









“Commercialization of conventional and sustainability-oriented innovations: a comparative systematic literature review”

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COMMERCIALIZATION OF CONVENTIONAL AND SUSTAINABILITY-ORIENTED INNOVATIONS: A COMPARATIVE SYSTEMATIC LITERATURE REVIEW

Abstract

Innovations play an important role in achieving competitiveness and long-term economic growth at all levels of the economic hierarchy. More recently, the role of sustainability-oriented innovation in achieving economic growth has become equally important. However, there is a scientific debate about the possibility of effective commercialization of sustainability-oriented innovations. The existence of such scientific debate, as well as the absence of citation-based systematic literature reviews, became a prerequisite for conducting a comparative literature review of research on the effective commercialization of conventional and sustainability-oriented innovations. The purpose of the study is to conduct a comparative review and analysis of research on the commercialization efficiency of conventional and sustainability-oriented innovations. The analysis was conducted on the basis of a citation-based systematic literature review method. The results show that sustainable innovation research is more focused on the relationship between commercialization and firm performance. In the field of conventional innovations, research trends have shifted from studying the impact of technology transfer office (TTO) size, staffing, compensation practices to how strategic factors affect the efficiency of commercialization. In the area of sustainability-oriented innovation, the issues of the strategic orientation impact cause the most sustained interest, while managerial concerns and the stringency of environmental regulations have been actively explored in the past few years. It was revealed that the commercialization efficiency of sustainability-oriented innovations is characterized by so called sustainability-oriented criteria. A distinctive output criterion for commercialization efficiency of sustainability-oriented innovation is the improvement of the firm's image. In addition, content analysis identified possible research directions to be investigated.

Keywords

commercialization efficiency, innovation management,
sustainable innovation, comparative review, content
analysis, input-output approach

JEL Classification O33, O44

INTRODUCTION

Nowadays, innovation plays an increasingly fundamental role in competitiveness at all levels of the economic hierarchy (Kaihua & Mingting, 2014; Secundo et al., 2016; Bayadilova et al., 2020; Kordonska, 2019; Marszałek-Kawa & Siemiątkowski, 2020; Popova et al., 2019). Along with conventional innovations, the importance of sustainability-oriented innovations is also increasing with the growing significance of sustainable development issues (Rajnoha et al., 2019; Atkociuniene & Mikalauskiene, 2019; Krawiec & Noga, 2017). However, R&D expenditures, knowledge and new technologies embodied in innovations can contribute to economic development only if they are effectively commercialized (Siegel et al., 2004; Min et al., 2019; Voropai et al., 2019; Kuchukova et al., 2020). As for sustainability-oriented innovations, there is a scientific debate about the possibility of effective commercialization of such kind of innovations. From investors' point of view, there is a discussion about the advantages

of integrating sustainability criteria in the investment decision-making process, as well as the profitability degree of such integration (Clark et al., 2014). In a research review by Camilleri (2017), some authors failed to prove the existence of a positive relationship between the practice of sustainability-oriented innovation and the economic performance of a firm. Some studies conversely prove the existence of a positive relationship between sustainability-oriented innovation and company's efficiency (Bekmezci, 2015; Kneipp et al., 2019; Aguilera-Caracuel & Ortiz-de-Mandojana, 2013). Thus, the existing scientific debate about the possibility of effective commercialization of sustainability-oriented innovations, as well as the lack of a comparative analysis of research on the commercialization efficiency of conventional and sustainability-oriented innovations, caused the need for a comparative review and analysis of research on the commercialization efficiency of these two kinds of innovations.

Moreover, the relevance of this study is driven by the following important gaps in previous systematic literature reviews:

- 1) none of the studies focused on commercialization performance indicators and methods for its evaluation;
- 2) none of the studies conducted a detailed content analysis of the most cited and relevant publications.

This study attempts to fill these gaps.

The purpose of this comparative review is to examine scientific groundwork on the effective commercialization of sustainability-oriented innovation versus conventional innovation that is not sustainability-oriented. The objectives of the comparative literature review are:

- 1) to identify and compare trends in the development of research directions on the problems of effective commercialization of innovations;
- 2) clarify and compare the most relevant research areas that cause the utmost scientific interest in the chosen topic;
- 3) identify distinctive features inherent in commercialization efficiency of conventional and sustainability-oriented innovations; and
- 4) define future research directions.

