

Knuepling, Louis; Wessendorf, Colin; Basilico, Stefano

Working Paper

Revisiting innovation typology: A systemic approach

Jena Economic Research Papers, No. 2022-002

Provided in Cooperation with:

Friedrich Schiller University Jena, Faculty of Economics and Business Administration

Suggested Citation: Knuepling, Louis; Wessendorf, Colin; Basilico, Stefano (2022) : Revisiting innovation typology: A systemic approach, Jena Economic Research Papers, No. 2022-002, Friedrich Schiller University Jena, Faculty of Economics and Business Administration, Jena

This Version is available at:

<https://hdl.handle.net/10419/251488>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



FRIEDRICH-SCHILLER-
UNIVERSITÄT
JENA

*Revisiting innovation typology:
A systemic approach*

Louis Knuepling | Colin Wessendorf | Stefano Basilico

JENA ECONOMIC RESEARCH PAPERS · # 2022-002

Revisiting innovation typology: A systemic approach

Louis Knuepling, Institute of Economic and Cultural Geography, Leibniz University Hannover, knuepling@wigeo.uni-hannover.de, ORCID: 0000-0001-8072-2908

Colin Wessendorf, Centre for Regional and Innovation Economics, University of Bremen, wessendorf@uni-bremen.de, ORCID: 0000-0002-0797-7151

Stefano Basilio, Chair of Microeconomics, Friedrich-Schiller-Universität Jena & Faculty of Economics and Business Studies, University of Bremen, stefano.basilico@uni-jena.de, ORCID: 0000-0001-9444-9893

Abstract

Innovation studies use labels such as *radical* or *disruptive* to qualify innovation according to different concepts. Within the literature, these labels are frequently used interchangeably due to overlaps in their characteristics. These various definitions present challenges when the labels are operationalized in empirical studies. Based on a quantitative analysis of the most common innovation labels' definitions in 532 scientific papers, we find that novelty and impact, predominantly used for empirical operationalization, differentiate only between ordinary and more exceptional innovations. Based on our findings, a differentiation between the impact's target and the consideration of positive versus negative effects enables better distinction between labels for more 'exceptional' innovations. We extend the existing literature and enable a more precise definition of (single) innovations by providing a novel, more nuanced description of innovations' different characteristics and a further distinction of their effects. Thereby, the relevant decisive aspects will be communicated more accurately.

Keywords: radical, incremental, disruptive, breakthrough, innovation typology

JEL Classification: O31; O32; O33

1 Introduction

Innovations are differentiated into various types. Rather exceptional innovations, are often labelled *radical*, *discontinuous*, *disruptive* or *breakthrough* (Kovacs, Marullo, Verhoeven, & Van Looy, 2019), whereas more ordinary innovations are labelled *incremental* or *continuous*. Between 1999 and 2015, radical innovation evolved as the most important concept that characterizes exceptional innovations (Kovacs et al., 2019). Despite its popularity, it lacks a coherent distinction from other important innovation concepts (Audretsch, Fornahl, & Klarl, 2021; Gopalakrishnan & Damanpour, 1997). For example, Kovacs et al. (2019) demonstrate that more than two thirds of the authors covering innovation-related topics use several labels in different publications, which they explain with a highly related ‘intellectual origin’ (p. 23). Innovations are often categorized based on their novelty, but the categories are inconsistent (Garcia & Calantone, 2002). One firm or one author may identify an innovation as *radical*, while other firms or authors would refer to the same innovation as *incremental* (Garcia & Calantone, 2002; Linton, 2009). As Gopalakrishnan and Damanpour (1997) point out, even the label *innovation* itself is interpreted differently from different perspectives and by different scholars. The resulting confusion bears multiple challenges: First, relevant literature which uses a different terminology may be overlooked in the research process. Second, at the same time, old findings can be simply refreshed with a new terminology instead of really bringing forward something new. Third, practitioners can hardly learn from scientific results if the terminology is too unclear (Garcia & Calantone, 2002).

Previous studies address the terminological problems in different ways. Gatignon et al. (2002) put forward a structural approach to innovation assessment into its locus, the type, and characteristics. Garcia & Calantone (2002) argue for a distinction into micro- and macro-level effects and between effects on technology and marketing. Linton (2009) calls for the consideration of innovation inputs, outputs, and the perspective (different perception of innovations depending on the firm). All these approaches can help to classify single innovations more precisely compared to labeling them as *radical* or *disruptive*. However, innovation labels are widely used, because they combine several underlying characteristics, which helps in classifying innovations in large-scale empirical studies and to compare empirical results. Though, it requires a delineation of the different innovation labels in order to assure the underlying characteristics are clear. In this regard, only Kovacs et al. (2019) systematically review the origin and scientific usage of *radical*, *disruptive*, *discontinuous*, and *breakthrough* as the most common labels for exceptional innovations. Their

analysis of definitions in 100 highly cited papers allows for a differentiation between on the one hand *radical* and *discontinuous* (as novel innovations) and on the other hand *disruptive* and *breakthrough* as impactful innovations. Though, it does not allow for any further discrimination.

Therefore, the objective of this paper is to systematically assess the characteristics associated with different innovation labels in the literature on a larger scale (over 500 articles), in order to come up with a set of distinctive properties. This categorization can enable clearer operationalization in empirical research, thus pushing knowledge creation in the field of innovation research further and rendering the applicability of scientific results easier for practitioners. Inspired by the studies of Gatignon et al. (2002) and Linton (2009) we collect innovation characteristics from definitions in scientific articles in a systemic way from requirements (input) to descriptive features (content), and effects (output), as also suggested by Audretsch et al. (2021). Differently from other studies, we do not limit ourselves to a basic distinction of the main requirements, features and effects. We provide a more in-depth analysis to better characterize the different innovation labels. Practitioners and other researchers, when faced with choosing the right label for their study, can be guided by the findings of our research, thus reducing ambiguity.

In the first step, we inductively code the characteristics assigned to different innovation labels in more than 500 scientific papers retrieved from the Web of Science. Then, we aggregate the codes to broader dimensions, allowing us to quantitatively assess the most decisive characteristics for a coherent distinction. In determining the core requirements, features, and effects associated with each innovation label, we develop a better understanding of their differences and commonalities. In order to detect also shared characteristics between all ‘exceptional’ innovations, we add *incremental* and *continuous* as labels for rather ordinary innovations to the four labels analyzed by Kovacs et al. (2019).

Our set of dimensions allows a clear differentiation between exceptional (more novel and more impactful) and ordinary innovations (less novel and less impactful). Innovation requirements, however, vary to a lesser extent between the labels, which highlights that the necessary conditions and inputs for innovation do not predict innovation outcomes as good as expected by previous studies (Kovacs et al., 2019). Moreover, beyond refining the positioning of labels within the dimensions of novelty and impact, we highlight two further dimensions (technology vs. market orientation and positive vs. negative effects) that help to differentiate the four labels for exceptional

innovations, especially for operationalization in quantitative studies. Even though these dimensions have been put forward in other studies (Lampert, 2001), we, first, confirm this pattern empirically through a systematic analysis of definitions of the most common innovation labels, and second, also show how the labels are positioned within the framework.

