 1985b, Powell & Dent-Micallef, 1997). Against this backdrop, the aim of this paper is to analyze how business models (BMs) and business model innovation (BMI) relate to technology innovation in shaping firm competitive advantage in the age of Industry 4.0. Thus, the research problem can be viewed as the nature of the interrelationships between technology innovation and BMI in the Industry 4.0 setting.

Following an analysis of available research methods, interpretative literature review has been chosen for its utility in reaching the stated research goal, thus contributing to the recent trend of increasing popularity of this method in management studies (Czakon, 2015). The rationale behind selecting it is thoroughly explained in the methodology section of the current paper.

The remaining part of the paper is structured as follows: the second section introduces the concepts of Industry 4.0, business model and business model innovation. The third section provides the rationale behind selecting interpretative literature review as the research method for the present study. The fourth section applies the research method to the analysis of the relations between technology and competitive advantage, and the interrelationships between technology innovation and BMI; the findings are then placed in the Industry 4.0 setting. Brief discussion and concluding remarks follow.

2. Basic concepts

2.1. Industry 4.0

Over the last few years, the concept of Industry 4.0, or the fourth industrial revolution, has attracted growing attention of scholars, practitioners and politicians. Despite its popularity, however, there is no generally accepted definition of the term (Hofmann & Rüsch, 2017). Working definitions comprise a variety of technologies, applications, and processes. The term itself appeared for the first time at the Hannover Fair in 2011 in the context of the high-tech strategy of the German government promoting automation and computerization of industry (Karabegović, 2018).

Industry 4.0 is presented in the literature as the fourth consecutive industrial revolution, preceded by: (1) the introduction of water and steam-powered mechanical manufacturing; (2) the development of electrically-powered mass production technologies and the introduction of the division of labor; and (3) the use of computers to support further automation of manufacturing (e.g. Drath & Horch, 2014; Schwab, 2016).

The advent of the fourth industrial revolution was predicated on increased research attention to the Internet of Things (IoT), Cyber-Physical Systems (CPS) and corporations catalyzing and coordinating priorities around the Industrial Internet of Things (IIoT) (Liao et al., 2017). The vision of Industry 4.0 consists in smart production, smart logistics, smart grids and smart products, and the increasing use of the Internet of Things in manufacturing jointly transforming value chains and leading to the emergence of new business models (Kagermann, Wahlster & Helbig, 2013).

Advancing digital and physical technologies and their coalescing into new CPSs enable a wealth of technology ecosystems, where multiple applications communicate with each other as a network (Desmet, Maerkedahl & Shi, 2017). Thus, digital technologies extend, complement and optimize physical operations (Ibid.). Schwab (2016) notes that the "fusion" of previously separate technologies leads to a confluence of emerging technology breakthroughs. The process covers fields such as artificial intelligence, robotics, IoT, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing,

 DOI 10.7172/1644-9584.82.2

etc. These technologies can grow on each other, mutually amplifying their impact (Ibid.).

A systematic literature review conducted by Liao, Deschamps, Lourdes and Ramos (2017) has shown Cyber Physical Systems, Smart Factories and (Industrial) Internet of Things as the main enabling features of Industry 4.0. Symptomatically, although the need for the emergence of new BMs was emphasized in the defining reference report by Kagermann, Wahlster and Helbig (2013), the term "business model" was not mentioned in the entire systematic literature review by Liao et al. (2017), while even more recent narrative literature review by Schlund and Baaij (2018, p. 342) only mentions in the introduction that "completely new business models are expected". Such omission may suggest significant difficulties in integrating business model thinking into Industry 4.0 literature, motivating the current study.

2.2. Business model and business model innovation

Before integrating business model and Industry 4.0 literature, it is pertinent to properly introduce the concepts of business models and business model innovation. The term business model first appeared in academic literature in the late 1950s, but it was not until the massive diffusion of the Internet that it gained wide recognition in managerial literature and among business professionals. Since then, it has been conceived of and conceptualized at different levels of abstraction, from various perspectives and often for idiosyncratic purposes of individual studies (Zott, Amit & Massa, 2011). BM has been referred to as an architecture, design, pattern, plan, method, assumption, and statement (Morris, Schindehutte & Allen, 2005), a tool (e.g. Baden-Fuller & Haefliger, 2013, Chesbrough & Rosenbloom, 2002; Magretta, 2002) and managerial philosophy (DaSilva & Trkman, 2014).

Despite the popularity of the term, there is no consensus on its meaning (e.g. Falencikowski, 2013). In simple terms, BMs are stories which describe how firms work (Magretta 2002), or abstract representations of businesses (Al-Debei and Avison, 2010). For Timmers (1998), BM is an architecture of product, service and information flow, encompassing various business actors and their roles, and a description of revenue sources and potential benefits for individual business actors. For Chesbrough and Rosenbloom (2002, p. 529), it is "the heuristic logic that connects technical potential with the realization of economic value". According to a widely cited definition of Teece (2010, p. 172), BM describes the "design or architecture of the value creation, delivery, and capture mechanisms" of a firm; similarly, Osterwalder and Pigneur (2010, p. 14) define it as "the rationale of how an organization creates, delivers, and captures value". In another important definition, Zott and Amit (2010, p. 216) state that BM is "a system of interdependent activities that transcends the focal firm and spans its boundaries".

BMs synthesize a way of creating value in a business by explicitly including multiple sources of value (Amit & Zott, 2001), emphasizing interactions

across organizational boundaries (e.g. Patzel, Knyphausen-Aufsess, & Nikol, 2008; Timmers, 1998; Zott & Amit, 2008), and depicting relations between components which jointly produce a value proposition for customers (Demil & Lecocq, 2010) and value for a company (Sousa, Manso, Costa & Almeida, 2011). They emphasize the need for consistency (Falencikowski, 2013), both static and dynamic, between its core components (e.g. Demil & Lecocq, 2010), and also stress the need for an external fit (e.g. Morris et al. 2005; Zott and Amit, 2008). BMs create "a heuristic logic" that connects technical potential with the realization of economic value (Chesbrough & Rosenbloom, 2002), and can be viewed as narrative devices of businesses (Doganova & Eyquem-Renault, 2009; Magretta, 2002), helping firms make sense of the business in which they are engaged, thus informing strategic analysis (e.g. McGrath, 2010) and decision making (e.g. Margetta, 2002).

Managers can purposefully innovate their BMs (Mitchell & Coles, 2003). BMI can be defined as a complete reinvention of the existing business model, as opposed to revising particular parts in the course of time (Johnson, Christensen & Kagermann, 2008). In a similar vein, Wirtz, Pistoia, Ullrich and Göttel (2016) see BMI as a more comprehensive approach, with more revolutionary implications than the long-term evolutionary change of BMs. Foss and Saebi (2017) define BMI as designed, novel, nontrivial changes to the key elements of a firm's BM and/or the architecture linking these elements. Bucherer et al. (2012) define BMI as a process that deliberately changes the core elements of a firm and its business logic. Finally, Massa and Tucci (2013) see BMI as a novel way of conducting business. For the purpose of the present contribution, BMI can be defined as a highly consequential change of a business model or its core components, involving novel ways of value creation, delivery, and/or capture.