1. LITERATURE REVIEW

As part of this study, a citation-based systematic literature review was conducted on the efficiency of commercialization of conventional and sustainability-oriented innovations. The literature review was guided by the methodological approach applied in Ahmad et al. (2020).

The citation counts of research papers have been extracted from the Web of Science database. Web of Science is the largest reference and quoted database of peer-reviewed literature (Zhidebekkyzy et al., 2019; Meho & Yang, 2007; Falagas et al., 2008), and a standard tool for much of the world's citation research.

A step-by-step article selection process is as follows:

1. By specifying relevant keywords in the "Subject" line, 6,945; 226; 283 and 3,080 results were obtained for Commercialization effect*; Commercialization efficiency; Sustainab* innovation commercialization; and Sustainab* innovation effect, respectively.
2. Restriction to categories such as: Management, Business, Economics, Social Sciences Interdisciplinary, Green Sustainable Science Technology; selection of the "Article" document type and English language.
After filtering and sorting, 790; 226; 113; 1,383 results were received for above-mentioned four keywords in the same order.
3. Results were sorted by relevance.

Then, by reviewing abstracts, the most relevant articles were selected. The final sample consisted of 128 and 44 papers for conventional and sustainability-oriented innovations, respectively.

Existing research analyzes the impact of legislative regulation (Shane, 2004; Cunningham & O'Reilly, 2018), institutional conditions (Rossi, 2018; Aguilera-Caracuel & Ortiz-de-Mandojana, 2013; Draskovic et al., 2019; Draskovic et al., 2020), strategic orientation (Cheng & Huizingh, 2014; Mu & Di Benedetto, 2011; Gans & Stern, 2003; Brown & Hendry, 2009; Walsh, 2012; Ardito & Dangelico, 2018), and organizational features of the firm (Brettel et al., 2011; Knockaert et al., 2011) on the efficiency of commercialization. Previous research has also evaluated the commercialization efficiency at the levels of a company (Shane, 2004; Cheng & Huizingh, 2014; Chen, 2009; Mu & Di Benedetto, 2011), a university (Powers & McDougall, 2005; Thursby & Kemp, 2002; Vinig & Lips, 2015), a region (Guan & Chen, 2010; Chen & Guan, 2012), a country (Guan & Chen, 2012), and commercialization or technology transfer office (Swamidass & Vulasa, 2009). These studies will undoubtedly be useful for all participants of the innovation process, in terms of evaluating the efficiency of commercialization processes, identifying influencing factors, and developing compre-

hensive measures to improve process at all levels of economic activity. However, existing literature reviews have not sufficiently systematized methodologies used and approaches to commercialization performance indicators. In addition, the existing reviews did not comprehensively identify the most relevant research areas and trends in their development.

In general, there are two types of literature review, namely, traditional literature survey (TLS) and systematic literature review (SLR). For more information about each of them, see Ahmad et al. (2020). Most research on innovations' commercialization efficiency is based on TLS (Siegel & Phan, 2005; Bozeman, 2000; Bozeman et al., 2015; Siegel et al., 2007).

As for systematic literature reviews on the commercialization efficiency (Wit-de Vries et al., 2019; Kirchberger & Pohl, 2016), none of them conducted a citation-based content analysis. In addition, most literature reviews analyze a relatively small number of articles, using 28 to 48 publications as the research object. This paper reviews 128 and 44 studies in the area of conventional and sustainability-oriented innovations, respectively. For a more detailed analysis of previous literature reviews see Table 1.

Table 1. Comparison of keywords, number of articles and type of literature review

Source: Compiled by the authors.

Authors	Article selection criteria (keywords used in the search process)	Number of papers	Type of a literature review
Conventional innovations			
Current study	Commercialization effect* Commercialization efficiency	128	SLR
Siegel & Phan, 2005	No criteria provided	39	TLS
Bozeman, 2000	No criteria provided	NP	TLS
Bozeman et al., 2014	No criteria provided	48	TLS
Wit-de Vries et al., 2019	'University – business', 'university – industry' "academic engagement" and "research partnership" 'collaborat*', 'cooperation*', 'partnership*', 'engage*', 'relation*' 'research' 'alliance*'	35	SLR
Siegel et al., 2007	No criteria provided	28	TLS
Kirchberger & Pohl, 2016	'technology commercialization' or 'technology transfer'	140	SLR
Sustainability-oriented innovations			
Current study	sustainab* innovation commercialization sustainab* innovation effect	44	SLR
Golicic & Smith, 2013	sustainability, performance, social responsibility, corporate responsibility, environmental management, green, sustainable practices, lean, reverse logistics, closed-loop supply chain, occupational health, occupational safety, efficiency, effectiveness + references from prior meta-analyses and reviews	77	SLR

Note: SLR: systematic literature review; TLS: traditional literature survey; and NP: not provided.

