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Commercialization of disruptive innovations: Literature review and proposal for a process framework

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ABSTRACT

The challenges of disruptive innovations have gained significant attention from both academics and practitioners, commercialization being one of the most critical phases. At the same time, however, it is the less studied area of disruptive innovation. Therefore, this article examined scholarly papers on the commercialization of disruptive innovations through a multidisciplinary systematic literature review. It resulted in the analysis of 64 high-quality peer-reviewed academic articles. The analysis highlighted the commercialization models and main constructs that are affecting the commercialization process: market orientation, market learning, user's involvement, market configuration, adoption networks and stakeholders, and innovation transference. The study evidences how commercialization has evolved from a later stage in innovation to influence even the early phases of innovation, characterized in turn by exploration, learning and ecosystem creation activities. Additionally, the analysis led to a proposition that established an integrated commercialization model for high uncertainty innovations. The model has three phases: 1) Concept/value proposition validation, 2) Business model validation & Market creation, and 3) Creating sales in the majority market. Lastly, the article contributes to a better understanding of commercialization processes in high uncertainty innovations, bridging also the academic-practitioner divide.

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1. Introduction

The current business environment is technologically oriented and highly dynamic. Hence, firms cannot only rely on incremental innovations. Especially, due to current digitization trends, radical innovations will still become more relevant (Kraus et al., 2019).

Even if management principles of operational excellence, customer satisfaction and incremental innovation continue to dominate large mature companies (O'Connor and Rice, 2013) focusing only on incremental innovations has negative consequences on the firms (Christensen, 1997; Christensen et al., 2015). Firms need to generate disruptive innovations to sustain their long-term competitiveness (Lettl, 2007; Al Natsheh et al., 2015; Helm et al., 2018).

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There is a broad consensus in both academia and industry that disruptive innovations have a critical value to the firms (Chandy and Tellis, 2000; McDermott and O'Connor, 2002). Different scholars have acknowledged and demonstrated by means of deep literature reviews the relevance and increasing interest on radical and disruptive innovation during the last decades (Li et al., 2017; Hopp et al., 2018a; Si and Chen, 2020; and Tiberius et al., 2021).

Over the years, the research landscape concerned with disruptive innovations has grown fast, leading to a fragmented research field which is difficult to overlook (Tiberius et al., 2021). The locus of disruption research has shifted from technology management to a broad set of loosely coupled disciplines including, among others, entrepreneurship, commercialization and strategic management.

Firms engaged in disruptive innovations face challenges managing them (O'Connor et al., 2008), especially technology development and commercialization (Chiesa and Frattini, 2011; Slater et al., 2014; Tiberius et al., 2021). Some scholars, such as Chiesa and Frattini (2011); Alberti-Alhtaybat et al. (2019); Cozzolino et al. (2018); or Snihur et al. (2018) buttress that commercialization is one of the most critical phases and also the less studied area of disruptive innovation (Aarikka and Lehtimäki, 2014a; Marx et al., 2014). Commercialization is key to understanding the relationships between innovation management processes and success in bringing new products to market. Additionally, commercialization is particularly challenging in tech transfer and the most important drive for change (Still, 2017). More research identifying and describing key factors to market commercialization is still needed (Al Natsheh, 2015), as well as on how to actively foster commercialization processes and increase the likelihood of a radical innovation's market success (Tiberius et al., 2021).

Research on the commercialization of disruptive innovation is also fragmented. Studies have approached the commercialization from different points of view, and they did not offer an integrative framework of the process, leaving the true potential of multidisciplinary research unexploited (Hopp et al., 2018b).

Furthermore, there is a lack of a unified definition of "disruptive innovation" (Si and Chen, 2020). For example, Lynn et al. (1996); and Veryzer (1998a, b), used "discontinuous innovation," Christensen (1997), employed "disruptive innovation," Coviello and Joseph (2012), used "major innovation" and O'Connor and Rice (2001), called it "breakthrough innovation". Each author uses different terminology, even when studying similar issues, which makes research inconsistent. Consequently, it can be established that disruptive innovation commercialization needs research on its process in order to establish a grounded theoretical framework.

Finally, inconsistency between theory and real business practice on disruptive innovation has been detected (Still, 2017; Si and Chen 2020; Shepherd and Gruber 2020), claiming for further research on this area.

This article aims to identify the main stages of the commercialization of disruptive innovation through these research questions:

1. What is the role of commercialization in the process of disruptive innovation?
2. How can the commercialization process framework be defined?

Answers to the above questions will enhance understanding of disruptive innovations, its commercialization process, and the challenges of the phenomenon. Having such knowledge is essential to provide direction for future research and insights for business enterprises. This article is structured as follows: definition of disruptive innovation, methodology, findings, discussion, contributions, limitations, and suggestions for future research.

2. Definitions of disruptive innovation

The phenomenon of disruptive innovation has been categorized differently, resulting in a myriad of definitions. The study from Garcia and Calantone (2002), reveals a consensus in categorizing innovativeness considering if they are causing marketing or/and technological discontinuities on macro or/and micro level. From a macro perspective, innovativeness is evaluated based on the newness of the innovation to the world, to the industry or to the market, creating thus new markets, modifying market structures, or changing performance metrics. The micro perspective defines innovativeness as new to the firm or new to the customer. In this case, it adds values or benefits as well as changes behavior and consumption patterns for the customers, whereas, for the company, it also serves as new capabilities and new knowledge.

Radical innovations could be defined as innovations that embody a new technology that results in new market infrastructure, Garcia and Calantone (2002); Song and Montoya (1998); and O'Connor (1998). They result in discontinuities on both a macro and micro level.

Garcia and Calantone (2002), define a really new product as the one that generates a market discontinuity or a technological discontinuity but will not incorporate both under the macro-level approach. On a micro level, any combination of marketing and/or technological discontinuity could occur.

A discontinuous innovation could be considered either radical or really new innovation depending on the level (macro/micro) and the discontinuities it causes (market/technological/both) when the innovation is introduced to the market. The majority of examples of discontinuous innovations found in the literature could be categorized as really new innovations since only one of the S-curves is affected.

O'Connor (2008), defines breakthrough innovations depending on its impact on the market. Breakthrough innovations could transform existing markets and industries or create new ones, on the macro level. Innovations that are only new to the firm but not to the market do not, in this conceptualization, constitute breakthrough innovations.

On Christensen (1997), and Danneels (2004), a disruptive innovation is represented by a new technology displacing incumbent firms that support the prior technology becoming obsolete. This generates in turn a new market infrastructure or creates new ones. Disruptive technology changes the bases of competition, and modifies the attributes that users value, as well as the performance metrics along which firms compete. A mismatching then occurs between current customer requirements. This kind of innovation impacts on both macro and micro level. Under this conceptualization, disruptive innovations may indeed be considered radical innovations.

Govindarajan et al. (2011) posit that radical product innovations draw on substantially new technology and could initially be targeted at an existing or an emerging market. Differently, disruptive innovations are initially targeted at an emerging or not-served market, and may not involve the newest technology. Under this perspective, disruptive innovation could be categorized also as radical, although not all radical innovations could be defined as disruptive. The willingness to cannibalize is related to disruptive innovation (Christensen, 1997) but not to radical innovation, supporting the idea that radical innovation does not require cannibalization of existing investments. Radical innovation is reliant on dynamic and organizational capabilities as well as on individual and organizational human capital. Leveraging core competencies or scaling faster than competitors is essential when faced with new technological breakthroughs.

We will define innovations throughout this article depending on whether they occur at both macro and micro levels, and on whether they generate marketing and/or technology discontinuities.

3. Research methodology

A systematic literature review (SLR) is needed for multidisciplinary studies to perform a robust analysis of the theories. As well as to reach a definitive conclusion on 'what is and is not known' (Denyer and Tranfield, 2009). Similarly, a methodological rigor with regards to management literature reviews is needed to consolidate the literature across a domain (Thorpe et al., 2005). Petticrew and Roberts (2006), add that a systematic literature review is a method that makes sense for large bodies of information and also a method for mapping out areas of uncertainty where new studies are needed. Consequently, a SLR was conducted for this article. A five-step approach, proposed by Denyer and Tranfield (2009), was followed. This approach has been combined with the application of a quality threshold that allows for a comprehensive, transparent, and replicable selection, such as suggested by Tranfield et al. (2003). Fig. 1 shows the five-steps methodology approach used to conduct this research.

3.1. Locating studies

An electronic database, specifically Web of Science (WoS), was scanned for publications on peer-reviewed academic business and management journals. This database was selected because of its renown among scholarly organizations.