The remainder of the paper is structured as follows: After a review of the literature (2), we explain the applied methodology (3). Our results (4) and their discussion (5) follow before we conclude in the last section (6).

2 Innovation concepts: interchangeability and systematization

In the economic literature, (technological) novelties are most frequently addressed by the labels *invention* and/or *innovation*. *Invention* is usually either explicitly or implicitly defined as ‘non-commercial’ or ‘not yet commercialized’ (Ahuja & Lampert, 2001; Arts, 2012; Dahlin & Behrens, 2005; Garcia & Calantone, 2002). An *innovation*, by contrast, is considered to be a novelty that contains new knowledge (out of the pool of new knowledge stemming from the inventions) which ‘has proven its relevance for the market economy’ (Lundvall, 2016, p. 142). These definitions lead to the ‘consensus in the literature that innovation is an outcome of new knowledge’ (Forés & Camisón, 2016, p. 1) and that *innovations* are commercialized *inventions* (Ahuja & Lampert, 2001; Hill & Rothaermel, 2003; Schoenmakers & Duysters, 2010) – a definition which is either explicitly emphasized in the literature or implicitly indicated (Arts, 2012; Arts, Appio, & van Looy, 2013). As our principal goal is to distinguish the different labels assigned to *inventions* and *innovations* and to outline the labels’ ambiguities, we do not further stress this particular differentiation. In most of the literature, the difference between *invention* and *innovation* seems to be at least implicitly clear. In contrast, the distinction within the group of so-called ‘exceptional innovations’ (Kovacs et al., 2019) is more difficult. In the following, we explain how the innovation labels are often used interchangeably and why it is difficult to distinguish them. The focus, for a matter of simplicity, lays on the label *radical* and on how to distinguish it from others. We select it, because it is the most widely used label for ‘exceptional innovations’ in the business and economics literature.

2.1 The interchangeable use of innovation concepts

Innovation labels, when first introduced by an author have a specific meaning. The author wants to emphasize some features of an innovation that have not been touched upon by other labels. As an example, Bower & Christensen (1995), when they first introduced ‘disruptive innovation’, referred to old technologies that are simplified and adapted to increase demand in the part of the market where existent products do not. Entrants introduce these new products in the market, while incumbents are still offering higher quality products. Eventually, through further innovations and gains in market shares, the former are able to create new business models and consequently completely ‘disrupt’ the industry (Christensen, Johnson & Rigby, 2002; Markides, 2006). Other pre-existing terms were not considering the simplification of a technology for marketing reasons as one of their main features. Therefore, Bower & Christensen (1995) identified examples of real innovations with exactly this feature and coined the label ‘disruptive innovation’.

Once the label started to diffuse, other researchers used *disruptive* as a term closely related to ‘radical innovation’. Hervás-Oliver, Albors-Garrigos, Estelles-Miguel and Boronat-Moll (2018, p. 1388) use *disruptive* as a characteristic of ‘radical innovation’, instead of considering it as specific innovation label in itself. They highlight how ‘radicalities’ can lead to disruption: ‘Radical innovation’ refers to technological discontinuities that incorporate new knowledge that destroys the value of incumbent systems and technologies in the marketplace’ (p. 1388). Hao & Feng, (2016) claim that radical innovations lead to changes in the existing way of thinking, which introduces a disruption of an established technological trajectory. In these two cases it is clear that the term “disruption” is used to identify events happening in technological domains after the introduction of a radical innovation. This is a usage of the term “disrupt” has not been considered originally by Bower & Christensen (1995) whom coined the term. Moreover, authors often use *radical* and *disruptive* as synonyms increasing the confusion around these two labels (Colombo, Franzoni, & Veugelers, 2015; Dijk, Wells & Kemp, 2016; Kaplan, 1999).

Another prominent example is dealing with three labels that can be used either as separately with different meanings or as synonyms: ‘radical innovation’, ‘discontinuous innovation’ and ‘breakthrough innovation’. ‘Discontinuous innovation’ is often regarded as the spark introducing a new technological path (Büschgens et al., 2013; Kassicieh, Kirchhoff, Walsh, & McWhorter, 2002; Lynn, Morone, & Paulson, 1996). However, it is also used as a characteristic of ‘radical

innovation’, as in the above quote of Hervás-Oliver et al. (2018), or as a synonym for ‘breakthrough innovation’. For example, the novelty introduced by ‘radical innovations’ can be defined as large and breaking with the existing paradigm (Kemp, 1994; Tripsas, 1997). Therefore, this characteristic of “breaking with the existing paradigm” is exactly named by different authors as *discontinuous* (O’Connor, 1998; O’Connor & Ayers, 2005). Moreover, as an example, O’Connor (1998) uses the term *discontinuous* as a synonym for *breakthrough*.

Similarly, Ayres (1988) describes the concept of ‘breakthrough innovation’ as the process to overcome a technological bottleneck, opening possibilities for further innovations. However, *breakthrough*, is also often used either as a synonym for *radical* (Arts et al., 2013; Della Malva & Riccaboni, 2015; Henkel, Rønne, & Wagner, 2015; Schoenmakers, Duysters, & Vanhaverbeke, 2008) or as a specific characteristic associated with a radical innovation, the so called “breakthrough-like” character (Ahuja & Lampert, 2001; Steenhuis & Pretorius, 2017).

Even though labels such as *radical* and *incremental* should be clearly delineated, because they are located at opposite ends of the continuum of the degree of innovativeness (Ettlie, Bridges, & O’Keefe, 1984; Schoenmakers & Duysters, 2010), some overlaps still remain. Incremental innovations are commonly described as improvements, small adjustments or further developments of an existing technology or product (Arts et al., 2013; Arts & Veugelers, 2015; Dewar & Dutton, 1986; Kasmire et al., 2012). However, Garcia & Calantone (2002) show how scholars interpret the degree of radicalness that is embedded in an innovative activity differently: “[T]he same innovation can be labeled on either ends of the scale of innovativeness depending on the researcher” (p. 118). Referring to the electric typewriter, which replaced the manual one, they point out that authors with a market perspective and practitioners would rather consider it *radical*, whereas authors with a technological perspective would regard the changes as rather *incremental*. Thus, the same innovation is labeled differently based on its impact on the technological (*incremental*) or on the market level (*radical*). This different labeling based on the type of characteristic considered generates confusion between the two concepts.

In this section we pointed out that innovation labels are often used interchangeably or as a specific characteristic of other labels. These practices are not wrong per se. However, the ambiguous application of innovation labels creates confusion among researchers and practitioners that

approach innovation studies. Other scholars have noticed the same patterns in the literature and tried to systematize innovation labels. We provide a review of these studies in the next subsection.

2.2 Literature on systematization of innovation concepts

Previous attempts, to systematize innovation labels, mainly focus on identifying innovations by using different characteristics (Garcia & Calantone, 2002; Gatignon et al. 2002; Linton, 2009). More recently, Kovacs et al. (2019) systematically review the definition of the labels. Here we revise these studies and we explain how our paper is different and contributes into the existing literature.