Moreover, some of the previous literature reviews focus on the knowledge and technology transfer (Bozeman, 2000; Bozeman et al., 2015; Wit-de Vries et al., 2019). Undoubtedly, publications on knowledge and technology transfer deserve careful scientific attention, since transfer and commercialization are closely interrelated concepts (Poór et al., 2018). However, they are different in essence. In this regard, this literature review is aimed at making a certain contribution to the existing theoretical framework in the field of innovative development.

Regarding the efficiency of commercialization of sustainability-oriented innovations, only one literature review was found (Golicic & Smith, 2013). This study contains a systematic literature review, but does not conduct a citation-based content analysis.

2. CONTENT ANALYSIS OF THE MOST CITED PAPERS

This section provides content analysis of the most cited papers in the area of commercialization efficiency of conventional (20 papers) and sustainability-oriented innovations (10 papers). The main purpose here is to identify common and distinctive features of conventional and sustainable innovation research. These features are going to be defined by detecting current research directions, trends in research areas, the methodology applied, systematizing research data and input-output approaches.

For content analysis, the most cited and the most relevant papers were selected. The relevance of the paper was determined by analyzing the abstract. Also, only empirical papers were selected for content analysis. Literature reviews were excluded. A list of articles selected for content analysis can be found in Appendix A.

2.1. Thematic analysis

Table 2 provides comparative thematic analysis of conventional and sustainable innovation research. Major attention was paid to the factors affecting the commercialization efficiency of both types of innovations. In comparison with thematic focus of conventional innovation research, papers in the field of sustainability-oriented innovation are more focused on the relationship between commercialization and firm performance.

In addition, trends in the development of research areas were identified. In the field of conventional innovations, the impact of organizational resources and mechanisms on commercialization efficiency is of constant interest. Since 2002, at least one study in the above-mentioned area has been published annually. Research on the measurement process is of increasing scientific interest. There is also a steadily growing interest in how strategic orientation affects the commercialization efficiency. Topics such as the impact of public and venture financial resources, legislative factors and human resources, as well as the impact of open innovations, despite their significance, cause insufficient scientific interest. Trends in the study of influencing factors are shown in Figure 1. Prior to 2008, research on the impact of technology transfer office (TTO) size, staffing, compensation practices on commercialization efficiency of conventional innovations was common. Since 2017, it has become common to study the impact of intermediary structures, university-industry collaboration on the efficiency of commercialization.

In the area of sustainability-oriented innovations, the impact of strategic orientation causes the most stable interest over the entire period of publication activity (Figure 2).

Table 2. Comparative thematic analysis of conventional and sustainable innovation research

Source: Compiled by the authors.

Conventional innovation		Sustainability-oriented innovation	
Influencing factors (11 and 5 papers, respectively)			
Measurement scheme (process)	7 papers	Relationship between sustainability-oriented innovation and firm performance	5 papers
Commercialization strategy	3 papers		