The rapidly growing interest in BMI in recent years (Foss & Saebi, 2017) can be viewed as spurred by strategic discontinuities and intense global competition (Doz & Kosonen, 2010). Johnson et al. (2008) link the need for BMI with a shifting base of competition, Voelpel, Leibold & Tekie (2004, p. 264) point at "major and unpredictable changes in the business environment" and their increased pace. Finally, some scholars (e.g. Pateli & Giaglis, 2005) find key antecedents of BMI in new opportunities brought about by the advancement of information and communication technologies. The advent of the era of Industry 4.0 can thus be expected to generate further interest in the topic.

3. Methodology

As it was stated in the introduction, the aim of this study is to analyze how business models and business model innovation relate to technology innovation in shaping the competitive advantage of firms in the age of Industry 4.0. Addressing such a broad research problem clearly exceeds the

 DOI 10.7172/1644-9584.82.2

possibilities of any single empirical study and requires the use of alternative approaches. Interpretative literature analysis has been selected as the most appropriate research method to achieve the stated goal, fitting in a trend observed in recent years in the management literature (Czakon, 2015). This methodological chapter provides rationale behind this decision, particularly in view of the often perceived, albeit not necessarily justifiably, superiority of systematic literature reviews.

The choice of literature review as a research method has been based on several premises, related to both the nature of the research question and the more general considerations of utility (value added) of various research methods. Firstly, as stated above, the research topic addressed in the paper is very broad, and literature review particularly applies to such broad research questions which cannot be addressed in a single empirical study (Baumeister & Leary, 1997). As these authors note, empirical studies may address such broad issues as implications in a speculative manner, whereas a literature reviews allow drawing relevant conclusions. Secondly, a literature reviews allow to operate at a higher level of abstraction as compared with the level of empirical studies (Ibid.), which resonates well with the aim of the study. Thirdly, the value of reviews as a broad category of research methods has been specifically acknowledged in the last two decades and it continues to grow (Ibid.), as the steadily increasing number of narrow empirical and theoretical studies impedes generalizations.

Review articles form a broad research category. However, there is no agreed set of discrete, coherent and mutually exclusive review types (Grant & Booth, 2009). Grant and Booth (2009) identify 14 types of reviews and associated methodologies used in medical literature, which they label as follows: critical review, literature review, mapping review, meta-analysis, mixed studies, overviews, qualitative systematic review, rapid review, scoping review, state of the art review, systematic review, systematic search and review, systematized review, and umbrella review (compiling evidence from multiple reviews). While such typology is very detailed, it contains inconsistencies and overlaps in descriptions, which its authors explicitly admit. Management scholars typically refer to much simpler categorization of systematic and narrative (interpretative) literature reviews.

Systematic literature reviews originate from and have gained most recognition in medical studies, reflecting the fit of meta-analyses (a special type of systematic reviews) for finding patterns in a great number of comparable (standardized), repetitive, quantitative empirical studies (Evans & Benefield, 2001). Although at the turn of the century, systematic literature reviews were given clear priority over narrative literature reviews also in some areas of social studies (including management), their superiority is by no means unproblematic (Polanyi 1966; Hammersley 2001). The proponents of systematic literature reviews advocate their objectiveness and replicability (e.g. Cooper, 1998), however they must assume that studies are best assessed

in purely procedural terms (Hammersley, 2001), an approach that disregards the tacit nature of a large part of knowledge (Polanyi, 1966).

What follows, one of the main criticisms of systematic literature reviews concerns the question whether it is necessarily the best way to represent the literature on a given topic (Hammersley, 2001). It can be argued that systematic literature reviews privilege particular kinds of evidence, different from that employed by researchers who produce narrative reviews (Ibid.). Such criticism is particularly pertinent in management studies as, comparing to natural studies or economics, disproportionately large part of studies is of qualitative character and they also have an incommensurate impact on the development of the discipline. Meanwhile, qualitative studies are hard to fit into the positivist framework of systematic literature reviews and are seen by many of its advocates as being of limited value (Hammersley, 2001). Thus, sticking to systematic literature reviews in management in many cases would produce distorted results and a false sense of validity of results. Although systematic reviews are so labeled as to implicitly disqualify alternatives – since who would want to use unsystematic reviews? – they privilege certain types of evidence, different from that employed by researchers who produce narrative reviews (Hammersley, 2001); this raises the question of representativeness.

In recent years, criticism of systematic literature reviews has been mounting (e.g. MacLure, 2005). Greenhalgh, Thorne and Malterud (2018) emphasize that although systematic literature reviews used to be put unequivocally above narrative literature reviews, it is no longer the case. Their mutual relation is better viewed as complementary, as they serve different purposes – in broad terms systematic literature reviews address narrowly focused questions and their main contribution consists in searching for regularities and testing hypotheses, while narrative literature reviews provide interpretation and critique, producing deeper understanding of the state of knowledge on (a) given stream(s) of literature, and offering post hoc hypotheses (Hammersley, 2001).

The advancement of interpretative studies is the newest trend in the development of management methodologies, as they allow deep understanding of phenomena and processes (Czakon, 2015, p. 10). In the editorial entitled "The Art of Writing a Review Article" published in the Journal of Management, Short (2009, p. 1315) emphasized that writing a good literature review necessarily involves moving "beyond simply a mechanical exercise (where the number of articles that use a particular scale or method to test a phenomena are counted and reported) to a more theoretical contribution." Procedural objectivity and formal neatness are not necessarily the uppermost, overriding principles in managerial literature reviews.

The last argument for selecting the interpretative literature review for present study is that such review type is said to be preferable to link many studies on different topics with a view to integrating or reinterpreting some

 DOI 10.7172/1644-9584.82.2

of them in light of other works (Baumeister & Leary, 1997), which is exactly the intention of the present study. Thus, despite some undeniable weaknesses of the interpretative literature review (mainly, the absence of an explicit procedure for choosing and analyzing pieces of research to be reviewed, and the resulting limited objectivity and replicability), it has been selected as it best fits the aims of the present paper.

4. Integrating relevant literature

4.1. Technology and competitive advantage

Competitive advantage is a central concept in the strategic management field (e.g. Amit & Schoemaker, 1993; Barney, 1991; Brown & Eisenhardt, 1998; Coff, 1999; D'Aveni, 1994; Dickson, 1992; Prahalad & Hamel, 1990; Kaplan & Norton, 1992, Kim & Mauborgne, 2005; Polowczyk, 2011; Sołoducho-Pelc, 2016; Urbanek, 2011). Although there is no clear definition of competitive advantage (Flint & Van Fleet, 2005), it can be interpreted as "the asymmetry among firms along any comparable dimension that allows one firm to compete better than its rivals" (Ma, 2000, p. 53), and viewed as gained and manifested at the level of value creation processes (e.g. Stabell & Fjeldstad, 1998), typically interpreted as Porter's (1985a) value chain. However, as Coff (1999), Lepak, Smith and Taylor (2007), Makadok and Coff (2002) and others have shown, firms that create value are not necessarily able to capture it, therefore competitive advantage does not always lead to superior performance.