Garcia & Calantone (2002) provide a framework for the theoretical operationalization of product innovation by grouping innovations into *radical*, *really new* and *incremental*. They argue to differentiate between the macro level (industry, world) and the micro level (firm) and between changes in technology versus changes in marketing. Accordingly, only radical innovations affect all dimensions, whereas really new innovations affect at least either technology or marketing on both the micro and the macro level, and incremental innovations only affect the micro level. Gatignon et al. (2002) systemize innovations by identifying three dimensions: The locus of an innovation, its type and its characteristics. Locus and type are mainly defined by a product's architecture and position within a system (e.g., core versus peripheral subsystem in a greater system, such as a car). Characteristics also comprise the innovation's magnitude and effect (p. 1105f.). Regarding the latter, they find that the distinction between radical and incremental innovation does not correspond to other common dichotomies, such as competence-enhancing versus competence-destroying or architectural versus generational innovation. All of these represent different dimensions in the description of an innovation. More generally, Linton (2009) puts forward a distinction between innovation inputs and outputs and the importance of the 'unit and level of analysis'. Among others, latter refers to the different perception of the same innovation as either radical or incremental, depending on the perspective, as outlined before.

More recently, Kovacs et al. (2019) investigate origin and usage of innovation labels. They show that the intellectual origin of the four labels for exceptional innovation tends to describe either their degree of novelty (*radical* and *discontinuous*) or their effects (*breakthrough* and *disruptive*). Contrary to these empirical findings, Sood & Tellis (2005, p. 153) claim: 'Many terms, such as "revolutionary," "disruptive," "discontinuous," or "breakthrough," [...] define an innovation in

terms of its effects rather than its attribute'. However, according to Kovacs et al. (2019), scholars tend to use both novelty and impact to describe and define a label. This might boost the interchangeable use we highlighted earlier.

In order to reduce ambiguity, Kovacs et al. (2019) systemize innovations in a two-by-two matrix along the axes of novelty and impact, based on a content analysis of 100 highly cited papers. Therein, *incremental* is the only label solely occurring in the quadrant of low novelty and low impact, whereas the four labels for exceptional innovations are either always novel (*radical* and *discontinuous*) or always impactful (*disruptive* and *breakthrough*) but varying in the other dimension (Figure 1). Though clearly advancing the understanding of origin and usage of common innovation labels, this classification does not allow for further differentiation of innovations, such as disruptive and breakthrough innovation. Moreover, all of the previously mentioned studies focus on specific and few characteristics of innovation labels, whereas their specific categorization is important to observe all possible different facets. The consideration of innovation inputs, a more nuanced description of characteristics (beyond the degree of novelty), as well as a further distinction within the effects, might enable to characterize not only single innovations, but also to define innovation labels more precisely.

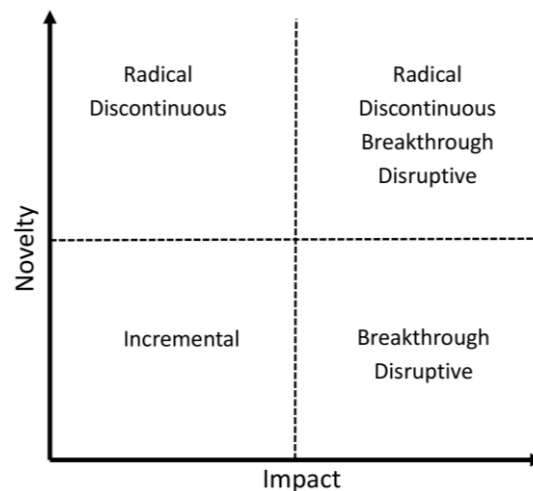


Figure 1: Dimensions of 'exceptional innovation' in Kovacs et al. (2019)

Source: Own representation according to Kovacs et al. (2019)

By combining the systemic framework along inputs, characteristics and effects with a more in-depth study of innovation labels' definitions in over 500 scientific articles we are able to improve current innovation typologies and the delineation of the six labels investigated. In this sense, we

extend the literature on the categorization of innovation labels by providing a novel framework and a more precise delineation of the labels.

3 Method

To specify the most prominent innovation labels (see section 2) and to highlight the inconsistencies in their distinction from another, we analyze how they are defined in a variety of peer-reviewed publications. We obtain our core dataset by conducting a manual, quantitatively oriented analysis of the relevant literature. Computational text analysis is improving quickly but still lacks precision when it comes to context (Arts, Cassiman, & Gomez, 2018). Since we focus on wording, we maintain a conservative approach of manual text coding. The relevant literature is obtained by a Web of Science (WoS) search for the labels *radical*, *discontinuous*, *disruptive*, *breakthrough*, *continuous*, and *incremental* alongside *innovation(s)*, *invention(s)*, *technology(ies)* or *technological change* appearing as a topic of the document. We choose the topic instead of the title to increase the number of hits while preserving the relevance of the keyword for the content of the document. The 5,042 documents found are reduced by filtering only documents belonging to the broader category of the social sciences (2,629 documents) (Figure 2). These fields are more likely to provide definitions and discussions of the innovation terminology. Subsequently, the set is reduced by filtering for ‘articles’, ‘proceeding papers’, and ‘book chapters’ to consider actual scientific contributions (no news outlets, editorial material, etc.). Further, we exclude documents with no or few citations. We believe that more influential work also shaped the use of innovation labels to higher degrees. Consequently, all documents belonging to the 25 percent of highest citations within arbitrarily chosen groups of years (see Figure 2 – ‘citation filter’) are selected. Nevertheless, some older articles receive high citation counts, wherefore we include all articles with more than 30 citations even if the 75 percentile is higher.