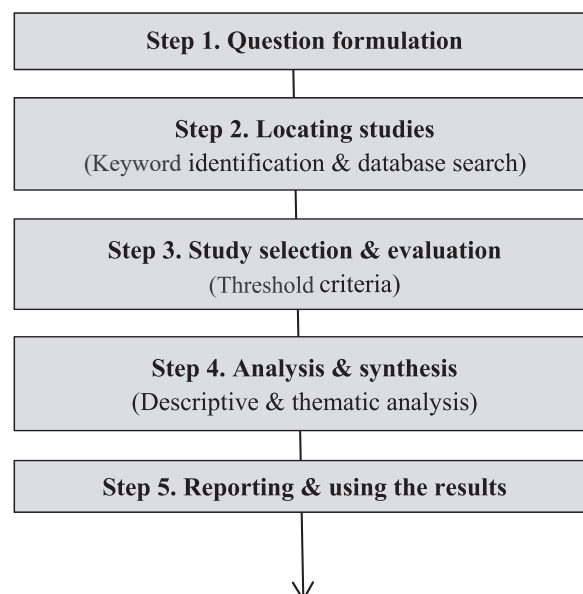


Fig. 1. Methodology approach adapted from Denyer and Tranfield (2009).

Similarly, the database was selected due to the multidisciplinary nature of disruptive innovation, making specific journals not enough to provide comprehensive information. Additionally, the database was used because it covers a wide range of journals in the field of innovation, product development, marketing, strategic management, and technology management from worldwide geographical locations.

The extensive review from Christensen et al. (2018), of research relevant to the theory of disruptive innovation shows that foundational works relating to discontinuities on technology and market appeared at the beginning of the 1980s. Therefore, the publication period researched in this study was defined as 1980–2020. However, despite the depth of the literature review from Christensen et al. (2018), these authors hardly address the strategic role that commercialization activities play in disruptive innovation.

The lack of consistency in operationalizing “disruptiveness” has resulted in the interchangeable use of constructs. This leads in turn to confusion concerning what studies are reporting. Due to the interchangeability of definitions when studying “disruptive innovations”, we used for this study the search strings “disruptive” as well as “radical”, “discontinuu*”, and “breakthrough”, in combination with “innovation*”, in order to understand and compare what is known and what is agreed, depending on the different perspectives and definitions employed. This will reveal where the potential gaps in knowledge are.

The keywords employed in combination with the terms mentioned above were “process*”, “commercializ*”, “market*”, “transfer*”, “adoption”, and “diffusion” (Table 1). These terms were selected from 20 key terms related to the research questions according to the experience of the researchers on the field. The initial search combining the different search strings resulted in the identification of 1180 scholarly papers for further evaluation.

3.2. Study selection

Due to the extensive number of results, a threshold quality criterion (Tranfield et al., 2003) was introduced in order to identify the highest-standard academics papers. The sample does not include books or conference papers. This quality threshold correlates to the quality of the sources, only keeping articles that were published in academic journals ranked by the Thomson Reuters “Journal Citation Reports (JCR) Impact Factor” with the cut-off factor of ≥ 1 . As a result of this limitation, we obtained a sample of $n = 192$ high-quality scholarly articles for further evaluation.

The researchers performed a second delimitation by examining the abstract of the 192 studies, and only potentially relevant articles were chosen for further analysis. The process followed to make that delimitation was to eliminate studies in which the focal phenomenon did not sufficiently represent our focus (research questions). First, we read the abstract, and if it was still not clear whether the article focused on our theme, we skimmed through the article. We eliminated papers in which the focusing phenomenon was only mentioned in passing. Articles concerning the different dimensions of disruptive innovation were excluded if they were not linked to disruptive innovation’s commercialization. This resulted in a final sample of 64 articles (Fig. 2).

3.3. Analysis

A systematic content analysis method was used to synthesize screened materials. Content analysis is an established method that enables minimal interference by the researcher on the phenomenon studied and enables large volumes of data to be handled (Krippendorff, 1980). The method enables the employment of both quantitative and qualitative textual analysis. We first read through the articles to acquire a general perspective on the focal research. Then, we compared, categorized, and coded the contents of the articles in terms of the following:

1. Identification of the role that commercialization plays in the process of disruptive innovation.
2. Categorization of the most relevant constructs affecting the commercialization of disruptive innovations.
3. Elaboration of a theoretical model for the process of commercialization of disruptive innovations.

Three researchers participated in data interpretation and categorization. To identify the main topics in our systematic sample, we scanned the sample multiple times and iteratively developed patterns of recurrent themes. Coding procedures

Table 1
Search filters and results, Web of Science database.

Filters	Search strings	Results	
Search on the article title, abstract and keywords 1980–2020	“Radical innovation” AND	Process* OR Commercializ* OR	735
	“Disruptive innovation” AND	Market* OR Transfer* OR	321
	“Discontinuu* innovation” AND	Adoption OR	110
	“Breakthrough innovation” AND	Diffusion	86
	Combined search strings		1180

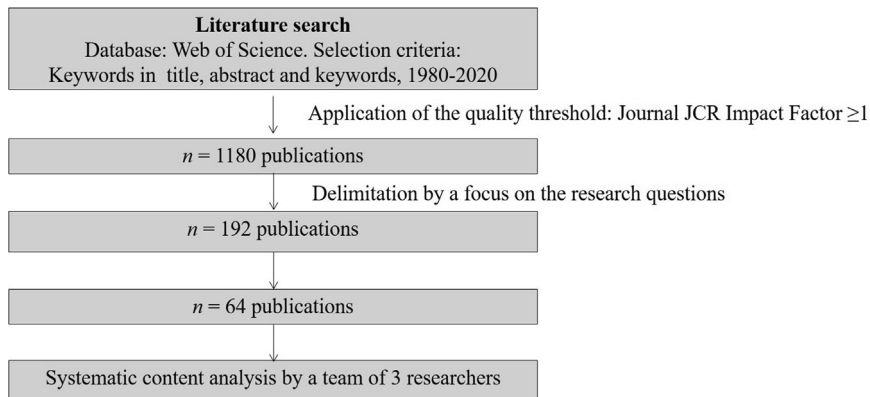


Fig. 2. Systematic research approach.

and categories were assessed in detail by the researchers collectively and compiled accurately. Excel tabling was employed to ensure a consistent, detailed categorization and interpretation of the research findings. As a result, researchers' triangulation increased the trustworthiness of the findings, and provided the opportunity to establish a theoretical model for the commercialization process of disruptive innovations as the main output of this SLR.

4. Findings

This section of the paper presents the findings of the descriptive and thematic analysis. Additionally, it assembles an integrative commercialization model developed from the main findings of the study.

4.1. Descriptive analysis

The of the existing literature reveals three types of studies, with different contributions to the research.

1. Global process models of high uncertainty innovations. They offer us a general framework to develop a better understanding on the role of commercialization activities in the different phases of innovation.
2. Studies that address activities and constructs that affect the commercialization innovation process at specific moments and circumstances. They offer us very focused approaches which require contextualization and positioning within the global commercialization process.
3. Studies that offer complete commercialization models, which will help us to establish an integrative framework for the commercialization phenomenon in high uncertainty innovations.

The researchers scanned the sample multiple times, identifying the main topics and iteratively developing patterns. This was the main approach of the studies (summarized in Table 2). This categorization allowed to better understand the contributions of each study in relation to the commercialization activities proposed. It also helped to identify when they happen during the whole innovation process and their influence. The definition of the type of innovation in the sample's studies (also showed in Table 2) is categorized in relation to the impact of the innovation at macro and/or micro levels, which then generates marketing and/or technology discontinuities. This codification also helps to understand under which perspective the phenomenon has been studied and it also verifies how authors use different innovation categorization when studying the same topics (such as O'Connor and de Martino, 2006; O'Connor, 2008; or O'Connor and Rice, 2013, using breakthrough, radical or discontinuous).

The analysis of the selected materials evidences how commercialization activities have been mainly approached through a Radical Innovation categorization (31 of the articles, almost fifty percent of the sample). They were addressed as Disruptive innovations in only 13 articles (20% of the sample). The Discontinuous approach also appeared in 11 articles, 5 of them using the term "high-tech" innovation or products. A little portion of the sample has been studied through the Breakthrough categorization, with 5 articles present. Finally, other articles have also used terms as "really new" or "major innovation".

These categorizations also revealed different trends. First, most of the articles during the 1990s discussed new technologies under a perspective of traditional New Product Development. However, during the last 20 years, the approach has changed to an exploratory and learning process. The challenge of how to manage user's involvement has been a topic of interest during the whole period of the research sample.