Technology have long been viewed as one of the determinants of firm performance and competitive advantage (e.g. Chyba, 2014; Porter, 1985b; Powell & Dent-Micallef, 1997; Prester, Buchmeister & Palčič, 2018; Sait, Muharam, Thoo, Sulaiman, Zakuan & Tan, 2018; Weinman, 2012; 2015), particularly in the context of technology innovation and information technologies (e.g. Carr, 2004; Devaraj & Kohli, 2003; Glabiszewski & Grego-Planer, 2016; Gołuchowski, 2007; Jin, Vonderembse & Ragu-Nathan, 2013; Kohli & Devaraj 2003; Rubera & Kirca, 2012; Sethi & King, 1994; Stratopoulos, 2016; Tornikoski, Rannikko & Heimonen, 2017). Findings on the impact of investment in information technology on organizational performance have been inconclusive (e.g. Kohli & Devaraj, 2003; Sabherwal & Jeyaraj, 2015), particularly at the industry level (Devaraj & Kohli, 2003). Devaraj and Kohli (2003) argue that results of many such studies are obfuscated by not taking into account the actual use of technology, which is the missing link between technology innovation and performance. Other researchers point to the mediating impact of human resources (Powell & Dent-Micallef, 1997), absorptive capacity (Narasimhan, Rajiv & Dutta, 2006), organizational structure (Grindley, 1991), learning and alliances (Lei 1997), supplier technologies (Jin, Vonderembse & Ragu-

Nathan, 2013), national institutions (Murmann, 2003), culture (Beaver, 2000) and environmental uncertainty (Berrich & Benkaddour, 2016).

Another important topic that should be addressed concerns technology dynamics and the sustainability of competitive advantage. It has been found that rapid changes in available technology lead to misalignment between strategy and operations, particularly in technology-based manufacturing industries (McAdam, Bititci & Galbraith, 2017). Christensen (1997), D'Aveni (1994), Eisenhardt (1989), Hamel (2000) and McGrath (2013) argue that in dynamic, technology-intensive environments any competitive advantage is temporary. Stratopoulos (2016) provides a framework for predicting the expected duration of a competitive advantage from adopting an emerging technology. As competitive advantage lasts only until rivals outmaneuver it, literature on the quickness or delay of competitive response developed (D'Aveni, Dagnino & Smith, 2010), suggesting that aggressive firms are more successful (Ferrier, 2001). To adequately and timely address rapidly changing environments, firms should develop an ability to integrate, build, and reconfigure internal and external knowledge and competences, that is, to develop dynamic capabilities (Teece, Pisano & Shuen, 1997; Penc-Pietrzak, 2015; Poniatowska-Jaksch, 2018).

With few notable exceptions (e.g. Christensen, 1997; Weinman, 2012; 2015), the topic of business models has rarely attracted attention in this strand of literature, and where it was elaborated in some detail, it was often case-based (e.g. cloud-based BMs in Weinman, 2012, 2015). However, if competitive advantage is seen as resultant from conceptually separate value creation and value capture (appropriation) processes (Mizik & Jacobson, 2003) and business model as a tool for describing a firm's value creation and value-capturing logic (e.g. Falencikowski, 2013; Shafer, Smith & Linder, 2005, Osterwalder & Pigneur, 2010; Timmers, 1998), BMs, by definition, should be viewed as mediating in achieving competitive advantage, and thus critical to both business practice and competitive advantage theory development. In fact, the extant BM literature portrays BMs as far more than just mediating between technology and firm success. This topic shall be elaborated on in Section 4.2.

4.2. Technology innovation and business model innovation

The BM concept remains understudied, and thus potentially underestimated as a factor mediating in technological change (Pietrewicz, 2017). However, the analysis of another stream of research – i.e. the BM literature allows to bridge technological change and BMI and analyze their mutual relations by identifying and describing approaches of BM theoreticians toward technology innovations. Although such studies take as a starting point BMs and BMI as the studied phenomena ("dependent variables"), which are then explained using technology as an "independent variable", the findings often show multifaceted and complex mutual relations

 DOI 10.7172/1644-9584.82.2

between BM and BMI on the one hand, and technology innovation and advancement on the other hand, allowing the identification of multiple roles that BMI play in relation to technology development. The aggregation of these roles is presented in Chart 1.

Firstly, BMs (and thus BMI) mediate in the commercialization of new technologies (e.g. Massa & Tucci, 2013). Secondly, BMI can be seen as a new dimension of innovation and become a source of competitive advantage superior to technology innovation (Chesbrough, 2007; 2010). Thirdly, BMI can take advantage of and build on technology innovation in creative ways without the need to incur high costs, thus leveraging technology innovation. Fourthly and fifthly, BMI elicits and fosters technology innovation, and causes disruption, changing rules of the game and triggering a new wave of technology innovations. Finally, thinking in terms of BMI helps companies look beyond their traditional industry boundaries and facilitates recognizing emerging opportunities and threats (Pietrewicz, 2017). Thus, BMI elicits inter-industry cross-fertilizing of technologies (Gawer & Cusomano, 2014), driving experimentation and fusion of previously separate technologies in novel applications.

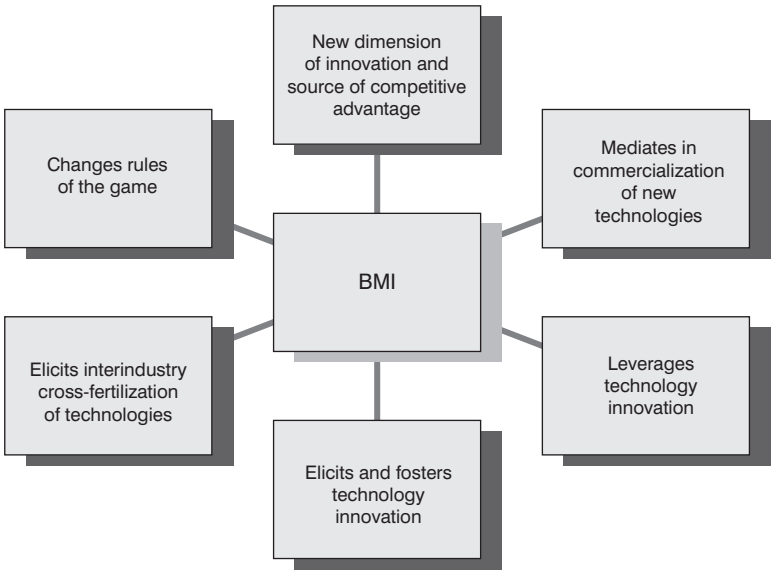

Chart 1. Multiple roles of business model innovation in the context of technology innovation. Source: Own elaboration.