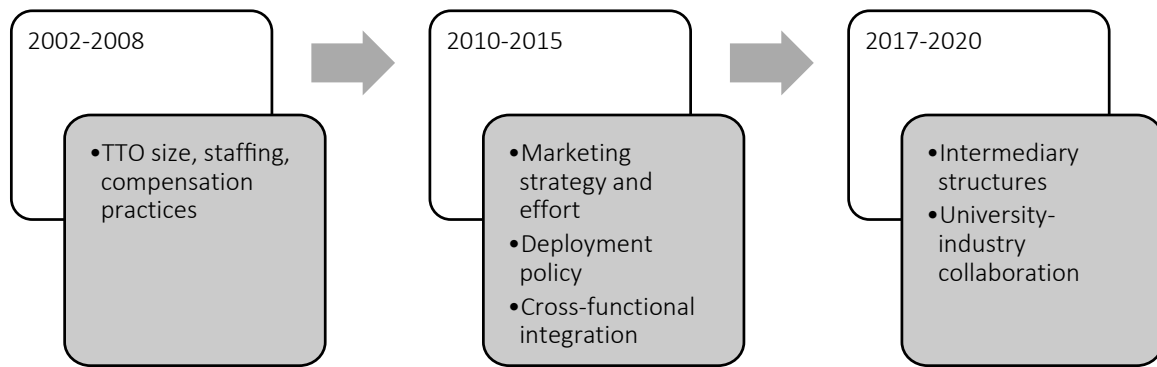


Figure 1. Trends in the development of conventional innovation research

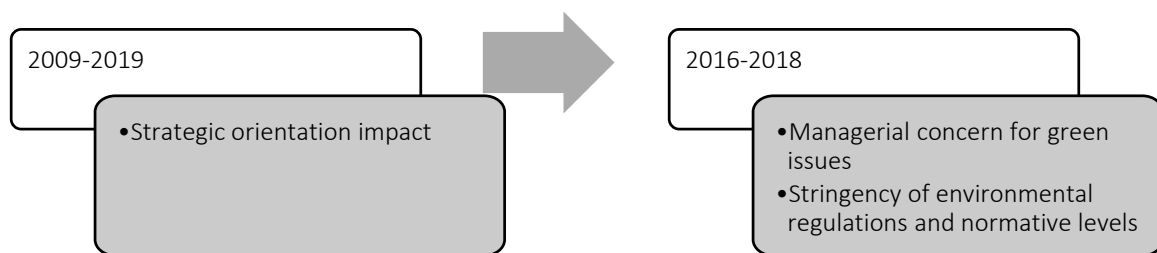


Figure 2. Trends in the development of sustainability-oriented innovation research

2.2. Overview of the methods used

The choice of the research methodology is an important issue for any researcher. A comparative overview of methods used is presented in Table 3.

There is a concentration of research methods in the field of conventional innovations, in particular, regression analysis and Data Envelopment Analysis (DEA) are mainly used. In the field of sustainability-oriented innovations, a combination of various research methods is employed.

Table 3. A comparative overview of the methods used

Source: Compiled by the authors.

Conventional innovation		Sustainability-oriented innovation	
Method	Number of studies	Method	Number of studies
Regression analysis	5	Questionnaire survey method + Regression analysis	2
Data Envelopment Analysis (DEA)	3	Panel estimation techniques + Sensitivity analysis	1
DEA combined with regression analysis	2	Heckman two-step selection model	1
Structured, in-person interviews	1	Matched-pairs analysis + Multiple and moderated regression analysis	1
Exploratory study based on in-depth interviews + regression analysis	1	Multinomial endogenous treatment effects model	1
Questionnaire + Regression analysis	1	Event study methodology + Cross-sectional analysis	1
Cox proportional hazard duration models+ Logistic and Tobit regression	1	Factor analysis + DEA-Tobit two-stage method	1
Structural equation modeling	1	Questionnaire + Structural equation modeling	1
Case study	1	Questionnaire + Exploratory factor analysis + Regression analysis	1

Note: Remaining four papers on conventional innovations apply the following methods: Exploratory factor analysis, Input-Output model, Importance-Performance analysis + Confirmatory factor analysis, Approach based on the potential for technology transfer.

Table 4. A comparative review of the data used

Source: Compiled by the authors.

Country	Number of studies		Research object	Number of studies		Time period	Number of studies	
	conventional	sustainable		conventional	sustainable		conventional	sustainable
USA	9	2	University/ Technology transfer office	6 (30%)	–	$T < 5$	2	4
China	3	2	Company	5 (25%)	10 (100%)	$5 \leq T \leq 10$	5	–
Taiwan	3	1	Country/ region	3 (15%)	–	$T > 10$	4	1

2.3. Characteristics of the data used

A comparative review of the data used is presented in Table 4. There is a difference in research objects in two compared themes: in case of conventional innovations, main research objects are the university/technology transfer office, company and country/region. The issues of sustainability-oriented innovations are studied only on the company level. The time periods for data used also differ. The remaining countries studied that are not shown in Table 4 represent a minority and include OECD countries, Germany, Belgium, South Korea, Netherlands, Zambia, Australia. The minority of research objects include interview/survey, project, patent.

2.4. Approaches to inputs and outputs

This section describes approaches to inputs that reflect costs and outputs reflecting performance indicators. When measuring the commercialization

efficiency of conventional innovations, macro-, micro-, original, and intermediary approaches are mainly used. The approaches were defined based on the measurement level. In other words, macro-approach (MacroA) means that the assessment is made at the state or regional level, micro-approach (MicroA) implies the company or firm level, original approach (OA) evaluates efficiency at the level of university as the primary source of innovation, and intermediary approach (IA) considers the level of commercialization or technology transfer office as an intermediary structure. Figure 3 reflects the distribution of input and output approaches used in research on conventional innovations.