Chronologically we can observe that during the decade of 1990–2000 a grounded theory about market learning was consolidated by scholars such as Dougherty (1990); Hamel and Prahalad (1991); Lynn et al. (1996); or O'Connor (1998), as well as on market orientation, through the studies of McGrath (2001); or Slater and Narver (1998). From 2000 onwards, the

Table 2
Analysis of papers according to ABS Journal type (n = 64).

Journal type	No of publications	Author	Type of innovation	Main approach
Innovation	24			
Journal of Product Innovation Management	15	O'Connor, (1998) Song and Montoya, (1998) Veryzer, (1998a) Veryzer, (1998b) O'Connor and Veryzer, (2001) McDermott and O'Connor, (2002) O'Connor and de Martino, (2006) Govindarajan and Kopalle, (2006) Markides, (2006) O'Connor, (2008) Govindarajan et al., (2011) Chiesa and Frattini, (2011) O'Connor and Rice, (2013) O'Connor, (2013) Slater et al. (2014)	Radical Really new Discontinuous Discontinuous Radical Radical Radical Disruptive Disruptive Major innovation Radical/ Disruptive High technology Breakthrough Radical Radical	Market Learning Success Factors Disruptive Innovation Process User Involvement Market Visioning Strategic Issues Organization Performance Metrics Business Model Innovation Disruptive Innovation Process Market Orientation Adoption and Networks Commercialization Process Uncertainty Management Organization
R&D Management	3	Lettl et al., (2006) Gassmann et al. (2012) Hansen et al., (2019)	Radical Radical High technology	User's Involvement Transition Transition
Technovation	2	Easingwood and Harrington, (2002) Bessant et al., (2006)	High technology Discontinuous	Market Configuration Networks
Research Policy	1	Gans and Stern, (2003)	High technology	Market Orientation
Journal of Engineering and Technology Management	1	Lettl, (2007)	Radical	User's Involvement
Journal of High Technology Management Research	1	O'Connor, (2008)	Radical/Really new	Market Learning
Creativity and Innovation Management	1	Petzold et al., (2019)	Disruptive	Disruptive Innovation Process
General management	15			
California Management Review	5	Lynn et al. (1996) Stringer, (2000) Birkinshaw et al., 2007 O'Connor and Rice, (2001) O'Reilly and Binns, (2019)	Discontinuous Radical Discontinuous Breakthrough Disruptive	Market Learning Market Learning Networks Market Visioning Disruptive Innovation Process
Harvard Business Review	4	Hamel and Prahalad, (1991) Von Hippel and Thomke, (1999) Chakravorti (2004) Garvin and Levesque, (2006)	Disruptive High technology Radical Radical/ disruptive	Market Learning User's Involvement Networks Organization
Academy of Management Journal	2	McGrath (2001) Sarasvathy, (2001)	Radical Radical	Market Learning Market Configuration
MIT Sloan Management Review	1	Rice et al., (2008)	Breakthrough	Uncertainties Management
Management Science	2	Von Hippel, (1986) Marx et al. (2014)	High technology Disruptive	User's Involvement Networks
Journal of Business Review	1	Aarijja and Lehtimaki, (2014)	Radical	Commercialization Process
Marketing	11			
Industrial Marketing Management	5	Story et al., (2009) Möller, (2010) Aarikkaa and Lehtimaki, (2014) Story et al., (2014) Aarikkaa and Sandberg, (2014)	Radical Radical Radical Radical Radical	Competences/DI Process Networks Commercialization Process Barriers Barriers
Journal of Marketing	3	Chandy and Tellis, (2000) Zhou et al., (2005) Coviello and Joseph, (2012)	Radical Breakthrough Major innovations	Success Factors Market Orientation User's Involvement
J. Targeting, Measurement & Analysis for Marketing	1	Sandberg, (2002)	Radical	Market Configuration
Journal of Marketing Research	1	Chandy and Tellis, (2000)	Radical	Organization
Journal of the Academy of Marketing Science	1	Jaworski et al., (2000)	Disruptive	Market Configuration
Operation and Tech.	7			
Research Technology Management	4	O'Connor et al., (2002) Markham, (2002) Paap and Katz, (2004)	Radical Radical Disruptive	Transition Disruptive Innovation Process User's Involvement

IEEE Transactions on Engineering Management	3	O'Connor and Ayers, (2005) Rice et al., (2002) Walsh et al., (2002) O'Reilly and Tushman, (2004)	Radical Discontinuous Disruptive Radical/ disruptive	Competences Commercialization Process Market orientation Organization
Strategy	4			
Strategic Management Journal	4	Dougherty, (1990) Slater and Narver, (1998) Ahuja, (2001) Ansari et al., (2016)	Radical Disruptive Breakthrough Disruptive	Market Learning Market Orientation Barriers Networks and ecosystems
Organization studies	2			
Organization Science	2	Day, (1994) Andriopoulos and Lewis, (2009)	Radical Radical	Championship Organization
Entrepreneurship	1	Shepherd and Gruber, (2020)	Radical	Market learning

approach turned to a market configuration perspective, as enunciated by Jaworski et al. (2000); Sarasvathy (2001); Easingwood and Harrington (2002); or Sandberg (2002). The papers published between 2004 and the beginning of the 2010s represented an early stage in investigating the influence of networks in the commercialization of innovations, as pointed out by Chakravorti (2004) and Bessant et al. (2006); with further in-depth studies about ecosystem creation in the works of Chiesa and Frattini (2011); Aarikka-Stenroos and Sandberg (2012); Marx et al. (2014); or Ansari et al. (2016) during the last decade (summarized in Fig. 3).

The scholar studies during the last years have also focused on competencies and organization for radical innovation: O'Connor and de Martino (2006); Slater et al. (2014); and Story, O'Malley and Hart (2009), as well as in commercialization transition activities in the scale-up stage, as shown by the works of Gassmann et al. (2012); or Hansen et al. (2019). Furthermore, during the last decade the research has also been focused on how to overcome barriers to this kind of innovations, as the work from Aarikka-Stenroos and Sandberg (2014b) shows. Still, recent studies such as the one carried out by Shepherd and Gruber (2020), evidence the controversial relationship between widely extended methods used by practitioners (Osterwalder and Pigneur, 2010; Ries, 2011; or Blank, 2013) and academic research. Scholars have barely taken into account these practitioner's methodologies and rarely appear as academic research. Table 2 shows the categorization by journal type according to the Association of Business Schools' (ABS) ranking. The 64 papers were published in 23 different journals, showing the diversity of research on the commercialization of high uncertainty innovations, and further explaining the phenomenon from different perspectives. More than forty percent of the publications are in the Innovation category, with 24 articles. The General Management and the Marketing categories contribute with 15 and 11 articles, respectively. Within this category, the Journal of Product Innovation Management published the majority of papers (15). The other journals publishing articles on this topic are the California Management Review, with 5 articles (General Management category), the Industrial Marketing Management, with 5 (Marketing category), and finally the Research technology Management (Operations and Technology Management category) and the Harvard Business Review (General Management category), with four papers (Table 2).

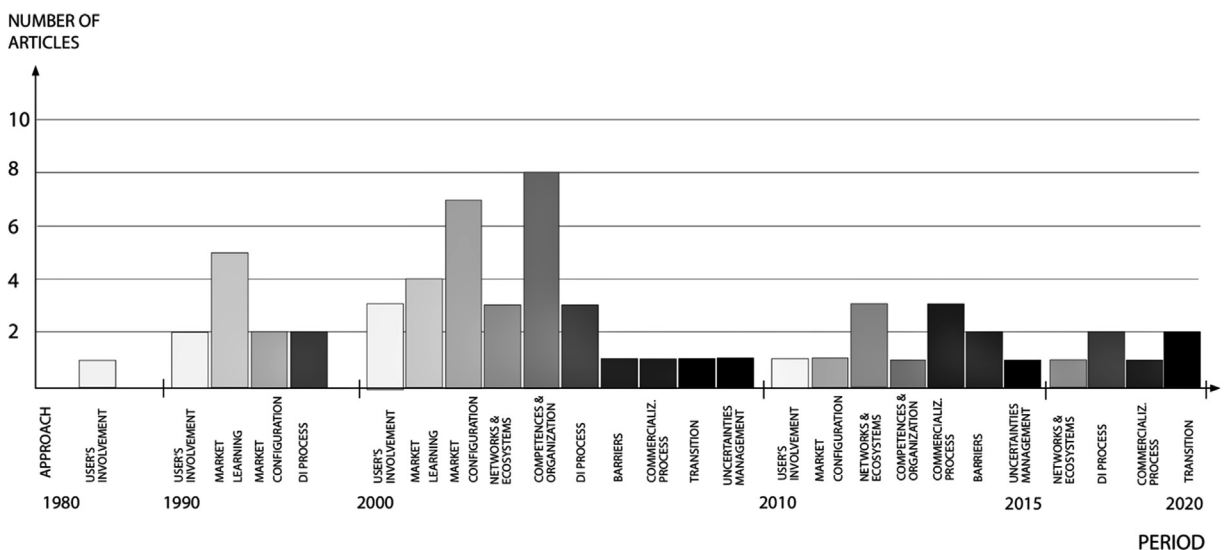


Fig. 3. Approach evolution on Disruptive Commercialization Research (1980–2020).