As already mentioned, innovative technologies or ideas per se have no economic value (Massa & Tucci, 2013), and adequate business models are necessary to successfully commercialize them (Baden-Fuller & Haefliger,

2013), making BMs and BMI a necessary complement of technology innovation (Massa & Tucci, 2013). For example, Zott and Amit (2008) established empirically that BMI and product innovation are complements, interacting positively in influencing firm performance Moreover, thanks to its cognitive role, BM "provides a coherent framework that takes technological characteristics and potentials as inputs, and converts them through customers and markets into economic outputs" (Chesbrough & Rosenbloom, 2002, p. 532). Thus, BM mediates between technology development and value creation, and it assists in establishing how to capture value from firm's technology investments (ibid.).

In recent years, technological progress, changing customer preferences and deregulation have created a growing number of opportunities for BM configurations (Casadesus-Masanell & Zhu, 2013). Given substantial evidence on the link between BMI and value creation (e.g. Johnson et al., 2008) and firm performance (e.g. Zott & Amit, 2008), BMI has emerged as an important separate form of innovation and source of competitive advantage (e.g. Bashir & Verma, 2017; Casadesus-Masanell & Zhu, 2013; Doz & Kosonen, 2010; McGrath, 2010).

Remane, Hanelt, Tesch and Kolbe (2017) have established that businesses are more frequently shifting their focus from technological innovation towards BMI. For Gilbert, Eyring and Foster (2012), launching a disruptive BM is a way to respond to new technologies, start-ups and resulting disruptive market shifts, and to secure future growth. Pohle and Chapman (2006) find emphasizing BMI over product or process innovation to be positively correlated with operating margins. For Maurya (2012), entrepreneurial success is not as much the consequence of developing an innovative product or a piece of technology, as of finding a working business model. The difficulty to fully understand BMs in their multidimensionality and complexity, and to secure both internal and external fit, make BMI more difficult to imitate compared to product or process innovations (Bashir & Verma, 2017) bringing Chesbrough (2007) to argue that BMI may have a strategic advantage over other forms of innovation.

The perceived superiority and popularity of BMI may also result from the fact that it does not involve incurring costs of developing technology innovations but it takes advantage of the latter in innovative ways (Amit & Zott, 2010). BMI involving opening BMs enables firms to pool the risks and improve options, which can be seen as a sensible strategy in the face of increased uncertainty and volatility of the business environment. Moreover, operating at the BM level can help companies to streamline entire supply chains, and to identify and tackle bottlenecks (Teece, 2017).

Novel BMs may be a source of disruption (Christensen, 1997), changing the logic of entire industries and replacing the old ways of doing things with a new standard (Massa & Tucci, 2013). On the other hand, radically new products tend to need a new BM to change the rules of the game in

 DOI 10.7172/1644-9584.82.2

an industry (Johnson et al., 2008). Therefore, expensive failures occur when disruption is framed in technological rather than BM terms (Christensen, Horn & Johnson, 2008).

BMI elicits and fosters technology innovation. It unlocks other forms of innovation in several ways. It may happen that the idea for an innovative business model already exists, but the necessary technology is still at an initial stage of development, as recently exemplified by the blockchain technology (Pietrewicz, 2017). If a firm recognizes the potential benefits of such a technology, it may initiate efforts to develop it. To achieve that, it may, for example, open its current BM to allow crowdsourcing or cooperation with startups. Thus, the desirable BM being conditional on developing required technology can create demand for technology innovation. Moreover, as stated above, opening business models may elicit and foster technology innovation development. BM design enabling the sharing of risks and costs of technology innovation should increase the willingness of firms to engage in such innovation (Ibid.). Thus, adequate BM design fosters technology innovation.

Finally, disruptors typically come from outside the industry (e.g. Christensen, 1997; 2006), bringing novel BMs that change the rules of the game. As underlying technologies are developed elsewhere, bringing them over often requires integration with certain technologies (or their elements) used in a given industry. Moreover, the commercialization of integrating technologies may require novel BMs that would create entirely new markets. Thus, BMI may elicit and foster inter-industry cross-fertilizing of technologies.

4.3. Technology innovation and business model innovation in the age of Industry 4.0

The extensive findings on the complexity and multifaceted nature of relations between BM and technology innovation described in the above section sharply contrast with the limited availability of sources to analyze such relations in the Industry 4.0 setting. Therefore, the aim of this section is limited to outlining some general characteristics and a few examples of the described relations in the new setting.

Technological advancements marking the advent of Industry 4.0 should be expected to affect individual elements of the business model construct disproportionately – there is no reason to expect that each would be affected to the same extent. Based on this premise, it makes most sense to address separately selected components of the BM construct, i.e. those in which technology plays a major role. For that purpose, the most widely accepted decomposition of the BM concept, proposed by Osterwalder and Pigneur (2010), is used. These authors decompose BMs into nine components: key activities, key partners, key resources, value propositions, customer relationships, customer segments, channels, cost structure and revenue streams.

Before addressing individual components of the BM construct, a more general observation based on relevant literature review is, however, pertinent. Industry 4.0 is predicated on the growing interconnectedness and interdependence of technologies and business organizations (Kagermann et al., 2013). Smart factories, a hallmark of Industry 4.0, require going beyond advanced physical manufacturing capabilities to harness advanced digital technologies. Effective use of such technologies depends heavily on effective collaborations, which should, therefore, be a priority for firms (Kiron, 2017). Network-based business models (Lund and Nielsen, 2014) and open business models (Chesbrough, 2006) are found to be effective ways of fostering cooperation for the benefit of all stakeholders in times of intensified competition and elevated uncertainty.

Getting into more detail, the use of IoT, essential for smart factories, involves value creation through collaboration by means of data exchange, especially with customers and suppliers, which deepens existing relationships between organizations and encourages new collaborations (Kiron, 2017), but also demands and enables innovating some key components of BMs. For example, information on how customers use a product can enable a model of usage-based rental instead of a one-time sale (Teece, 2017), innovating value proposition, revenue streams and customer relationships components of BM.

The clarity of analysis of the relation between technology and individual components of the BM construct (and their dynamics) in the Industry 4.0 setting demands referring to digitalization as an intermediate stage between "traditional" economy and Industry 4.0, as digitization of business upends the key components of every BM (De Jong and van Dijk, 2015), and Industry 4.0 can be expected to transform them (and their interrelationships) even further.

The customer relationship component of the BM construct is a clear example. In traditional BMs, the pursuit of customer loyalty was a top priority, and face-to-face personal relationships were seen as the most effective. In the digital world, pursuit of loyalty has become more complicated, as customers empowered by transparency that the internet offers and by the ubiquity of peer reviews can more easily choose between available options, and the switching cost are low (De Jong & van Dijk 2015). Growing customer competencies and expectations (e.g. Weinman, 2012; 2015) paired with increasingly transient customer preferences (e.g. Heim & Sinha, 2010; Simonson, 2005) make the task of assuring loyalty even more unrealistic. These developments call for transforming customer interactions. While the technologies of the third industrial revolution took traditional face-to-face personal relationships online, thus increasing their scale, sophisticated algorithms designed to produce strong inferences about customers from weak signals (big data) move customer relations component of BMs to a new level (Weinman, 2015). Moreover, online communities can provide ideas and vote on product designs, and many products can be

 DOI 10.7172/1644-9584.82.2

efficiently manufactured to order (mass customization) in smart factories (De Jong & van Dijk 2015) thanks to modular product design, 3D printing and other Industry 4.0 technologies.