Regarding the commercialization of sustainability-oriented innovations, the classification of approaches was based on the study by Golicic and Smith (2013). They identify a number of input approaches, among which the production-oriented approach (POA) is one of the most common in the studies analyzed in the current literature review. Also, such

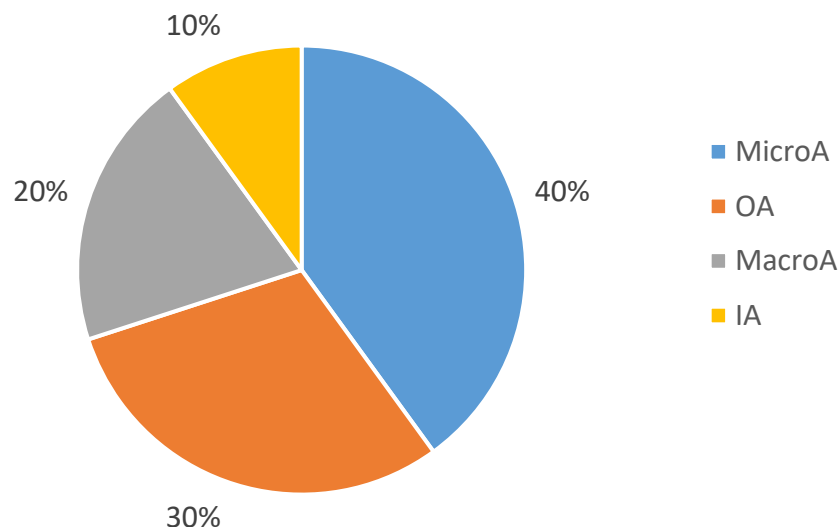


Figure 3. Distribution of approaches to inputs and outputs on the commercialization efficiency of conventional innovations

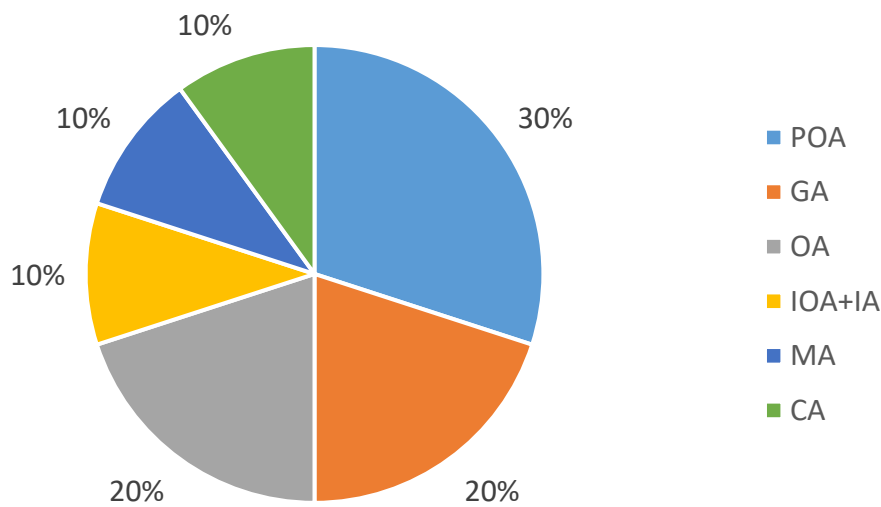


Figure 4. Distribution of input approaches used in sustainability-oriented innovation research

input approaches were identified as: generalized approach (GA); organizational approach (OA); intensity-oriented approach (IOA); institutional approach (IA); managerial approach (MA); and collaborative approach (CA). Figure 4 presents the distribution of input approaches used in research on sustainability-oriented innovation. The most common approach is the production-oriented approach (POA): 30% of the articles applied production indicators as an input parameter. The generalized approach (GA) involves using index indicators as an input, whereas the organizational approach (OA) considers various organizational mechanisms.

With regard to outputs, the classification of approaches described in Golobic and Smith (2013) was also applied. They classified the output parameters depending on whether the performance indicators are market-based (market-based approach, MBA), operational (operational-based approach, OBA) or accounting (accounting-based approach, ABA). Besides, the aggregate approach (AA) was highlighted. AA includes not only economic efficiency, but also quality efficiency, innovation efficiency, environmental and social efficiency. Figure 5 shows the distribution of output approaches.