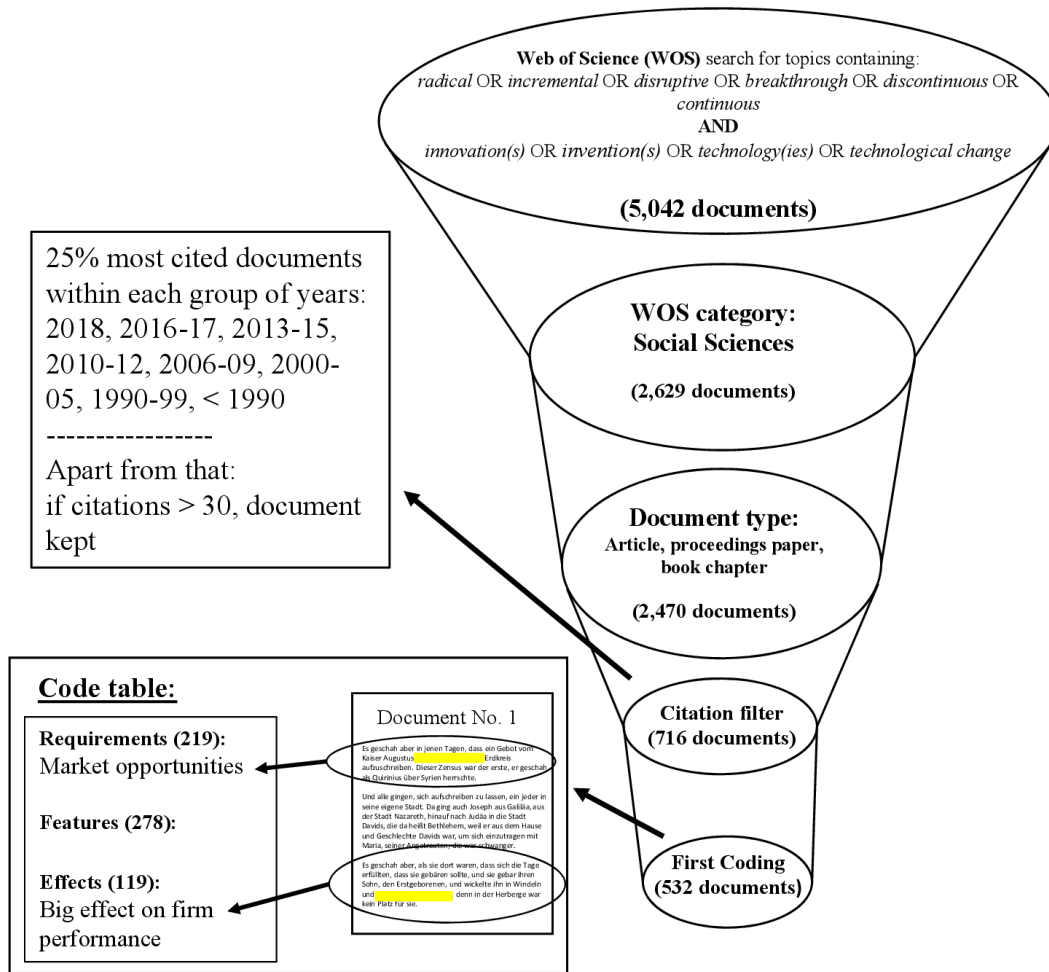


Figure 2: Data retrieval and coding

Source: Own representation

In the subsequent review of the remaining 716 documents, we search for each innovation label that was assigned as a topic of the document and check for definitional phrases around the label's occurrences (Figure 2 – 'first coding'). In a group meeting of the three authors with another four members of the research group, we discussed the joint approach to coding. Based on the systematic divisions of Linton (2009) and Kovacs et al. (2019) with inputs as necessary condition for a certain type of innovation, its very nature (features, such as the degree of novelty) and its outputs (or effects), we reached agreement about assigning each phrase containing definitional elements about the respective innovation label to one of the three phases *Requirements* (Input), *Features* (Content), or *Effects* (Output). In this way, further and other systematizations were excluded in advance but ensured that all codes could be clearly assigned. The following phrases exemplify the coding procedure:

To develop radical innovations, firms depend on technological and market related capabilities. One important market related capability is the competence to involve the 'right' users at the 'right' time in the 'right form'. (Lettl, 2007, p. 53)

This paragraph is coded as *'market opportunity'* and is assigned to the *requirements* phase. It is *'market related'* and describes the involvement of *'the right users at the right time'*, which refers to opportunity detection. Such a capability can be regarded as a requirement or cause (input) of radical innovation.

Most innovations in operational Business Units (BU's) are incremental and build on established products and technologies and exploit the current knowledge base of a company. They are mere improvements in the product to reinforce the current viability of the company in a particular business or market (Berends, Vanhaverbeke, & Kirschbaum, 2007, p. 316)

This is, among others, assigned to the *features* and coded as *'small product modification or improvement'* as it describes the content of an incremental innovation.

Moreover, radical innovations can be a key to firms opening new markets and can have a significant effect on overall firm performance (Green, Gavin, & Aiman-Smith, 1995, p. 203)

This example can clearly be identified as an *effect* (output). Moreover, the effect is described as *'significant'*, why we code it as *'large effect on firm performance'*.

532 documents contain definitional information. From these, we obtain 219 distinct codes (803 mentions) for requirements, 231 codes (2,196 mentions) for features, and 119 codes (730 mentions) for effects¹. In total, we have 3,729 mentions of the six innovation labels (57% *radical*, 23% *incremental*, 8% *breakthrough*, 5% *disruptive*, 5% *discontinuous*, and 2,5 % *continuous*).

The inductive coding results in many codes occur rarely. However, they are very similar to others. For example, *'financial benefit to the firm'* and *'greater likelihood of, or longer business survival'* both refer to positive effects on the innovating organization. To systemize and aggregate the codes for an easier quantitative assessment, the research group engaged in a second round of discussions (and subsequent coding). Thereby, five dimensions were defined to which the first-

¹ Tables with complete list of codes are available upon request.

round codes could be assigned with a specific expression. The result (Table 1) is strongly oriented towards linguistic, grammatical components.

Table 1: Definitions of dimensions for assignment in second round of coding

Subject	Object	Intensity	Direction	Perspective
			Describes an	
Describes <i>what</i> the code is about (e.g. <i>performance</i> , <i>structure</i> , <i>power</i>)	Describes <i>to which</i> <i>entity</i> the code is associated(e.g., <i>market</i> , <i>organization</i> , <i>technology</i>)	Describes whether the code specifies an <i>intensity</i> , such as <i>high</i> or <i>low</i>	additional subject or adjective like <i>positive</i> , <i>negative</i> , <i>change</i> or <i>creation</i>	Describes whether the code is about something <i>internal</i> or <i>external</i> to the innovating entity

Notes: The first-round codes are assigned to these dimensions to aggregate more representations of the innovation labels' definitions

Based on the description of these five dimensions, for each phase (*requirements*, *features*, *effects*) a team of two members of our research group assigned each first-round code to an inductively generated expression in each of the five dimensions. For example, when the code describes an effect on performance (of the firm, the market, etc.) the code is assigned the expression *performance* in the dimension *subject*. In the data aggregation process, each dimension was given the minimum number of distinct expressions needed to preserve important differences. In some cases, especially with very general codes (e.g., '*change*'), not all dimensions could be filled. As can be seen in Table 2, the first-round code '*market opportunities*', for example, is neutral in its *intensity* and does not have a *direction*.

In a second step, the results were passed on to another team, which in turn created its own assignment to expressions in the five dimensions based on its own inductive expressions. Ambiguous assignments and expressions were then discussed in the group until a common solution was found. Table 2 exemplifies the assignment for one code of each phase. For example, the code '*big effect on firm performance*' (*effects*) is assigned to the *subject* '*performance*', the *object* '*organization*', the *intensity* '*high*' ('big effect'), the *direction* '*neutral*' as it is not further valued, and to '*internal*' as it describes the *perspective* of the innovating firm.

Table 2: Second round of coding: Assignment of codes to dimensions

Code	Phase	Dimension					Innovation Label (No. of Occurrences)	
		Subject	Object	Intensity	Direction	Perspective	Radical	Incremental
Market opportunities	Requirements	Structure	Market	Neutral	-	External	9	1
Small product modification or improvement	Features	Novelty	Product	Low	Improvement	Neutral	1	81
Big effect on firm performance	Effects	Performance	Organization	High	-	Internal	20	1

Notes: Empty spaces are left if the code does not contain the respective dimension. The labels ‘radical’ and ‘incremental’ are chosen exemplarily. Note that, e.g. ‘market opportunities’ is an external requirement, whereas ‘opportunity detection’ is internal.