The category type of the articles seemed to influence the different approaches to the phenomenon. The more prolific authors are O'Connor, with thirteen articles, followed by Rice, with five articles. O'Connor covers several research fields through different terminologies over time, such as Major, Breakthrough, Radical or Discontinuous innovations. Veryzer published three articles at the end of the 1990s. During the last decade, Aarikka-Stenroos (three articles), Sandberg (two articles), and Story (two articles) are the more prolific scholars.

4.2. Thematic analysis

Based on a systematic literature review of 64 scientific articles from 1980 to 2020, this study provides a thorough picture of the current state of affairs in the commercialization of disruptive innovations. As a result, in this chapter, we will describe the information gathered to advance the research field.

4.2.1. Approaches to the commercialization of disruptive innovation

The analysis showed that the number of scholarly articles dedicated to the disruptive innovation process is limited. Only seven articles seem to deal with the complete process, understood as a succession of interrelated phases and activities, and all of these articles employ different approaches. They are as follows: [Veryzer \(1998a, b\)](#); [Markham \(2002\)](#); [O'Connor and de Martino \(2006\)](#); [O'Connor \(2008\)](#); [Story et al. \(2009\)](#); [Petzold et al. \(2019\)](#) (only under the perspective of incumbent failure); and [O'Reilly and Binns \(2019\)](#).

The approaches could be grouped into two categories: linear and nonlinear. A linear view shows that the disruptive innovation process begins with an idea, follows with product development, and ends when the product creates wealth through commercialization. On the other hand, a nonlinear approach emphasizes product development but also interaction with partners during product development, as well as marketing and commercialization activities. In this approach, both development and marketing activities overlap.

Linear Process models: The models from [Veryzer \(1998a, b\)](#), and [Markham \(2002\)](#), present a linear framework where the focus is on concept building, technical feasibility, internal demonstration for obtaining the required approval and support from top company's management, and getting critical resources to develop and launch a new product. The work from [Veryzer \(1998b\)](#) also stresses that the "commercialization phase" is what happens after the innovation project has moved beyond the prototype testing phase. These examples follow a product development-based model ([Cooper, 1986](#)). Despite the high rates of technical and market uncertainty, interaction with customers or markets only appears after the prototype phase, in the final stages of the innovation process, and never before. They share a common approach in that commercialization is a separate and later stage of the innovation process that takes place after the front-end and technical development stages.

Nonlinear Process models: From a competences-based approach, the works from [O'Connor and de Martino \(2006\)](#); [O'Connor \(2008\)](#); and [Story et al. \(2009\)](#), identify four phases for disruptive innovation: discovery, incubation, acceleration and full commercialization, each of which requires distinctive types of expertise and processes.

A discovery capability involves activities that create, recognize, elaborate, and articulate disruptive innovation opportunities. Whereas discovery competencies generate or recognize disruptive innovation opportunities, the incubation competency involves an activity that matures radical opportunities into business proposals.

Incubation is not complete until that proposal has been tested in the market, with a working prototype. The skills needed for incubation are also experimentation skills. Experiments are conducted to reduce not only technical but also market uncertainty, to initiate market creation, and to test the business proposal's match with the market and even with the company's strategic roadmap. As [O'Connor \(2008\)](#), stated, this phase involves probing real prospective customers, developing early commercial versions, testing them, identifying complementary technologies or products, and exploring potential partnership opportunities, as also recognized by [Slater et al. \(2014\)](#). The aim is to maximize learning about customers and markets.

Acceleration focuses on building a business to a level of some predictability in terms of sales and operations and trying to make the innovation ready for the market. This stage is also characterized by market exploration and experimentation, working with real customers to refine the product, the target users and the business models through early commercialization, as also recognized by [Rice et al. \(2002\)](#). Furthermore, [O'Connor and de Martino \(2006\)](#); [O'Connor \(2008\)](#); and [Story et al. \(2009\)](#), agreed that the difficulties of transmitting the R&D project to an operating unit would be eliminated if early commercialization is considered. These assertions have also been confirmed in the work of [Gbadegeshin \(2019\)](#). Acceleration competency ramps up the new business to a point where it can stand on its own before transferring to the corresponding receiving unit. Full commercialization entails launching and scaling up activities and distribution networks in the context of mainstream market creation.

[O'Reilly and Binns \(2019\)](#), presented a variation of the previously described process, and divided it into three main phases: idea generation, or the discovery and development of ideas for potential new businesses; incubation, where the new ideas are validated in a preliminary market; and scaling, where existing assets and capabilities are reallocated to help the new venture grow. To be successful at scaling, a new venture needs to add customers, capacity, and capability fast enough to maximize the market opportunity.

[Petzold et al. \(2019\)](#), describe the process as having an initiation phase, in which a disruptive technology emerges and is incorporated into a business model; a niche market phase, in which the business model is refined, grows and develops; and a final mainstream market phase, which describes the innovation's disruptive effect in an established market. The fundamental

Table 3
Phase comparison between linear and nonlinear models.

Author	Process evolution				
Veryzer, (1998a)	Discovery or convergence phase	Incubating, concept building or preliminary formulation	Formal evaluation	Formative prototype phase	Commercialization phase
Markham, (2002)	Driven by a visionary. Match of an invention with a possible market application	Translating technical capabilities into product attributes or features	Obtaining the critical resources to support the innovation	Technical validation. First testing with customers about needs/ attributes	Launch and scale-up activities
O'Connor and de Martino, (2006)	Discovery	Incubation	Acceleration	Full commercialization	
O'Connor, (2008)	Sense making, finding the potential	Activities aimed at maturing the articulated	Make the innovation ready for the market. Market exploration:	Launch and scale-up activities and distribution networks on the context of market creation	
Story et al., (2009)	offered by the idea	radical opportunity and transforming it into a business proposal, and also at generating a tech platform and new market specifications that will evolve into a concept and a prototype	working with customers to refine the product iteratively before full commercialization		
O'Reilly and Binns, (2019)	Ideation or initiation	Incubation	Scaling/mainstream market phase		
Petzold et al., (2019)	Discovery and development of ideas/tech for potential new businesses	Validation of innovation and business model in a niche market	Reallocate assets and capabilities to help the venture grow		

Commercialization activities carried out during phases of disruptive innovation are colored in this grey tonality.

approach is to analyze the process via the underlying dynamics within each phase. These authors identified events and actions as a dynamic progression: the perception and expectations of the opportunity and the entrant's innovation, the entrant's strategy, and finally the utilization of enabling technologies and factor markets that shape the dynamics characterizing each phase and provoking a proliferation of multiple paths when the innovation is introduced.

The most recent sources from the sample corroborate the consolidation of the DIA (Discovery, Incubation and Acceleration) approach to face disruptive innovations. Table 3 compares the different stages and the evolution of the disruptive innovation, highlighting when commercializing activities appear in the process.

In relation with the commercialization phenomenon, after comparing the previous linear and nonlinear approaches it was learned that the approach to the disruptive innovation process evolved from a more traditional and rigid stage-gate and product development-based model (more commonly applied to incremental innovations) to a process where product development and market and commercialization activities are closely interrelated. These assertions are also recognized by Prebble et al. (2008), and Aarikka-Steenroos and Lehtimäki (2014a), who stress that many decisions and activities relative to technical development and marketing do interact and evolve in parallel throughout the disruptive innovation process and are therefore mutually linked.

Consequently, the commercialization definition changes from a final stage activity that is only based on exploitation to a competence that will have to be developed from early stages of the innovation process, and that is mainly based on exploration and experimentation (Fig. 4).

This school of thought is consistent with the works of Blank (2013), and Ries (2011), where the authors explain that the process of “customer development” should be made in parallel with the “product development” process. This remains especially important in disruptive innovations entering a new market.