As for the key activities component of BMs, operational excellence was traditionally seen as a source of competitive advantage (Treacy & Wiersema, 1995). Digitalization demands replacing focus on operational excellence with "information excellence" (or "analytics excellence") (Weinman, 2015). The age of Industry 4.0 calls for combining operational excellence with "analytics excellence", as now value derives from leveraging digital technologies in physical production system, as the two converge to form CPSs. Moreover, as De Jong and van Dijk (2015) suggest, products may become obsolete before firms manage to fully optimize production processes, making businesses focus on flexibility and embedding intelligence into production processes with machine learning, while customer relationship tools mentioned above additionally improve customer value, thus empowering firms to go beyond efficiency. CPSs can produce value for both manufacturers and customers, thus transforming the business activities aspect of BMs.

Let us move to another component of the BM construct, namely key resources; here innovations are also required and enabled in the age of Industry 4.0. Digitalization is argued to significantly lower transaction costs, both within and between organizations with transactions within organizations being less affected (Butler, Hall, Hanna, Mendonca, Auguste, Manyika & Sahay, 1997), making the ownership of assets less attractive (e.g. Williamson, 1996). Internet-enabled increased market transparency reduces the benefits of organizational integration (Christensen, 2001), and the development of big data analytics can be argued to have the same effect. And while integrated companies may have an advantage in extracting maximum performance out of the available technologies, innovations that enhance a firm's ability to shorten time-to-market may require modular architectures, where nonintegrated, focused firms can cooperate in a network, with lower overheads and increased flexibility and customization (Christensen, 2001). In the age of Industry 4.0, the name of the resource game is access and not ownership. For example, the focus on access to rather than the ownership of assets (De Jong & van Dijk, 2015) lies behind the enormous success of cloud computing BM (Weinman, 2015), a landmark invention of the Industry 4.0 era (European Commission, 2017).

Finally, digitalization transforms value proposition component of BMs from traditional "quality and brand" (Treacy & Wiersema, 1995) to "solution leadership", where ease of adding, modifying or upgrading digital features enables an ongoing connection with customers and transition from selling products to selling experiences (Weinman, 2015). In the age of Industry 4.0, value propositions compete in "datafication" – of production, consumption and interactions, enabling individualized offerings, quick responses, and early trend recognition.

5. Discussion and conclusions

Today's unprecedented pace of technological innovation has created a business environment that is more complex and turbulent than ever. Such characteristics severely impede traditional sources of competitive advantage and favor flexibility and speed, which, in turn, demand new forms of organizing value creation. Thus, although technology innovation as such is critical to meeting the demands of today's markets, it must be accompanied by BMI to allow firms to compete successfully.

The relation of technology innovation and BMI is, however, much more complex and multifaceted – they are much more than necessary complements for the firm's competitive advantage. The present study set investigating this relation as its aim, specifically in the Industry 4.0 setting. It has been found that appropriate BMs improve the ability of firms to respond effectively to rapid changes in the business environment. BMs mediate in the commercialization of new technologies, they can be a source of innovation in and of themselves and also a conduit for other types of innovation, unlocking technological innovation, leveraging it, eliciting it and fostering further innovation, including inter-industry cross-fertilizing of technologies, which drives fusion of previously separate technologies in novel business applications. Consequently, it is not only technology itself, but also the manner in which it is "wrapped" into business models that is crucial to firms' competitive advantage in the age of Industry 4.0. Analyzing one without paying due attention to the other would give only a partial view of the sources of competitive advantage in the age of Industry 4.0.

The above findings have been produced using the interpretative literature review method. Interpretative literature review suffers from undeniable weaknesses, particularly related to its limited objectivity and replicability. However, the importance and popularity of this and other qualitative methods even in the most prestigious management journals suggests that benefits of such methods clearly outweigh their weaknesses. For example, a study by Aguinis and Solarino (2019) found that none of the recent 52 qualitative studies published in Strategic Management Journal allowed either empirical or conceptual replication. The latter would also apply to the present paper.

From the methodological point of view, achieving the goal of this paper hinged upon interpreting and integrating different streams of qualitative managerial literature, which are typical premises for using the interpretative literature review. The growing popularity of this research method in recent years suggests that, at least for certain purposes, the value of deep understanding that allows the interpretation of observable phenomena grows relative to less in-depth, but more formally neat and objective systematic literature reviews. This finding is all the more interesting in light of the clear emphasis on formal models in economics. However,

 DOI 10.7172/1644-9584.82.2

instead of speculating on possible explanations of this discrepancy, it is better to watch the developments and try to apply a scientific method to find data-based answers.

Similarly, further studies enriching our understanding of the nature of competitive advantage and the interplay between technology innovation and BMI in the age of Industry 4.0 are needed to prepare firms to identify and face future challenges and opportunities. The present paper developed some ways of addressing these issues.

References

Aguinis, H., & Solarino, A. (2019). Transparency and replicability in qualitative research: The case of interviews with elite informants. *Journal of Strategic Management*, forthcoming. https://doi.org/10.1002/smj.3015.

Al-Debei, M., & Avison, D. (2010). Developing a unified framework of the business model concept. *European Journal of Information Systems*, *19*(3), 359–376.

Amit, R., & Schoemaker, P. (1993). Strategic assets and organizational rent. *Strategic Management Journal*, *14*(1), 33–46. https://doi.org/10.1002/smj.4250140105.

Amit, R., & Zott, C. (2001). Value creation in e-Business. *Strategic Management Journal*, *22*(6/7), 493–520.

Baden-Fuller, C., & Haefliger, S. (2013). Business models and technological innovation. *Long Range Planning*, *46,* 419–426.

Baheti, R., & Gill, H. (2011). Cyber-physical Systems. In: T. Samad, A.M. Annaswamy (eds.), *The impact of Control Technology* (pp. 161–166). IEEE Control Systems Society. Retrieved from: www.ieeecss.org.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage, *Journal of Management*, *17*(1), 99–120. https://doi.org/10.1177/014920639101700108.

Bashir, M., & Verma, R. (2017). Why Business Model Innovation Is the New Competitive Advantage. *IUP Journal of Business Strategy*, *14*(1), 7–17.

Baumeister, R., & Leary, M. (1997). Writing narrative literature reviews. Review of General Psychology, 1(3), 311–320. http://dx.doi.org/10.1037/1089-2680.1.3.311.

Beaver, G. (2000). Technology, culture and competitive advantage: Inextricable links, *Strategic Change*, *9*(3), 145–146.