For a quantitative differentiation between the labels, we aggregate the information contained in Table 2 according to matching expressions in the different dimensions. If we are, for example, interested in the potential of the dimension *subject* to discriminate between the *effects* of the different innovation labels, we aggregate the codes of the *effects* phase to their expressions in the dimension *subject* regardless of their assignment to the other dimensions (Figure 3). We then calculate the share of each expression as a label-total. Hence, we observe and interpret differences in the distribution across the expressions (Figures A1-A3). When all dimensions (*subject, object, intensity, direction, perspective*) are combined, the 569 first-round codes (Column ‘Code’ in Table 2) are aggregated into 350 unique combinations of expressions along the dimensions (unique combinations of all ‘Dimension’ columns in Table 2). For example, the codes ‘*revitalization of incumbents*’ and ‘*value creation for the whole industry*’ are both aggregated to the expressions ‘*performance - industry - neutral - positive - external*’ in the respective five dimensions. Even though the codes do not have identical meaning, they refer to relatively similar phenomena.

Code	Phase	Dimension	Innovation Label		Dimension	Innovation Label		Dimension	Innovation Label	
			Radical	Incremental		Subject	Radical		Incremental	Subject
Code1	Effects	Structure	10	5	Structure	16	6	Structure	51.6%	33.3%
Code2	Effects	Structure	5	0	Performance	5	18	Performance	16.1%	66.7%
Code3	Effects	Performance	0	10	Power	10	0	Power	32.3%	0%
Code4	Effects	Structure	1	1				Total/label	100%	100%
Code5	Effects	Power	10	0						
Code6	Effects	Performance	5	8						

Figure 3: Calculation of label-wise shares over expressions of a dimension (here: subject)

Notes: Irrespective of the original Code (Code1 – Code6), the expressions (structure, performance, and power) are aggregated and the number of occurrences is summed up.

4 Results

The results section is structured as follows: First, in comparison with Kovacs et al. (2019) we show the distribution of codes between the phases (requirements, features, effects) to identify which labels are more input- or output-associated in the literature. Next, to get an impression of overall similarities and differences between the labels we display the cosine similarity between the six innovation labels, based on their distribution over the 350 unique codes that result from the aggregation in the second round of coding (also divided into *requirements*, *features* and *effects*). Finally, to identify the origin of these differences, the central distinguishing characteristics are evaluated and combined into a summarizing table. The evaluation is based on Figures A1 to A3, which display the label-wise shares of expressions in the different dimensions (as exemplified in Figure 3). Further details, such as most frequent codes per dimension and label (Table A2) can be found in the appendix.

Table 3: Share of occurrences between input/content and output (by label)

	Rad	Disc	Disr	Bt	Con	Inc
Requirements/	1682					
Features	(79%)	140 (77%)	141 (73%)	212 (75%)	80 (83%)	744 (88%)
Effects	445 (21%)	42 (23%)	52 (27%)	71 (25%)	16 (17%)	104 (12%)

Notes: Requirements and Features are aggregated and compared against Effects (as comparable with Kovacs et al., 2019, comparing the input (novelty) orientation of labels with the output orientation

Looking at the frequency of codes divided by phases, the shares slightly reflect the higher output orientation of *breakthrough* and *disruptive*, contrary to *radical* and *discontinuous* (Table 3) as found by Kovacs et al. (2019), although few differences are statistically significant (Table A1). Hence, even though the distribution to a certain extent reflects a differentiation between the labels for rather ordinary and more exceptional innovations, it does not allow a clear differentiation between different exceptional innovations. Thus, it justifies a deeper analysis of the underlying characteristics.

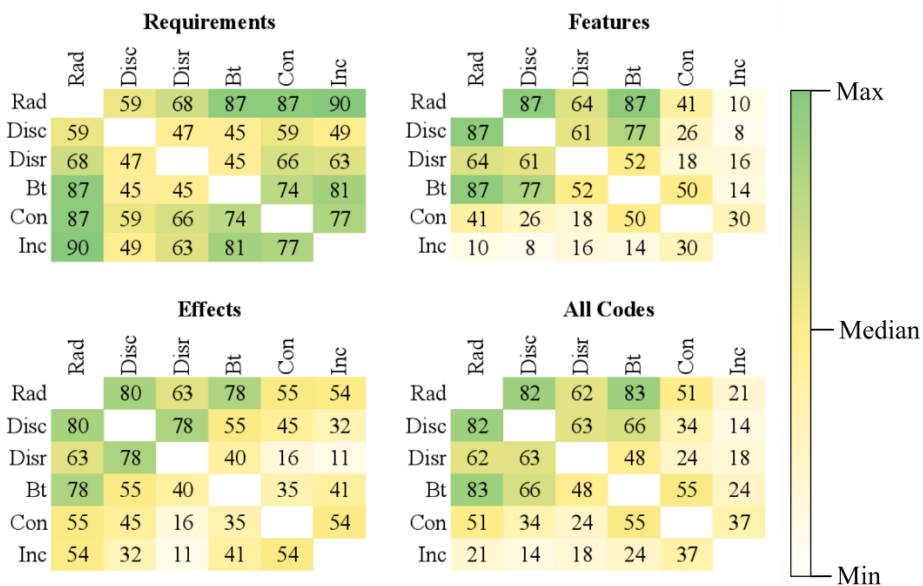


Figure 4: Cosine similarity (in percent) between innovation labels (by phase)

Notes: Values indicate similarity (in percent) of each two labels based on the overlap in (the frequency of) association with the 350 unique codes

Using all 350 unique codes retrieved from the second round of coding the requirements of *radical* show a high similarity not only with *breakthrough* but also with both labels for rather ordinary innovations (Figure 4). This overlap is far lower (especially with *incremental*) in *features* and *effects*. Hence, the same conditions and other requirements might lead to innovations with extremely different effects. In the *features*, the difference between exceptional and ordinary innovations becomes most apparent, although *continuous* is more similar to the exceptional innovations than *incremental*. In terms of *features* and *effects*, both *breakthrough* and *discontinuous* seem to be more strongly related to *radical* than *disruptive*. Moreover, while *discontinuous* and *disruptive* are associated with a different semantic origin (input- vs. output-related, respectively) (Kovacs et al., 2019), their *effects* have a high similarity, equally as high as the one between *breakthrough* and *radical*. With the similarity based on all codes together, both *discontinuous* and *breakthrough* are most similar to *radical*, despite having less overlap individually. Showing overall lower similarity with other labels, *disruptive*, *continuous*, and *incremental* seem to be more distinct. Surprisingly, *continuous* has a higher overlap in codes with *radical* and *breakthrough* than with *incremental*, the other label for a rather ordinary innovation. In the following, we identify the decisive characteristics in each phase to understand the observed similarities and differences between the labels.