Even if it could be affirmed that the approach to disruptive innovation has evolved from linear to non-linear models, as the aforementioned distinctly shows, scholars should seek to advance the state of knowledge on the complex interplay that exists between the disruptive innovation process and the specific commercialization activities that are required for the innovation implementation, as recognized by Slater et al. (2014), or Petzold et al. (2019).

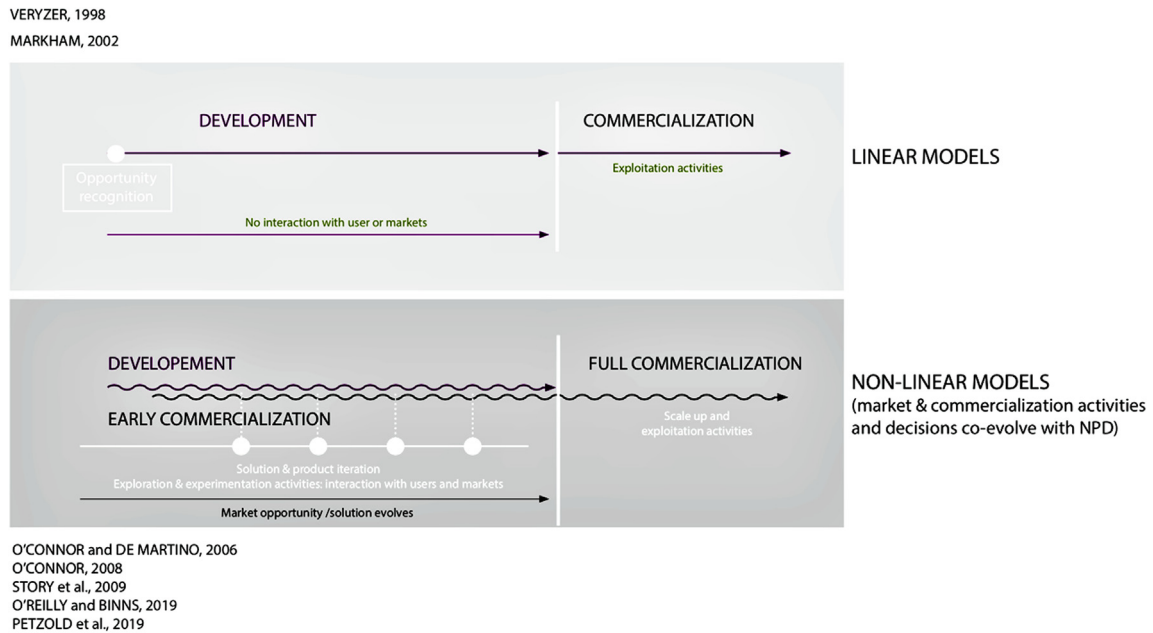


Fig. 4. Comparison between linear and non-linear disruptive innovation models.

4.2.2. The constructs that affect the commercialization of disruptive innovations

Despite the fragmented nature of the sample, which studies the phenomenon under different points of view, this section summarizes the main constructs affecting the commercialization process. This helps to identify the main activities and market strategies to be performed during the different stages of the innovation. This will allow us to correlate them with the integrative commercialization model proposed in the last section of the article.

Market orientation. This area has been mainly studied through the disruptive innovation terminology. It also appears under the breakthrough and radical innovation approach (confirming the interchangeability of terms on these kinds of innovations). Several scholars stressed that innovative companies launch a new product for a specific market when incumbent companies do not usually consider that the new product could be a competitor and such products are not addressed to their customer base. Under this perspective, disruptive innovations often underperform established products in the mainstream markets and offer benefits to emerging customers. Christensen (1997), supports this notion by stating that leading suppliers do not launch disruptive innovations. The main reason is that incumbents are embedded in an existing value network that constrains their ability to introduce disruptive products or business models. They listen too carefully to their current customers. Other authors also know this as the “path dependence” (e.g., McGrath, 2001).

Additionally, Govindarajan and Kopalle (2006), stated that firms capable of developing truly disruptive innovations have a customer orientation focused on emerging customer segments and unfamiliar markets rather than on mainstream customer segments. Similarly, Day (1994); Chandy and Tellis (2000); and Slater and Narver (1998), state that a customer-oriented firm can serve current customers and remain vigilant for *unserved* emerging markets. Christensen (1997), defined an “Over-served” market as one where standard products based on the dominant technology platform are not needed, and a “non-customers” market one where needs are not met with standard products. Dougherty’s work (Dougherty, 1990) pointed out that new product development in unfamiliar markets should be done outside the firm’s strategy (consistent with Burgelman, 1983).

Market learning. This area has been studied through the radical and discontinuous innovation approach. In these scenarios it is crucial to prioritize uncertainties that must be solved, define alternative approaches to explore them, and continually assess the value of cumulative learning. This iterative learning loop allows managers to adopt decisions according to the learning obtained and to warrant the continuation of the project. Exploring as much of the entire landscape as possible before committing to any single direction is regarded as key to advancing organic growth options through innovation (McGrath, 2001). Exploratory learning has focused on identifying appropriate processes to enhance the effectiveness and efficiency of learning. Lynn et al. (1996), enunciated the importance of and organization’s ability to learn about new markets beyond the conventional market techniques. This should be done by probing potential markets with early versions of the concept or the product through successive approximation. Each step creates a more significant understanding and acceptance of the product idea in relation to the markets and customers. The higher the environmental uncertainty, the better those the organizations proving to have superior abilities to manage exploration will be able to adapt to changing circumstances, as stressed by McGrath (2001).

Hamel and Prahalad (1991), used the term “expeditionary marketing” as the way to maximize learning and determine the precise direction in which to design products or services that will fit with the customer needs and drivers, as well as with the market to target. This should be done through market experimentation and learning through low cost, fast-paced market incursions, enabling successive approximations, and minimizing the time and cost relative to product iteration.

Market knowledge and strategy should be redefined iteratively to build on each other. This is why creating effective knowledge on new markets and customers becomes crucial, as recognized by O'Connor (1998), who enunciated several market-related questions and learning mechanisms during the feasibility and prototype phases in disruptive innovation projects.

Furthermore, O'Connor et al. (2008), recognized that *experimental learning* and *early harvesting strategies* through interaction with markets lead to quick learning and can be used to compensate limited understanding of high uncertainty contexts and unfamiliar markets. This also contributes to decision making in the management of disruptive innovation processes.

User involvement. This area has been studied through the different terminologies of “innovativeness”, but mainly under the radical innovation approach. Scholars noted that in these innovations, customers are often unaware of their need until they purchase, test, touch, feel or use a product or service that satisfies their different needs. Scholars advanced different recommendations for managing this issue. For instance, Slater and Narver (1998), stated that it is necessary to systematically understand both the expressed and latent needs, and to proactively create customer value by listening to customers' existing needs, as well as by proactive research of unarticulated needs from potential customers. Paap and Katz (2004), advised that it is crucial to focus on understanding the levels of needs and drivers users have for the new technology. Veryzer (1998b), also stated that customers could not express their latent or future needs, because of a cognitive limitation; they tend only to think about issues relevant to them at that time, concerning their current life or business situation or context, and they are conditioned by what they have learned to do or by their daily behavior. Chiesa and Frattini (2011), added that until customers see new opportunities for improved services or characteristics, these unarticulated needs are not often mentioned. These scholars also added that customers perceive uncertainty about their benefits and the need to alter their behavior in order to realize the potential benefits of the new product. Sandberg (2002), noted that explaining disruptive innovation's benefits to potential customers could be very difficult because the product is still non-existent, and customers would have to visualize functionalities and benefits based on concept descriptions.

Customer and stakeholder involvement should appear from the early stages of innovation. An immediate identification of customers and their involvement in each of the phases of the innovation project becomes crucial, generating a portfolio with tight or loose relations (Coviello and Joseph, 2012). According to Athaide and Klink (2009), ineffective relationship management with potential buyers during New Product Development (NPD) can be a major contribution for new product failure in technology-based industries' markets. Therefore, scholars concluded that testing disruptive innovations with customers to detect latent needs is essential, and they also noted that such testing is very challenging, even with lead users.