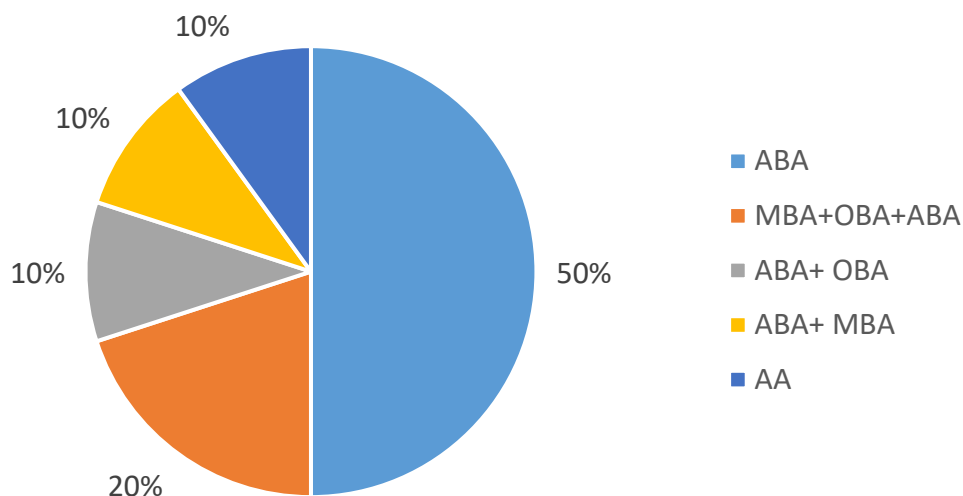


Figure 5. Distribution of output approaches used in studies on the commercialization of sustainability-oriented innovations

2.5. Generalization of the main statements

The most studied topic in the field of conventional and sustainable innovation is the factors affecting the commercialization efficiency of innovations. Also, in the field of sustainable innovation, a lot of attention is paid to studying the relationship between the practice of sustainable innovation and firm efficiency.

Regarding the trends in the development of research areas, the measurement process and the impact of strategic orientation are of increasing scientific interest. The impact of state and venture financial resources, legislative factors, human resources, as well as the impact of open innovation have not been sufficiently studied.

In terms of factors affecting the commercialization efficiency, research trends have shifted from the level of TTO (size, staffing, compensation practices) to a more strategic level – the interaction between universities and industry.

In the field of sustainable innovation, the impact of strategic orientation is of constant interest. The influence of managerial concern for green issues and the stringency of environmental regulations and normative levels are of increasing scientific interest.

Regression analysis and Data Envelopment Analysis (DEA) are two most common research methods in the field of conventional innovation. For sustainable innovation research area, there is no preferred research method. Commercialization efficiency of conventional innovation is mainly evaluated by the example of research objects such as university/technology transfer office, company and country/region, while company is the only research object for the issues of sustainability-oriented innovations.

Most of the research in the field of conventional innovations was conducted using a company and a university as an example (40% and 30%, respectively). 30 % of studies in the area of sustainable innovation applied production indicators as an input parameter. As for the output parameter, half of the research on sustainable innovation applied accounting-based indicators.

3. DISCUSSION

Answering the research questions stated in the introduction, an attempt was to discuss the main findings.

- 1) *Identify and compare trends in the development of research directions on the problems of effective commercialization of innovations.*

In research on the commercialization of conventional and sustainable innovations, there is a shift in trends towards a more active study of the impact of strategic orientation on the commercialization efficiency. Indeed, to achieve effective commercialization, it is necessary to realize the importance of the role of innovation processes at the strategic level. In addition to the factor of strategic orientation, the impact of the managerial concern for green issues, the stringency of environmental regulations and normative levels on the company's performance are of increasing scientific interest. In other words, it is important for companies to assess the impact of both strategic orientation and institutional incentives on the commercialization efficiency of sustainable innovations.

- 2) *Clarify and compare the most relevant research areas that cause the utmost scientific interest in the chosen topic.*

The most relevant research area in the field of commercialization of sustainable innovations is the relationship between the practice of sustainable innovation and firm efficiency. The fact that commercialization efficiency of sustainable innovations is studied exclusively at the company level suggests that companies first need to know how the practice of sustainable innovations affects their economic efficiency.