For all six innovation labels, *requirements* relate mostly to resources and structures (*subject*, Figure A1). Likewise, external sourcing (e.g., for new knowledge) is not regarded as particularly important for generating exceptional innovations compared with rather ordinary innovations (*perspective*, Figure A1). However, there are also clear differences: *Disruptive* is associated with a stronger market-relation (*object*, Figure 6; code: ‘*market opportunities*’). In this sense, firms pursuing *disruptive* innovations are keen to develop new marketable products to achieve or maintain competitive advantage (Pandit, Joshi, Gupta, & Sahay, 2017). *Breakthrough* is strongly related with the knowledge dimension (*object*, Figure A1). In order to successfully develop *breakthrough* innovation according to the original codes and to the literature, firms should rely on ‘*external knowledge*’ sources (*object-perspective*, Figure A1; (Phene, Fladmoe-Lindquist, & Marsh, 2006) or draw from different knowledge sources (code: ‘*knowledge breadth*’, Srivastava & Gnyawali, 2011). Moreover, *continuous* is strongly associated with specific organization-internal structures, such as flexibility and openness (*direction*, Figure A1). In fact, to develop *continuous* innovation, dynamic capabilities (such as: knowledge creation, absorption, integration

and reconfiguration) are considered necessary assets (Verona & Ravasi, 2003). Nevertheless, altogether the definitions of different innovation labels differ much less in their *requirements* compared with their *features* and *effects*, as validated before (Figure 4).

Even though all innovation labels are to the largest degree described by their novelty (*subject*, Figure A2), the precise extent and quality varies. *Breakthrough*, for example, is more related to its knowledge components and technology (*object*, Figure A2), with ‘*multiple knowledge sources*’ as the respectively most frequent code. According to the literature, to develop *breakthroughs* firms should collaborate with heterogeneous partners, which permits them to draw knowledge from different sources (Qi Dong, McCarthy, & Schoenmakers, 2017). Moreover, among the exceptional innovations, *breakthrough* is least clearly associated with progressive features (*direction*, Figure A2). Accordingly, breakthrough innovations seem to feature combinations of existing knowledge or novelties resulting from deepening of current knowledge and capabilities as well. *Discontinuous* is most strongly associated with novelty in technology (*object, subject – without ‘low’*, Figure A2). As shown by Birkinshaw, Bessant, & Delbridge (2007), in order to pursue discontinuous innovation firms in high-tech industries should implement new technologies to remain competitive with other companies. Contrarily, *radical, disruptive, incremental* and *continuous* relate relatively more to market and product features (*object*, Figure A2), even though within, the contrast between *radical* and *incremental* becomes clear (*subject, direction*, Figure A2): While the former is described by dissimilarity, uncertainty, and associated with negative features (original codes: ‘*market and or consumer uncertainty*’, ‘*business inexperience*’ and ‘*unfamiliar market*’), the latter is described by the opposite (original codes: ‘*driven by consumer needs*’ and ‘*in a well-established market*’). *Disruptive* differs from the other exceptional innovation labels because of the particular importance of new entrants to the market with initially lower performance of the products (*subject, direction*, Figure A2). Disruptive innovations are said to initially target small niches of the market and to redefine old technologies (Govindarajan, Kopalle, & Danneels, 2011, Ansari, Garud, & Kumaraswamy, 2016). Finally, *continuous* is more strongly described as dissimilar than *incremental* (*subject*, Figure A2), but this dissimilarity relates more to products and processes (original code: ‘*new product(s) and services*’) compared with technology and the market (for the ‘exceptional’ innovations) (*object*, Figure A2).

The clearest delineation between exceptional and ordinary innovations is visible in the extent of their *effects*. *Radical* (code: ‘*big effect on firm performance*’), *discontinuous* (code:

'*competence destroying*'), *disruptive* (code: '*failure, destruction of established firms*'), and *breakthrough* (code: '*high profitability*') are to a considerable degree associated with high impact, whereas *continuous* and *incremental* are not (*intensity*, Figure A3). Furthermore, *radical* and *breakthrough* are both associated with more positive effects (*direction*, Figure A3), but the former is more strongly affecting the market, whereas the latter rather affects technology (*object*, Figure A3). The firms developing radical innovations gain competitive advantage (Shahin, Barati, & Geramian, 2017) whereas breakthrough innovations rather describe the creation of novel technological combinations shaping industry trajectories (Kaplan & Vakili, 2014). *Disruptive* and *discontinuous* are associated with negative effects (*direction*, Figure A3), with the former strongly relating to changes in the market, whereas the latter also significantly affects the innovating firm (*object*, Figure A3). When a disruptive innovation is introduced in the market, incumbents face new challenges, possibly leading to a crowding-out effect (Bergek, Berggren, Magnusson, & Hobday, 2013). According to the literature, the focus of discontinuous innovations lies on the outcomes of single firms even though these firms face an initial reduction in performance and the rewards are distant in time (Birkinshaw et al., 2007). By contrast, *incremental* is strongly described by the positive effects on the firm and on performance (of the firm) (*object – direction, subject – direction*, Figure A3), for example, by creating value, which increases profitability and strengthens the market position. However, compared to the more 'exceptional' innovations, these positive effects are characterized by a relatively low magnitude and they become apparent only in the short run (Benner & Tushman, 2002). Finally, contrary to *incremental*, *continuous* shows a share of external effects comparable to the labels for exceptional innovations (*perspective*, Figure A3). However, due to the small sample size, the results for *continuous* should be treated cautiously.

Altogether, *features* and *effects* are much more useful to delineate the different innovation labels than their *requirements*, even though the discussion about the four 'exceptional' innovations is more focused on the output in contrast to the rather 'ordinary' innovations. However, confirming the results of Kovacs et al. (2019), we find no significant difference in the input/content vs. output orientation among the 'exceptional' innovations.