Market configuration. This area has been studied through the disruptive innovation approach, mainly because the new entrant's need of reconfiguring the status quo. Scholars as Jaworski et al. (2000); Sandberg (2002); and Easingwood and Harrington (2002), discussed that disruptive innovation usually needs to influence the structure of the market and/or the behaviors of market players in a direction that enhances the competitive position of the new business. More recently, Sandberg (2002) uses the term *Proactiveness*, that could be seen as a firm's tendency to influence the environment and initiate change by anticipating the coming circumstances, and also by showing the opportunities and risks of markets, which are presumably not served by the firm. According to Easingwood and Harrington (2002), persuading a market to adopt new technology is generally comprised of four stages: market preparation, targeting, positioning, and execution. These authors argue that market preparation aims to ready customers and other companies for the innovation stage that usually occurs while the product is still in development. Market preparation includes building relationships and awareness as main strategies. The *Effectuation theory* by Sarasvathy (2001), states that shaping a new market depends on building relationships to create a future (as a result of the interaction between actors) rather than analyzing the competitive landscape. Furthermore, the *Opportunity Creation theory* from Baker and Nelson (2005), and Alvarez and Barney (2007), recognizes that opportunities are not always created by the change in a market but rather they may be endogenously created by the actions of people seeking ways to develop new offerings.

Network and stakeholders. The first decade of 2000 represented an early stage in investigating the influence of networks in the commercialization phase, mainly studied under the radical innovation approach. Chakravorti (2004); Chiesa and Frattini (2011); Möller (2010); and Aarikka-Stenroos and Lehtimäki (2014a), emphasized that networks and collaboration with different stakeholders play essential roles in the commercialization of innovations within interconnected markets. Ansari et al. (2016); and Marx et al. (2014), provided examples of moving from a disruptive to a cooperative strategy with incumbents in order to gain the support of the market actors. Chakravorti (2004); argued that interconnection between market players has an effect on the adoption of innovations and that networked markets can allow a rapid diffusion. Innovators should create a new status quo where the different players (partners, suppliers, distributors, policymakers and regulators, retailers, or consumers) could find an interesting choice. As innovation could change several players' behavior, the innovator should define benefits and incentives for them to guide the adoption network to choose their new product. According to Chiesa and Frattini (2011), in a fully interconnected market, customer acceptance is influenced not only by the commercializing firm but also by the decisions of the members of the adoption network. Thus, it is critical to orchestrate the actions that will influence the key members of this network in order to persuade them to support the innovation and sustain diffusion of the new product or service. Easingwood and Harrington (2002), argued that building relationships is not an option

but rather necessary to obtain extensive support from the adoption network. Aarikka-Stenroos and Sandberg (2014b), developed in an in-depth study an integrative framework explaining the network actors and their main contribution to commercialization. The resources in the network should be focused on creating trust and credibility, awareness-building, developing customer education, making visible the benefits and how can users and opinion leaders use the innovation, generating trial opportunities, defining complementary offerings in interconnected markets, or mobilizing user communities to ensure market pull effects.

Transference activities (scale-up phase). This issue has been approached under the radical innovation perspective. The ambidexterity literature introduces the concept of separated units for exploration and exploitation activities, coordinated at the top management level. This structural detachment guarantees that the exploration activities are preserved from the bureaucracies, managerial routines, and the culture of exploitation (Tushman and Anderson, 1990).

Nevertheless, the detachment of these units from the corporate parent is a necessary yet insufficient condition for success. The work from Andriopoulos and Lewis (2009), argues that ambidextrous organizations require methodologies to activate, organize, and incorporate separated exploration and exploitation units in organizations. This topic should be an area for further research in order to better manage the integration mechanisms that guarantee the transition process to mainstream commercialization.

4.2.3. Commercialization processes

This study provides a thorough picture of the current state of affairs in the commercialization of disruptive innovations through a multifaceted approach. Two papers have been identified in the analyzed sample presenting a framework that describes the process of commercialization of disruptive innovation (activities to perform during the different phases of the innovation and also before full commercialization).

The first, from O'Connor and Rice (2013), is a qualitative prospective cross-case comparison of breakthrough projects in large established companies, mainly focused on market creation. In this, the processes and challenges associated with creating new markets for disruptive innovations are explored. A framework is presented for enabling and constraining mechanisms that teams and organizations impose through the processes and decisions they take in the course of the project's development. A series of propositions regarding the dynamics of successful new market creations for disruptive innovations were enunciated. The results of the study show again that business model development and market creation are nonlinear. Still, they are exploratory processes due to high market and organizational uncertainty and require an exploratory and experimental approach (as enunciated by McGrath, 2001). Opportunities arise and are perceived and elaborated via interactions between firms and potential customers, but also through dynamic intra-organizationally activities. Furthermore, market creation in non-familiar markets may require as much time and investment as their technical development.

O'Connor and Rice (2013), argue that new market creation is the result of managing a set of events and challenges, and identify six market creation activities to implement:

1. Generation and choice of applications
2. Discovering the business model
3. Stimulating the value chain
4. Developing market priming activities
5. Initial market entry
6. Managing market evolution.

Each one may involve constructionist, deconstructionist, and/or modification activities to shape markets and customers or stakeholders' behavior, as also described by Jaworski et al. (2000). These scholars described that the *generation and choice of applications* takes place when the company selects various areas of application for disruptive innovation. They note that the bigger the number of early application ideas, the higher chance of success for the innovation. Also, if the choice of the initial application is based on the firm's past experience with users and markets, it is quite possible to sub-optimize the innovation's market impact, as recognized by Gruber et al. (2008). Furthermore, O'Connor and Rice (2013), described *discovering the business model* as a stage in which the company co-evolves its revenue model of innovation. They advised that the process should be explorative and iterative. Still, the authors explained the importance of *stimulating the value chain* when the company conceptualizes and builds a supply chain for its innovation that involves the whole set of stakeholders. This explanation is consistent with the target endgame concept from Chakravorti (2004). The scholars also added that the *market priming activities* are an early interaction with the market, which can affect the success of disruptive innovations. They stated that articles' publication, advertising in technical journals, product trials, and small market entries are good examples of market priming activities. The final stages, according to these authors, are initial *market-entry* and *market evolution activities*.

The second model, from Aarikka-Stenroos and Lehtimäki (2014a), is focused on business-to-business firms (offering radical products and services). This qualitative cross-case comparison also presents an approach where commercialization activities interact with the ideation and R&D phases. The commercialization processes are complicated by technological uncertainties, but especially by customer and marketing ones. Customer discontinuities mean newness of the customer's needs and customer's behavior. Market discontinuities appear as new products are needed to create new markets that generate in turn new value chain ecosystems and new stakeholder's behaviors.

This work identified six main challenges to overcome: choosing a feasible market strategy under uncertainty conditions, understanding the customer perspective, creating credibility for the innovation and the firm, acquiring support from stakeholders, overcoming adoption barriers, facilitating diffusion, and finally creating sales in the early majority market.

Their results also revealed key constituents of the commercialization process, based on the identified challenges. This results in a straightforward nonlinear process where the disruptive innovation evolves, moving back and forth across three significant zones:

1. Defining market strategy includes developing knowledge on the market, customers, and stakeholders and results in modifying the innovation concept, the targeted segments, the value propositions, and the business model, which in turn refine the innovation strategy.
2. Creating and preparing the market, including building awareness, educating the market, demonstrating benefits, credibility building, and activating and gaining support from stakeholders. These activities will facilitate overcoming adoption barriers from markets and customers.
3. Creating and developing sales in the mainstream market reveals that a different approach should be taken to capture the sales potential of the majority in comparison with early adopters (consistent with the “chasm” concept enunciated by Moore, 2002, and acknowledged by Goldenberg et al., 2002). This mainly occurs because of the different needs between the two segments and because of the difficulty of getting cross-market communication among visionaries and pragmatists, causing a slower adoption from the latter group.

Scholars assumed that moving across these zones would make the commercialization of disruptive innovation effective and efficient. All activities to develop during the different phases are characterized by interaction with relevant stakeholders, customers and users (from the early beginning). This involves continuous experimenting and probing with prototypes and early versions in order to trigger learning about customers and markets, as well as about benefits of the innovation or the potential adoption barriers. All this results in a continuously refined project. According to these authors, neglecting the market preparation and creation stage seems to be a major reason for disruptive innovation failures.

When the above two models are juxtaposed, several common elements can be identified. The two models share patterns in the case of dealing with unfamiliar markets through new categories of products, which are also new for the companies. They suggested not concentrating on targeting familiar markets to avoid underperforming the innovation potential. Furthermore, they both described that market development and innovation development in uncertainty contexts are mutually linked. As the project team explores applications, the market learns about innovation. They evolve in a tandem, and each affects the other. Also, the two models are characterized by an iterative and nonlinear straightforward process. They both put the focus on uncertainty management, itself based on early exploration and discovery, to maximize learning about customers and markets. These learnings affect not only the innovation concept and its value proposition but also the targeted segments and the business model, co-evolving as the market responds.