Berrich, A., & Benkaddour, A. (2016). The effect of information technology on competitive advantage of firm: the role of environmental uncertainty. *The International Journal of Management Science and Information Technology*, 22, 16–39.

Brown, S., & Eisenhardt, K. (1998). *Competing on the Edge: Strategy as Structured Chaos*. Boston: Harvard Business School Press.

Carr, N. (2004). *Does It Matter? Information Technology and the Corrosion of Competitive Advantage*. Harvard Business Press.

Butler, P., Hall, T., Hanna, A., Mendonca, L., Auguste, B., Manyika, J., & Sahay A., (1997). A revolution in interaction. *The McKinsey Quarterly*, 1, 5–23.

Casadesus-Masanell, R., & Zhu, F. (2013). Business model innovation and competitive imitation. The case of sponsor-based business models. *Strategic Management Journal*, *34*(4), 464–482.

Chesbrough, H. (2006). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business Press.

Chesbrough, H. (2007). Business model innovation: It's not just about technology anymore. *Strategy & Leadership*, *35*(6), 12–17.

Chesbrough, H. (2010). Business Model Innovation: Opportunities and Barriers. *Long Range Planning*, *43*, 354–363.

Chesbrough, H., & Rosenbloom, R. (2002). The Role of the Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spin-off Companies. *Industrial and Corporate Change*, *11*(3), 529–555.
Christensen, C. (1997). *The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business*. Cambridge, MA: Harvard Business Press.
Christensen, C. (2001). The Past and Future of Competitive Advantage. *MIT Sloan Management Review, 42*(2), 105–109.
Christensen, C. (2006). The ongoing process of building a theory of disruption. *Journal of Product Innovation Management*, *23*(1), 39–55.
Christensen, C., Horn, M., & Johnson, C. (2008). *Disrupting Class: How Disruptive Innovation Will Change the Way the World Learns*. McGraw-Hill Irwin.
Chyba, Z. (2014). Potencjał technologiczny a kreowanie konkurencyjności przedsiębiorstw. *Przegląd Organizacji*, 2, 21–25.
Coff, R. (1999). When Competitive Advantage Doesn't Lead to Performance: Resource-Based View and Stakeholder Bargaining Power. *Organization Science*, *10*(2), 119–133.
Cooper, H. (1998). *Synthesizing research: a guide for literature reviews*. (3rd ed.). Thousand Oaks: Sage.
Czakon, W. (2015). Wstęp. In: W. Czakon (ed.), *Podstawy metodologii badań w naukach* o *zarządzaniu*. 3rd ed. (extended). Warszawa: Wolters Kluwer.
DaSilva, C., & Trkman, P. (2014). Business model: what it is and what it is not. *Long Range Planning*, *47*(6), 379–389.
D'Aveni, R. (1994). *Hypercompetition: Managing the Dynamics of Strategic Maneuvering*. New York: Free Press.
D'Aveni, R., Dagnino, G., & Smith, K. (2010). The age of temporary advantage. *Strategic Management Journal*, *31*(13), 1371–1385. https://doi.org/10.1002/smj.897.
Demil, B., & Lecocq, X. (2010). Business Model Evolution: In Search of Dynamic Consistency. *Long Range Planning*, *43*, 227–246.
Desmet, D., Maerkedahl, N., & Shi, P. (2017). Adopting an ecosystem view of business technology. Retrieved from: https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/adopting-an-ecosystem-view-of-business-technology (30.11.2018).
Devaraj, S., & Kohli, R. (2003). Performance Impacts of Information Technology: Is Actual Usage the Missing Link?, *Management Science*, *49*(3), 273–289.
De Jong, M., & van Dijk, M. (2015). Disrupting beliefs: A new approach to business model innovation. Retrieved from: https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/disrupting-beliefs-a-new-approach-to-business-model-innovation.
Dickson, P., (1992). Toward a general theory of competitive rationality. *Journal of Marketing*, *56*(1).
Doganova, L., & Eyquem-Renault, M. (2009). What do business models do? Innovation devices in technology entrepreneurship. *Research Policy*, *38*(10), 1559–1570.
Doz, Y., & Kosonen, M. (2010). Embedding strategic agility: A leadership agenda for accelerating business model renewal. *Long Range Planning*, *43*, 370–382.
Drath, R., & Horch, A. (2014). Industrie 4.0: Hit or Hype? *IEEE Industrial Electronics Magazine*, *8*(2), 56–58. https://doi.org/10.1109/MIE.2014.2312079.
Eisenhardt, K. (1989). Making fast strategic decisions in high-velocity environments. *Academy of Management Journal*, *32*(3), 543–576.
European Commission. (2017). Germany: Industrie 4.0. Digital Transformation Monitor. Retrieved from: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industrie%204.0.pdf (15.11.2018).
European Patent Office. (2017). *Patents and the Fourth Industrial Revolution*. European Patent Office.
Evans, J., & Benefield, P. (2001). Systematic reviews of educational research: does the medical model fit? *British Educational Research Journal*, 27, 527–541.

 DOI 10.7172/1644-9584.82.2

Falencikowski, T. (2013). *Spójność modelu biznesu. Koncepcja i pomiar*. Warszawa: Wydawnictwo CeDeWu.

Ferrier, W. (2001). Navigating the competitive landscape: The drivers and consequences of competitive aggressiveness. *Academy of Management Journal*, 44, 858–877.

Flint, G., & Van Fleet, D. (2005). A Comparison and Contrast of Strategic Management and Classical Economic Concepts: Definitions, Comparisons, and Pursuit of Advantages. Retrieved from: http://www.uvsc.edu/schools/business/facultyScholar/jbi/jbi_v3.html.

Foss, N., & Saebi, T. (2017). Fifteen Years of Research on Business Model Innovation: How Far Have We Come, and Where Should We Go? *Journal of Management*, *43*(1), 200–227.

Gawer, A., & Cusomano, M. (2013). Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management*, *31*(3), 417–433. https://doi.org/10.1111/jpim.12105.

Gilbert, C., Eyring, M., & Foster, R. (2012). Two Routs to Resilience. *Harvard Business Review*, *90* (12), 65–73.

Glabiszewski, W., & Grego-Planer, D. (2016). Abilities to exploit newly-acquired Technologies as a source of competitive advantage of finance companies in Poland, *Management*, *20*(2), 35–48. https://doi.org/10.1515/manment-2015-0049.

Gołuchowski J. (2007). *Technologie informatyczne w zarządzaniu wiedzą w organizacji*, Katowice: Wydawnictwo AE.

Grant, M., & Booth, A. (2009). A typology of reviews: an analysis of 1 review types and associated methodologies. *Health Information and Libraries Journal*, 26, 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x.

Greenhalgh T., Thorne, S., & Malterud, K. (2018). Time to challenge the spurious hierarchy of systematic over narrative reviews? *European Journal of Clinical Investigation*, *8*(6), e12931. https://doi.org/10.1111/eci.12931.

Grindley, P. (1991). Turning Technology into Competitive Advantage. *Business Strategy Review*, *2*(1), 35–48.