- 3) *Identify distinctive features inherent in commercialization efficiency of conventional and sustainability-oriented innovations.*

Commercialization efficiency of conventional innovations is evaluated at the macro-level, micro-level (company level), and university level. Therefore, efficiency is characterized by indicators inherent in each of these levels. Below are the main input and output parameters that character-

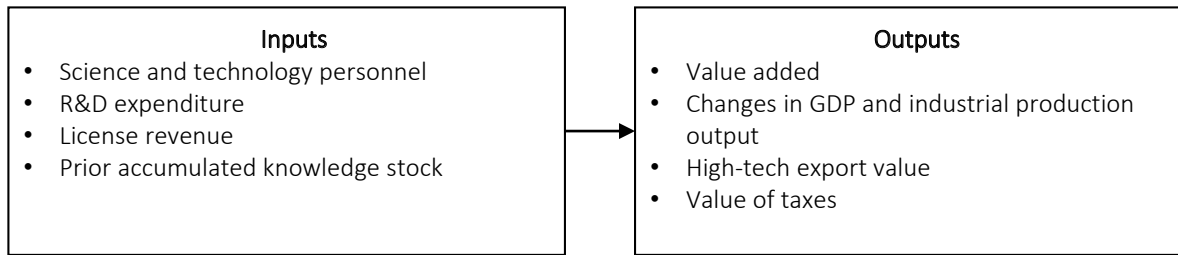


Figure 6. Commercialization efficiency indicators at the macro level

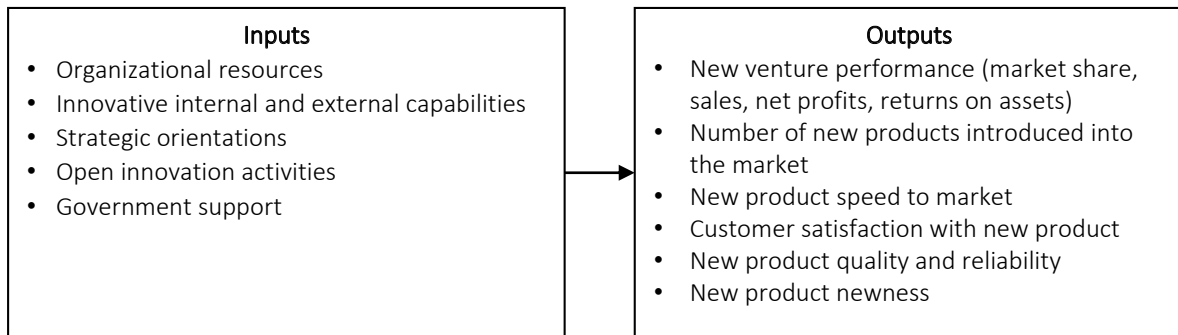


Figure 7. Commercialization efficiency indicators at the company level

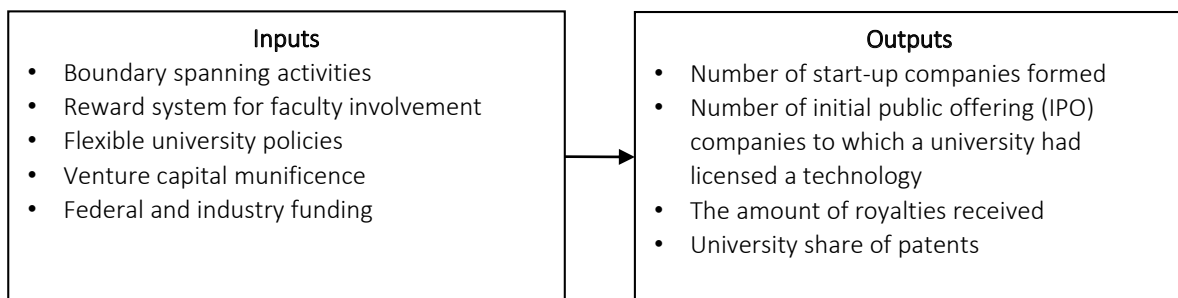


Figure 8. Commercialization efficiency indicators at the university level

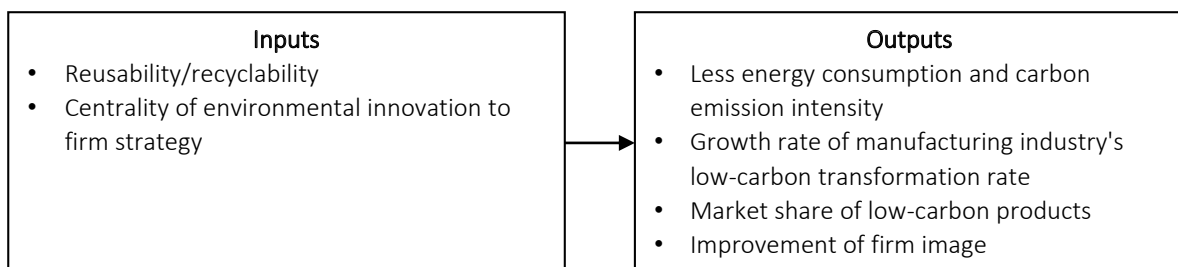


Figure 9. Commercialization efficiency indicators for sustainability-oriented innovation

ize commercialization efficiency of conventional innovations at the macro-, micro- and university levels (Figures 6-8).

When evaluating commercialization efficiency at the company level, along with internal factors, increasing attention is paid to the influence of exter-

nal factors, such as open innovation activities and government support.

Unlike conventional innovations, commercialization efficiency of sustainability-oriented innovations is characterized not only by economic indicators, but also by so called sustainability-oriented

criteria (Figure 9). Distinctive output criteria for sustainability-oriented innovation is the improvement of firm image. Moreover, commercialization efficiency of sustainability-oriented innovation is influenced by regulatory factors such as the stringency of environmental regulation, environmental governance and normative levels.

Regarding the comparison of the results of the current review with the results of previous stud-

ies, Kirchberger and Pohl (2016) found that research trends in the field of factors of effective commercialization have shifted from a strategic orientation to the level of intermediary structures. The current review came to the opposite conclusion. However, there is a limitation in the review of Kirchberger and Pohl (2016): an analysis of studies published up to 2013 was carried out. The current review analyzes articles published up to 2020.

CONCLUSION