However, the model from O'Connor and Rice (2013), explains the commercialization challenges mainly as a process of market creation through different key activities to be implemented during the Incubation and Acceleration phases. Aarikka-Stenroos and Lehtimäki, 2014a, differentiate three main phases in which to develop commercialization activities in order to overcome the innovation uncertainties, from the stage of Discovery.

4.2.4. Proposal for an integrative commercialization framework

This article puts forward an integrative theoretical model after examining, comparing, and synthesizing the aforementioned disruptive commercialization frameworks' main characteristics. It puts together the key constructs affecting commercialization and the related activities to be performed, and also establishes when and how to implement them along the whole innovation process.

First, the model completely distances itself from those commonly used in incremental innovation (Stage-gate and variants) in which the newness is minimal. In disruptive innovation, the commercialization activities should be implemented mainly to manage uncertainty (Lynn and Akgün, 1998; and Rice et al., 2002). This is a model characterized by iteration, market experimentation, continuous discovery and learning, and validation (Dougherty, 1990; Hamel and Prahalad, 1991; Lynn et al. 1996; O'Connor, 1998; and McGrath, 2001) and particularly influenced by the need to create new contexts, markets and balances between the whole set of agents involved. Final scaling also poses completely different challenges from incremental innovation, such as moving between different adoption segments or transferring the innovation cell to the corporate ecosystem. Commercialization activities have evolved from exploitation activities to become discovery, learning and validation competences. The model is divided into three main phases, summarized in Fig. 5.

The first stage, *Concept and Value proposition Validation* is focused on determining if the innovation concept could be interesting for a potential user (Fig. 5). It verifies the initial concept hypotheses and identifies the market to target and the precise direction in which to design products or services fitting with the customer needs and drivers. Commercialization activities go beyond traditional market research tasks. They should be carried out through first experiments with early users and stakeholders in order to learn about customer's preferences, perceived benefits, or potential use contexts, and also as a driver to begin finding the segments to target. This step takes place during the Discovery stage. Successive fast and low-cost iterations should be done in different fidelity prototype levels until arriving to first commercial versions of the product or

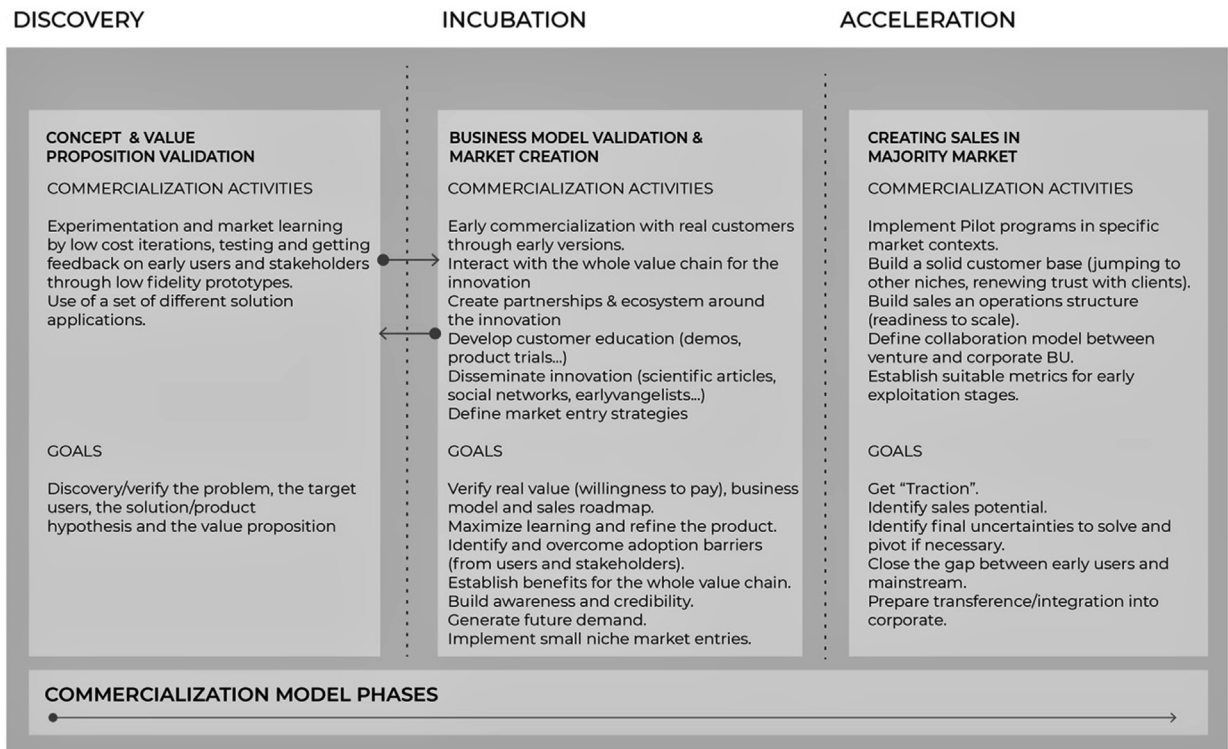


Fig. 5. Integrative framework for the commercialization of disruptive innovations.

service. The market orientation strategy adopted by the firm, focused on unfamiliar or emerging markets (Slater and Narver, 1998; Chandy and Tellis, 2000; and Govindarajan and Kopalle, 2006) is crucial in this phase, in which users and stakeholders should be involved from the very beginning (Veryzer, 1998b; Slater and Mohr, 1998; and Paap and Katz, 2004).

A second main stage, named *Business validation and Market Creation*, aims to gradually disseminate the innovation and to identify and overcome adoption and market barriers. As the innovation is introduced into the market through early versions, the product or service is also modified in an iterative way in terms of the innovation concept, the targeted segments, the value propositions, and finally refining the business model. It is suggested that a wide range of early application ideas that can improve the innovation's chance of success are developed (also corroborated by Gruber et al., 2008). Testing as soon as possible the validity of the business model and the sales roadmap through first sales to real customers is crucial, and reveals a certain willingness to pay for the innovation in the early stages of commercialization that allows evaluating different market entry strategies. This dissemination of the innovation is crucial for overcoming adoption barriers and changing customer's mindset towards innovation. It could also generate the creation of future demand for innovation. This stage takes place during the Incubation phase.

Market configuration activities play an essential role in this stage. Scholars as Jaworski et al. (2000); Sandberg (2002); Easingwood and Harrington (2002); Alvarez and Barney (2007); or Sarasvathy (2001), discussed that disruptive innovation needs to influence the structure of the market and the behaviors of market players in a direction that enhances the competitive position of the new business. The value chain should be stimulated (defining and building it, generating rewards of innovation for all players) through partnerships, and should also offer complete solutions, complementary offerings, share technology platforms or licensing, and create new distribution channels. Furthermore, market priming activities such as articles' publication, advertising in technical journals, developing customer education, product trials, and small market entries are good examples of how to positively affect the success of disruptive innovations. Still, the need of an ecosystem around the innovation integrated by other than members of the company is crucial. Network building enables interconnection between market players and helps towards the adoption of innovations. This garners in turn support from stakeholders, and allows a rapid diffusion (Chakravorti, 2004; Chiesa and Frattini, 2011; and Aarikka-Stenroos and Lehtimäki, 2014a).

The final phase *Creating Sales in Majority Market* appears in more advanced stages of the Acceleration phase. It is characterized by capturing the sales potential of the majority market and by the optimization of operations. This is because some organizational uncertainties usually remain unsolved, and require transition management to integrate the innovation project into the exploitative business units (Rice et al., 2002; and Gassmann et al., 2012). Managing the integration process and balancing exploratory and exploitative market activities is a crucial step under an organizational perspective.

It is vital during this stage not only to achieve first sales with a customer in specific initial niches but also to build customer loyalty and obtain new sales with similar clients. This will confirm the potential of the innovation through establishing a broader and more stable customer base, which can jump to parallel niches (Cubero and Segura, 2020). It is also crucial not to approach the market via a unique killer application, but instead through a series of smaller, niche applications implemented through pilot projects. These early sales favor continuous market learning and enable testing the hypotheses related to the projects and linked to the particularities of the target market. This helps gathering new knowledge in order to refine or pivot the innovation product. Managing the expectations for the innovation and establishing suitable performance metrics is also a crucial activity in order to implement the project properly.

5. Contributions and discussion

Research related to the commercialization of disruptive innovations is quite fragmented and, in addition, the sample here studied reveals that there are partial views from very diverse fields of knowledge. Through a rigorous process of location, selection and analysis, this article presents an integrated model for the commercialization process of high uncertainty innovations and joins together the contributions of the highest-standard academic papers from 1980 to 2020.