Hamel, G. (2000). *Leading the Revolution*. Boston MA: Harvard Business School Press.

Hammersley, M. (2001). On 'Systematic' Reviews of Research Literatures: a 'narrative' response to Evans & Benafield. *British Educational Research Journal*, *27*(5), 543–554.

Heim, G., & Sinha, K. (2001). A Product-Process Matrix for Electronic B2C Operations: Implications for the Delivery of Customer Value. *Journal of Service Research*, *3*(4), 286–299. https://doi.org/10.1177/109467050134002.

Hofmann, E., & Rüsch, M. (2017). Industry 4.0 and the current status as well as future prospects on logistics. *Computers in Industry*, 89, 23–34. http://dx.doi.org/10.1016/j.compind.2017.04.002.

Jazdi, N. (2014). Cyber physical systems in the context of Industry 4.0. 2014 IEEE International Conference on Automation. Quality and Testing, Robotics. Cluj-Napoca, Romania, 1–4. https://doi.org/10.1109/AQTR.2014.6857843.

Jin, Y., Vonderembse, M., & Ragu-Nathan, T. (2013). Proprietary technologies: Building a manufacturer's flexibility and competitive advantage. *International Journal of Production Research*, *51*(19), 5711–5727.

Johnson, M., Christensen, C., & Kagermann, M. (2008). Reinventing Your Business Model. *Harvard Business Review*, *86*(12), 50–59.

Kagermann, H., Wahlster, W., & Helbig, J. (2013). Recommendations for Implementing the Strategic Initiative Industrie 4.0. Industrie 4.0 Working Group of Acatech. Berlin.

Kaplan, R., & Norton, D. (1992). The Banalced Scorecard – Measures that Drive Performance. *Harvard Business Review*, *70*(1), 71–79.

Karabegović, I. (2018). The role of industrial and service robots in the industrial revolution – "Industry 4.0". Acta Technica Corvininesis – Bulletin of Engineering, 11(2), 11–16.

Kim, M., & Mauborgne, R. (2005). *Blue Ocean Strategy*. Boston, MA: Harvard Business School Press.
Kiron, D. (2017). Why Your Company Needs More Collaboration. *MIT Sloan Management Review*, Fall Issue.
Kohli, R., & Devaraj, S. (2003). Measuring Information Technology Payoff: A Meta-Analysis of Structural Variables in Firm-Level Research. *Information Systems Research*, *14*(2). https://doi.org/10.1287/isre.14.2.127.16019.
Lee, J., Bagheri, B., & Kao, H. (2015). A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems. *Manufacturing Letters*, 3, 18–23.
Lei, D. (1997). Competence-building, technology fusion and competitive advantage: the key roles of organisational learning and strategic alliances. *International Journal of Technology Management*, 14(2–4), 208–237. https://doi.org/10.1504/IJTM.1997.001724.
Lepak, D. Smith, K., & Taylor, S. (2007). Value Creation and Value Capture: A Multilevel Perspective. *Academy of Management Review*, *22*(1), 180–194.
Liao, Y., Deschamps, F., Lourdes, E., & Ramos, L. (2017). Past, present and future of Industry 4.0 – a systematic literature review and research agenda proposal. *International Journal of Production Research*, *55*(12), 3609–3629. http://dx.doi.org/10.1080/00207543.2017.1308576.
Liu, Q., & Vasarhelyi, M. (2014). Questions in AIS Research: Measurement, Information Processing, Data Analysis, and Reporting. *Journal of Information Systems*, *28*(1), 1–17.
Lund, M., & Nielsen, C. (2014). The Evolution of Network-based Business Models Illustrated Through the Case Study of an Entrepreneurship Project. *Journal of Business Models*, *2*(1), 105–121.
Lycett, M. (2013). 'Datafication': making sense of (big) data in a complex world. *European Journal of Information Systems*, *22*(4), 381–386. https://doi.org/10.1057/ejis.2013.10.
Ma, H. (2000). Of Competitive Advantage: Kinetic and Positional. *Business Horizons*, *43*(1), 53–64.
MacLure, M. (2005). 'Clarity bordering on stupidity': where's the quality in systematic review? *Journal of Education Policy*, 20, 393–416.
Makadok, R., & Coff, R. (2002). The theory of value and the value of theory: Breaking new ground versus reinventing the wheel. *Academy of Management Review*, 27, 10–13.
Massa, L., & Tucci, C. (2013). Business model innovation. In: M. Dodgson, D. Gann, N. Phillips (eds), *The Oxford Handbook of Innovation Management* (pp. 420–441). OUP Oxford.
Magretta, J. (2002). Why Business Models Matter. *Harvard Business Review*, *80*(5), 86–92.
Massa, L., Tucci, C.L., & Afuah, A. (2017). A critical assessment of business model research. *Academy of Management Annals*, *11*(1), 73–104.
Maurya, A. (2012). *Running lean: iterate from plan A to a plan that works*. O'Reilly Media Inc.
McAdam, R., Bititci, U., & Galbraith, B. (2017). Technology alignment and business strategy: A performance measurement and Dynamic Capability perspective. *International Journal of Production Research*, *55*(23), 7168–7186.
McGrath, R.G. (2010). Business models: a discovery driven approach. *Long Range Planning*, *43*, 247–261.
McGrath, R. (2013). *The End of Competitive Advantage: How to Keep Your Strategy Moving as Fast as Your Business*. Boston, MA: Harvard Business Review Press.
McKinsey. (2015). Industry 4.0: How to navigate digitization of the manufacturing system. *McKinsey & Company*.
Mitchell, D., & Coles, C. (2003). The ultimate competitive advantage of continuing business model innovation. *Journal of Business Strategy*, *24*(5), 15–22.
Mizik, N., & Jacobson, R. (2003) Trading Off Between Value Creation and Value Appropriation: The Financial Implications of Shifts in Strategic Emphasis. *Journal of Marketing*, *67*(1), 63–76.

 DOI 10.7172/1644-9584.82.2

Morris, M., Schindehutte, M., & Allen, J. (2005). The entrepreneur's business model: toward a unified perspective. *Journal of Business Research*, *58*(6), 726–735.

Murmann, J. (2003). *Knowledge and Competitive Advantage: The Coevolution of Firms, Technology,and National Institutions*. Cambridge: Cambridge University Press.

Narasimhan, O., Rajiv, S., & Dutta, S. (2006). Absorptive Capacity in High-Technology Markets: The Competitive Advantage of Haves. *Marketing Science*, *25*(5), 510–524.

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. John Wiley & Sons.

Paprocki, W. (2016). Koncepcja Przemysł 4.0 i jej zastosowanie w warunkach gospodarki cyfrowej. In: J. Gajewski, W. Paprocki, J. Pieriegud (eds), *Cyfryzacja gospodarki i społeczeństwa. Szanse i wyzwania dla sektorów infrastrukturalnych* (pp. 39–57). Gdańsk: Instytut Badań nad Gospodarką Rynkową – Gdańska Akademia Bankowa.