Table 4: Summary of the quantitative text analysis

	Requirements	Features	Effects
Rad	<i>Resource and structural requirements. Internal (human capital) and external resources (knowledge and interaction) equally important.</i>	Described by <i>novelty</i> and <i>dissimilarity</i> and associated with the <i>technology-, market- and product-level</i> . Has also <i>negative</i> features (high risks and costs)	<i>Higher</i> impact, specifically on <i>performances</i> and <i>structures</i> . <i>External</i> effects. Strong <i>market</i> effects, but also on the <i>firm</i> . Besides leading to <i>change</i> and <i>creation</i> also <i>positive association</i> of effects.
Disc	<i>Progressive structures (internal and external and related to change and creation (novelty). Changes in human resources and external changes (environment) important.</i>	Described by <i>novelty</i> (of the inherent <i>technology</i>). High <i>dissimilarity</i> to the existing and highest share of <i>uncertainty</i> .	<i>Higher</i> impact, especially on <i>structures</i> . Strong <i>market</i> effects but also on the <i>firm</i> . Effects rather <i>external</i> and substantial share of <i>negative</i> associations.
Disr	<i>Resource and structural requirements, specifically market-related. External resources and flexibility particularly important as well as new firm strategies. Changes in policies (e.g., regulations) can be required.</i>	Described by <i>novelty</i> , but also the way of <i>introduction</i> (by young and small firms in niches of the market). Particularly <i>negative</i> features (initially worse performance).	<i>High</i> impact. <i>Structures</i> and <i>performance</i> , but also <i>capabilities</i> affected. Strongly associated with the <i>market</i> and with <i>negative</i> effects (especially for established companies and knowledge).
Bt	<i>Resources and structures (mostly knowledge-related) important. Besides change and knowledge breadth also deepening of existing capabilities.</i>	Described by <i>novelty</i> , but also the <i>search process</i> and <i>resources</i> (especially <i>knowledge</i> and <i>technology</i>). Associated with <i>existing knowledge</i> and its <i>recombination</i> .	<i>Higher</i> impact. <i>Performance</i> and <i>structures</i> affected. Besides effects on <i>market</i> and <i>firm</i> , particularly affecting (future) <i>technology</i> . More related to <i>creation</i> than to <i>change</i> and (therefore) <i>positive</i> association.
Con	<i>Structures (internal) more important than resource-related requirements. Change, flexibility and openness (regarding human capital and interaction) required.</i>	Described by <i>novelty</i> as well as the <i>search process</i> . Mostly about new or adapted <i>products</i> and <i>processes</i> which can be <i>similar</i> or <i>dissimilar</i> to the existing.	<i>Lower</i> impact. Related to <i>power</i> and <i>performance</i> of the innovating <i>firm</i> in the market. Also <i>external</i> effects
Inc	<i>Structural and resource requirements and strongly associated with knowledge and interaction. Even though conservative requirements dominate (persistence, depth, centralization), external sources (e.g. of knowledge) are particularly important</i>	Described by <i>novelty</i> as well as the <i>search process</i> . Features relate to <i>products</i> and <i>processes</i> and <i>rather low degree of change</i> . Comparably low risks and costs.	<i>Lower</i> impact. Related to the <i>performance</i> and <i>power</i> of the innovating <i>firm</i> in the market. Rather <i>internal</i> effects, but <i>highly positive</i> association.

5 Discussion

Our first and broad results largely correspond to the innovation typology by Kovacs et al. (2019) presented in Figure 1, with the central dimensions of novelty and impact. The label *incremental* is clearly described as less novel and less impactful. On the other end, the more ‘exceptional’ innovations can be divided into the more novelty-oriented (*radical* and *discontinuous*) and the more (high) impact-oriented (*disruptive* and *breakthrough*) labels: *radical* and *discontinuous* have lower shares of occurrences for specifically ‘high’ effects, but a stronger relation to novelty as descriptive dimension for their *features* as well as an overall slightly higher percentage of rather ‘progressive’ *requirements* and *features* (Figure 5a). *Continuous*, which we additionally consider, tends to describe ‘ordinary’ innovations, but not as clearly as *incremental*. More importantly, however, our results advance the literature by highlighting at least two further considerations for the evaluation and classification of innovation concepts.

First, according to our results and in contrast to Kovacs et al. (2019), the differences between the labels are not so pronounced that either of the dimensions ‘novelty’ and ‘impact’ alone would be sufficient to mark a clear-cut differentiation. Our results highlight two additional dimensions along which the labels need to be differentiated (Figure 5b). On the one hand, they can be categorized as more product- and market-related versus more knowledge- and technology related. On the other hand, their effects can be categorized as rather positive or negative. The first dimension has already been stressed in several publications, though for a limited number of innovation labels: Ahuja and Lampert (2001), for example, divide impactful innovations into *radical* (market impact) and *breakthrough* (technological impact). By contrast, Rosenkopf & Nerkar (2001) mention that radical and breakthrough innovations are both valuable from the market and technology side. Our findings suggest that *disruptive* and *incremental* are clearly related to the market- and product level, whereas the association is unclear for *discontinuous* and *radical*. Even though *discontinuous* is strongly linked to technological *features*, the *effects* are associated with the market to a considerable degree, based on our results. *Breakthrough*, by contrast, has a clear technology- and knowledge association. Therefore, it refers more to the technical invention than to marketed products, which suggests a more general distinction between inventions and innovations (Figure 5b). As stated in section 2, inventions are technical advances that are not yet commercialized (Ahuja & Lampert, 2001), whereas innovations are products or processes that are relevant for the market (Lundvall, 2016).

Accordingly, *breakthrough* is closer to the knowledge and technological dimension and thus only impacts the technical trajectory, whereas *disruptive* mostly refers to the market dimension. The frequent association of *breakthrough* with invention further underlines this characterization, in contrast to *disruptive*, which is usually associated with innovation. The second dimension, the positive or negative connotation of effects, is less present in the discussion of innovation concepts. Nevertheless, the notion of ‘competence-destroying’ or ‘competence-enhancing’ effects of innovations has been stressed, for example, by Cooper (2000), R. Henderson (1993), Kostoff, Boylan & Simons (2004) and Lettl, Herstatt & Gemuenden (2006).

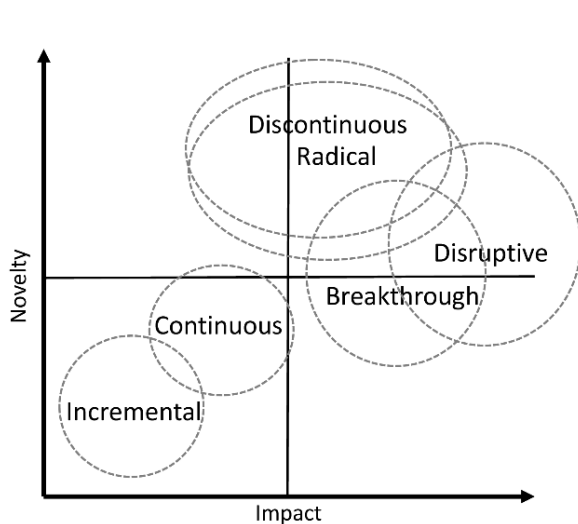


Figure 5a: Innovation typology based on impact and novelty

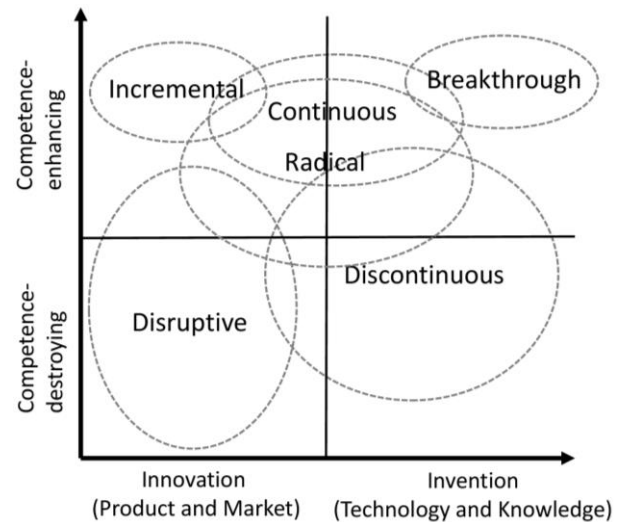


Figure 5b: Innovation typology based on direction and entity of impact

Notes: Circles around the labels refer to how widely or narrowly they are defined in the literature

However, these studies mostly contrast concepts for exceptional and ordinary innovation. Our data reveals that effects of incremental innovation are the most positively connoted in comparison to exceptional innovations, albeit *breakthrough* is also associated with mostly positive effects. Moreover, *disruptive* and *discontinuous* tend to be more strongly associated with negative effects, apart from the positive effects for the innovating company itself. The proportions of positive and negative associations lie between the other labels for *radical*.