The study corroborates the use of the DIA (Discovery, Incubation, Acceleration) model and delves into the interplay of the model with the different commercialization activities to be carried out in each of its phases.

The paper shows the evolution of the definition of commercialization, from a purely exploitative concept, present only in the final phase of the innovation process, to an approach where commercialization activities are mutually linked with those of product development and those based on the experimentation, discovery and validation, which appear from the first stages of innovation. Under this approach, opportunity recognition could appear not only at the beginning of the process but in parallel with the development process, due to a continuous iteration with customers, networks, and markets. This will serve to validate hypothesis about the target users, their problems and the proposed solutions. These innovations impacting at the macro level, defining new markets, modifying market structures, or changing user's drivers, require processes of a mainly explorative nature, far from traditional models of innovation and commercialization. Here, the concepts of market creation and network building take on a crucial relevance in these types of innovations. Targeting emerging customers also requires special attention to the strategies to be implemented in order to create and promote sales in the majority market. The article also provides important challenges to consider before the scaling up, proposing an iterative approximation to the majority sales potential.

The proposed model sets out key activities to be carried out and the time and manner of implementing them within the global innovation process, with the main objective of reducing the uncertainties related to the project. The model is divided into three main phases that coexist within the innovation process and enunciates the key challenges to overcome and the activities to carry out in each moment.

The results show that the mindset of the model as well as the activities described present high similarities (Fig. 6) to the five primary building blocks from the Lean Startup framework (Blank, 2005; Osterwalder and Pigneur, 2010; Ries, 2011): (a)

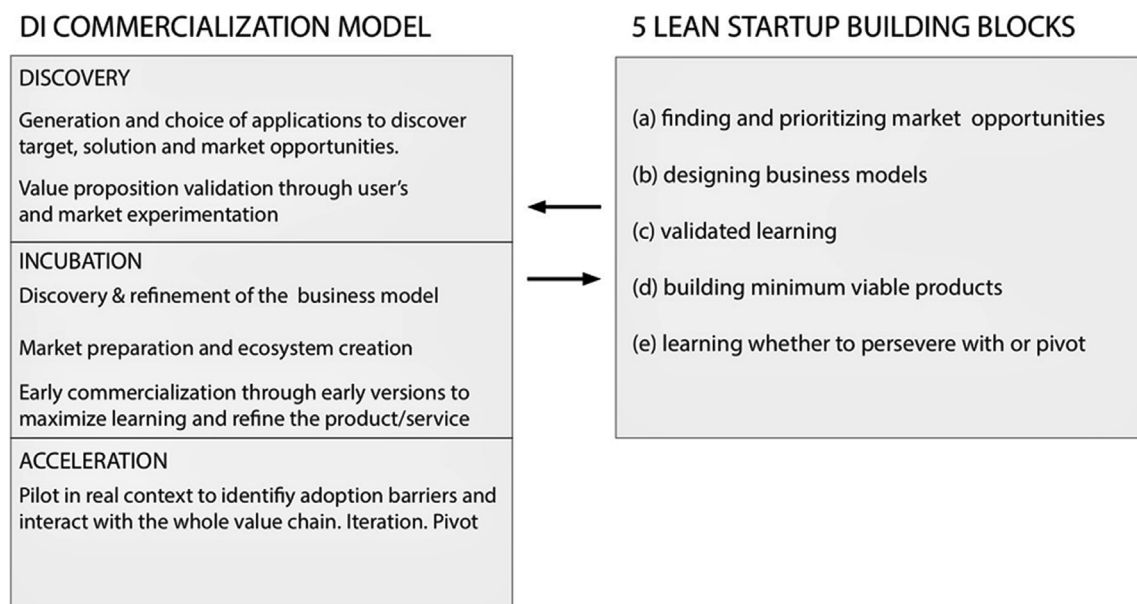


Fig. 6. Key activities comparison between the Disruption Commercialization Model and the Lean Start-up Framework.

finding and prioritizing market opportunities in startups, (b) designing business models, (c) validated learning (including customer development), (d) building minimum viable products (MVPs), (e) learning whether to persevere with or pivot from the current course of action (Gruber et al., 2008). Lean Startup is one of the most popular contributions in the practitioner-oriented entrepreneurship literature from the recent past, and it is surely the framework most widely used by entrepreneurs and practitioners, although it lacks evidence from academic research.

Consequently, the commercialization model resulting from this SLR also provides an academic grounded framework that allows bridging the research–practice gap and establishes a theoretical basis for the different contributions of the Lean Startup framework. This will help academics by offering insights that can guide them towards questions of interest to both academics and practitioners, thus coupling research in both fields.

6. Conclusions and future research

During the past four decades, academic research has explored the commercialization of disruptive innovation from multiple perspectives. Nowadays, the knowledge is mostly still fragmented, and the studies offer little understanding about the whole process of commercialization and its relation to innovation development. At this point, research was needed to develop a comprehensive approach to the disruptive commercialization process and to evaluate what has been studied in this field and what has been left out. This study has taken a broad look at current academic research in the role of commercialization within disruptive innovations.

To examine the field's current state, we conducted a systematic literature review that was based on a multidisciplinary SLR resulting in a sample of 64 high-quality peer-reviewed scholarly articles across 23 journals obtained through a rigorous data collection and analysis process. This article updated theoretical knowledge about the commercialization of disruptive innovations. Six main constructs related to the commercialization of disruptive innovations were identified: market orientation, user's involvement, market learning, market configuration, adoption networks and stakeholders and organization culture.

The paper proposes a commercialization model that results from the examination, comparison, and synthetization of the main characteristics of the disruptive commercialization frameworks that exist in current literature. They describe the commercialization activities to perform according to three main phases: 1) Concept and Value proposition Validation, 2) Business model validation and Market Creation and 3) Creating Sales in a Majority Market. This conceptualization stresses the relationship between the constructs mentioned above and the commercialization model, pointing out when and how each of them interacts during the process. The study also presents a reviewed definition of the concept of commercialization in high uncertainty innovations.

Although the SLR is a rigorous and well-established research approach, this paper has some limitations that need to be acknowledged. First of all, although it is comprehensive in its kind, the systematic literature review could be criticized for not including all relevant work on commercialization disruptive innovations, hence taking a slim selection of publications as a starting point for the analysis. However, through the rigorous procedure of our systematic data collection, we developed a literature base representing as ultimately as possible the relevant thoughts within current research. In addition, we recognize the limitations concerning the objectivity of the analyses' results. The choice of data, the allocation of the main themes, and the interpretation of the results are subjective. To minimize this issue of subjectivity, the multiple researchers' method was applied. The individual assessments were discussed until agreement was reached, and the present analysis and interpretation represent the point of view of all researchers.

Through the comprehensive approach carried out in this systematic literature research, we reveal potential research gaps that can be used as input for forthcoming projects. First, the hypothetical model for commercialization developed here requires empirical validation, generating avenues for future works. Still, more research could be carried out to close the practitioner–academic gap on the explorative manner of approaching high uncertainty innovations. This will help establishing a more consolidated approach that will inspire academics and practitioners, particularly concerning the issues related to scaling. To develop a more mature acceleration and commercialization competency, more research should be done on how to manage leaders' expectations with regards to the sales development in disruptive innovations. Consequently, also on how to develop appropriate performance metrics for the people responsible for market creation that go beyond technical discovery and engineering development. Future research could also be directed toward performance metrics to better measure the success of innovation transition, to balance the activity in exploration–exploitation teams and to overcome the natural tendency to prioritize sustaining innovations.

Additionally, as market preparation and creation seem to be crucial for innovation success, more research in this area is needed. For instance, the manner of mobilizing and committing potential actors. Furthermore, Alvarez and Barney (2007), recognizes that opportunities are not always created by the change in a market but rather that they may be endogenously created by the actions of people seeking ways to develop new offerings. More research is needed to further explore how the activities shaping a new market could be created and leveraged and how they interact with the dynamic commercialization process.

Finally, O'Connor et al. (2008), recognized that experimental learning and early harvesting strategies through interaction with markets lead to quick learning. This can be used to compensate limited understanding of high uncertainty contexts and unfamiliar markets, therefore contributing with decision making in the management of disruptive innovation processes. More research on this area should be carried out to answer how market learning can be implemented across the different

phases of the innovation project. With special attention to how customer participation and their perceptions could be managed and how to accurately define the boundaries of their capabilities for effective customer involvement.

Declaration of competing interest

The authors declare no conflicts of interest.

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