Pateli, A., & Giaglis, G. (2005). Technology innovation-induced business model change: A contingency approach. *Journal of Organisational Change Management*, *18*, 167–183.

Patzelt, H., Knyphausen-Aufsess, D.Z., & Nikol, P. (2008). Top management teams, business models, and performance of biotechnology ventures: an upper echelon perspective. *British Journal of Management*, *19*, 205–221.

Penc-Pietrzak, I. (2015). Charakterystyka zdolności dynamicznych przedsiębiorstwa w warunkach hiperkonkurencji. *Studia Ekonomiczne*, 229, 143–156.

Pietrewicz, L. (2017). Business model innovation: A driving force behind the fourth industrial revolution. Paper presented at the Management in the Digital Era conference, Prague.

Polanyi, M. (1966). *The Tacit Dimension*. Garden City: Doubleday.

Polowczyk, J. (2011). Przewaga konkurencyjna – trwała czy tymczasowa? *Przegląd Organizacji*, 6, 6–10.

Poniatowska-Jaksch, M. (2018). Dynamiczne zdolności źródłem przewag konkurencyjnych platform wirtualnych. *Ekonomika i Organizacja Przedsiębiorstwa*, 3, 82–91.

Poovendran, R. (2010). Cyber-Physical Systems: Close Encounters Between Two Parallel Worlds. *Proceedings of the IEEE*, *98*(8), 1363–1366. https://doi.org/10.1109/JPROC.2010.2050377.

Porter, M. (1985a). *Competitive Advantage: Creating and Sustaining Superior Performance*. New York: Free Press.

Porter, M. (1985b). Technology and competitive advantage. *Journal of Business Strategy*, *5*(3), pp. 60–78.

Powell, T., & Dent-Micallef, A. (1997). Information technology as competitive advantage: The role of human, business, and technology resources. *Strategic Management Journal*, *18*(5), 375–405.

Prahalad, C., & Hamel, G. (1990). The Core Competence of the Corporation. *Harvard Business Review*, *68*(3), 79–91.

Prester, J., Buchmeister, B., & Palčič, I. (2018). Effects of Advanced Manufacturing on Manufacturing Company Performance. *Journal of Mechanical Engineering*, *64*(12), 763–771. https://doi.org/10.5545/sv-jme.2018.5476.

Remane, G., Hanelt, A., Tesch, J., & Kolbe, L. (2017). The business model pattern database – A tool for systematic business model innovation. *International Journal of Innovation Management*, *21*(1), 1–61.

Rubera, G., & Kirca, A. (*2012*). Firm Innovativeness and Its Performance Outcomes: A Meta-Analytic Review and Theoretical Integration. *Journal of Marketing*, *76*(3), 130–147. https://doi.org/10.1509/jm.10.0494.

Sabherwal, R., & Jeyaraj, A. (2015). Information Technology Impacts on Firm Performance: An Extension of Kohli and Devaraj (2003). *MIS Quarterly*, *39*(4), 809–836.

Sait, S., Muharam, F., Thoo, A., Sulaiman, Z., Zakuan, N., & Tan, L. (2018). Impacts of Technology Assessments on Firm Performance. AIP Conference Proceedings 2018, p. 020009-1-020009-10.

Schlund, S., & Baaij, F. (2018). Describing the technological scope of Industry 4.0 – A review of survey publications. *LogForum*, *14*(3), 341–353. http://dx.doi.org/10.17270/J.LOG.2018.289.
Schwab, K. (2016). *The Fourth Industrial Revolution*. Geneva: World Economic Forum.
Sethi, V., & King, W. (1994). Development of Measures to Assess the Extent to Which an Information Technology Application Provides Competitive Advantage. *Management Science*, *40*(12), 1601–1627.
Shafer, S., Smith, H., & Linder, J.C. (2005). The power of business models. *Business Horizons*, *48*(3), 199–207.
Short, J. (2009). The Art. Of Writing a Review Article. *Journal of Management*, *35*(6), 1312–1317. https://doi.org/10.1177/0149206309337489.
Simonson, I. (2005). Determinants of Customers' Responses to Customized Offers: Conceptual Framework and Research Propositions. *Journal of Marketing*, *69*(1), 32–45.
Sołoducho-Pelc, L. (2016). Przewaga konkurencyjna – główne trendy badawcze. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, nr 444, 422–433. https://doi.org/10.15611/pn.2016.444.38.
Sousa, P., Manso, V., Costa, J., & Almeida, F. (2011). Ontology for entrepreneurs – risk analysis for start-up tech. *Journal of Advanced Research in Management*, 3(1), 59–68.
Stabell, C., & Fjeldstad, O. (1998). Configuring Value for Competitive Advantage: On Chains, Shops, and Networks. *Strategic Management Journal*, *19*(5), 413–437.
Strange, R., & Zucchella, A. (2017). Industry 4.0, global value chains and international business. *Multinational Business Review*, *25*(3), 174–184. https://doi.org/10.1108/MBR-05-2017-0028.
Stratopoulos, T. (2016). Duration of Competitive Advantage due to Emerging Technology Adoption. *Academy of Management Annual Meeting Proceedings*.
Teece, D. (2010). Business models, business strategy and innovation. *Long Range Planning*, *43*(2), 172–194.
Teece, D.J. (2017). Business models and dynamic capabilities. *Long Range Planning (in press)*.
Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509–533.
Timmers, P. (1998). Business models for electronic markets. *Electronic Markets*, *8*(2), 3–8.
Tornikoski, E., Rannikko, H., & Heimonen, T. (2017). Technology-Based Competitive Advantage of Young Entrepreneurial Firms: Conceptual Development and Empirical Elaboration. *Journal of Small Business Management*, *55*(2), 200–215.
Treacy, M., & Wiersema, F. (1995). *The Discipline of Market Leaders*. Addison-Wesley.
Urbanek, G. (2011). Od operacyjnej do strategicznej przewagi konkurencyjnej. *Przegląd Organizacji*, 12, 6–10.
Voelpel, S., Leibold, M., & Tekie, E. (2004). The wheel of business model reinvention: how to reshape your business model to leapfrog competitors. *Journal of Change Management*, *4*(3), 259–276.
Weinman, J. (2012). *Cloudonomics: The Business Value of Cloud Computing*. Hoboken, NJ: Wiley.
Weinmann, J. (2015). *Digital Disciplines: Attaining Market Leadership via the Cloud, Big Data, Social, Mobile, and the Internet of Things*. Wiley CIO.
Williamson, O. (1996). *The mechanisms of governance*. Oxford and New York: Oxford University Press.
Wirtz, B.W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business Models: Origin, Development and Future Research Perspectives. *Long Rang Planning*, *49*, 36–54.
Zott, C., & Amit, R. (2008). The fit between product market strategy and business model: implications for firm performance. *Strategic Management Journal*, *29*(1), 1–26.
Zott, C., Amit, R., & Massa, L. (2011). The Business Model: Recent Developments and Future Research. *Journal of Management*, *37*(4), 1019–1042.

 DOI 10.7172/1644-9584.82.2