This study contributes to a better understanding of the scientific groundwork of the effective commercialization of conventional and sustainability-oriented innovation. Research results show that the most relevant research areas are influencing factors, measurement process and the relationship between sustainability-oriented innovation and firm performance. Besides, stable interest is caused by topics such as the impact of organizational resources, strategic orientation on the commercialization efficiency, whereas the impact of state and venture financial resources, legislative factors, human resources and open innovations cause insufficient scientific interest.

Regarding the commercialization efficiency indicators, they vary depending on the level of the economic hierarchy. In addition, commercialization efficiency of sustainability-oriented innovation is characterized by so called sustainability-oriented criteria, among which the most distinctive output criteria is the improvement of firm image. Commercialization efficiency of sustainability-oriented innovations is influenced, among other things, by regulatory factors such as stringency of environmental regulation, environmental governance and normative levels.

The content analysis of the most relevant research areas identified possible areas for future research that need to be explored. It would be interesting to know the impact of factors such as legislation in the field of commercialization and intellectual property protection, industry differences, time-to-market and speed to market on commercialization efficiency of innovations. In addition, research in the field of post-IPO performance of firms holding university licenses, the reasons for the success and failure of commercialization in individual cases, the impact of sustainability-oriented innovation practices at the macro-level is of future interest.

AUTHOR CONTRIBUTIONS

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APPENDIX A

Table 1A. List of papers selected for content analysis

№	Reference	
	Conventional innovations	Sustainability-oriented innovations
1	Siegel et al., 2004	Chen et al., 2006
2	Powers & McDougall, 2005	Wagner, 2010
3	Thursby & Kemp, 2002	Rennings & Rammer, 2011
4	Shane, 2002	Aguilera-Caracuel & Ortiz-de-Mandojana, 2013
5	Shane, 2004	Manda et al., 2016
6	Guan & Chen, 2010	Tang et al., 2018
7	Guan & Chen, 2012	Yadav et al., 2016
8	Cheng & Huizingh, 2014	Bi et al., 2016
9	Brettel et al., 2011	Jones & Corral de Zubielqui, 2017
10	Chen, 2009	Maletič et al., 2016
11	Link & Scott, 2010	
12	Knockaert et al., 2011	
13	Swamidass & Vulusa, 2009	
14	Chen & Guan, 2012	
15	Mu & Di Benedetto, 2011	
16	Roessner et al., 2013	
17	Lo et al., 2012	
18	Vinig & Lips, 2015	
19	Ho et al., 2014	
20	Kang et al., 2013	