Second, innovation labels are defined by and described with specific characteristics to map distinguishable innovation concepts. This distinction is particularly important when these labels are used to operationalize innovation in empirical studies. Many quantitative studies use large data sets such as patent data. The dimensions of novelty and impact are frequently used in these studies to distinguish exceptional from ordinary innovations. Within the group of exceptional innovation, however, empirical approaches usually do not differentiate. *Breakthrough*, for example, is mostly measured on the basis of the impact (patent citations) (Kaplan & Vakili, 2015; Phene et al., 2006). Regarding the other dimension, a different label, *atypical*, has been used several times to capture particularly new innovations or innovations that deviate from existing ones (Kim, Cerigo, Jeong, & Youn, 2016; Mewes, 2019; Uzzi, Mukherjee, Stringer, & Jones, 2013). *Radical*, on the other hand, is operationalized based on both dimensions, separately or as a combination of both novelty and impact (Dahlin & Behrens, 2005). However, the quality of these dimensions is usually not further specified. Particularly, no differentiation between effects on technological development or the market (and industries) and between positive and negative effects is made.

The positions of the different labels within the frameworks of Figure 5 highlight why a clear operationalization might be very difficult: Some labels are rather narrowly defined, such as *incremental* – with low novelty, low impact, related to product and market and associated with positive effects. Others, such as *discontinuous* or *radical*, are much more widely defined in the literature. Operationalization, however, usually is and should be based on accurate indicators for specific characteristics (which a certain type of innovation fulfills) and not on a rather spurious label (see Downs & Mohr, 1976). Researchers need to clarify what innovation characteristics they ought to measure. This concerns, for example, whether the degree of impact, the degree of novelty or both are important in the respective study. Further, a differentiation between (technological) inventions and (marketed) innovations and the direction of their effects (rather competence-enhancing or competence-destroying) can be very important for policy implications derived from innovation studies. It clearly makes a difference whether the investigated type of innovation has a big negative impact on established structures, or whether it enables all industry or market actors to improve their products and processes. The same holds for the status as either a technological advancement (which might affect further patenting) or as a marketed product (which already affects the industry, its structures and its customers).

Following these considerations, the innovation literature might offer a concept (and label) that describes, or at least includes, an innovation with the selected characteristics. However, the respective label might be used in the literature in several ways or with overlaps with others.

6 Conclusion and Limitations

The aim of this paper was to bring more clarity in current innovation typology by quantitatively assessing the decisive characteristics of prominent innovation labels based on their use in the innovation literature. In another recent paper, Kovacs et al. (2019) have already examined the bibliographic origins of four labels for exceptional innovations. In particular, they considered the use of the dimensions of novelty and impact as descriptive elements of innovation labels. These dimensions largely form the basis of quantitative operationalization of innovation but reflect only to a limited extent the content of some innovation concepts. Moreover, they still yield potential to confound and lead to the use of the labels interchangeably. To further improve the typology of innovation, we examined the definitions of the labels *radical*, *discontinuous*, *disruptive*, *breakthrough*, *continuous* and *incremental* in over 500 scholarly articles. Like Kovacs et al. (2019), we find that the degree of novelty and the impact are key descriptive features of all innovation labels, although their linguistic origins rather belong in either of the two dimensions.

Moreover, we show two additional aspects: On the one hand, it is important to consider whether an innovation is more market- and product-related or technology- and knowledge-related, which can also be referred to as a distinction between innovations and inventions. On the other hand, it is essential to pay special attention to what degree the resulting effects have positive or negative connotations (particularly ‘competence-destroying’ vs. ‘competence-enhancing’). The connotation of innovation labels can be even more relevant when scientific research is transported to the political sphere. However, rarely, one of the innovation labels examined (especially exceptional innovations) can be assigned exclusively and solely to distinct categories. These implications show above all that for an accurate operationalization and, thus, replicability of studies, the existing labels should be used cautiously. As we aim for more clarity in innovation terminology, we refrain from presenting even new labels for the quadrants within our extended typology. Nevertheless, we encourage further research to investigate the decisive characteristics of innovations. Our typology and the additional and more detailed results presented in the appendix present a useful starting point.

Notwithstanding, our study has few limitations. Firstly, we selected a distinct set of innovation labels based on their presence in the innovation literature and on their investigation in the previous study of Kovacs et al. (2019). Other popular labels for exceptional innovations, such as ‘architectural’ (Henderson & Clark, 1990) are likely to reflect characteristics other than the ones represented by the labels used in our study. Secondly, our quantitative analysis does not consider the research context of the papers from which we code the definitional characteristics. For example, our finding that *breakthrough* as a label for a technological and impactful innovation fits well with its operationalization in quantitative innovation studies might be caused by an overrepresentation of these studies in the definitions of *breakthrough* in the literature. Thirdly, a bibliographic analysis of the diffusion of the innovation labels might explain how and why certain definitional characteristics are more frequently mentioned than others – an endeavor we leave for our further research. Fourthly, *radical* and *incremental* are very common in many papers included in our analysis. However, the literature mentioning *continuous* or *disruptive* is much more limited, so our findings might be less valid for these labels. Lastly, even though our coding system has been cross-validated, it is possible that other research teams would have conceived of different assignments and therefore produce at least slightly different results. Nevertheless, this paper contributes to a better understanding and careful use of innovation concepts and respective labels in scientific research.

Future research could validate our innovation typology with additional qualitative studies about the perception and interpretation of innovation labels by both researchers and practitioners. When performing quantitative innovation studies, researchers should carefully consider the appropriate operationalization of the type of innovation they investigate.

Acknowledgements

We would like to thank our supervisors, Uwe Cantner, Holger Graf, Dirk Fornahl, and Tom Broekel for their support throughout the writing process of this paper and especially for their contribution to the coding. We also gratefully acknowledge the financial support by the German Federal Ministry of Education and Research (BMBF) (161FI016, 161FI017, 161FI018). Lastly, we would like to thank Nele Wiesner for support in the early stage of the text analysis, Lukas Dreier for useful comments, and our research assistant Alyssa Mahoney for her English language

proofread. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Achilladelis, B., Schwarzkopf, A., & Cines, M. (1990). The dynamics of technological innovation: The case of the chemical industry. *Research Policy*, *19*, 1–34. Retrieved from papers2://publication/uuid/B538EB27-7D01-4CB6-8BC2-8D4E04F27EC8
- Ahuja, G., & Lampert, C. M. (2001). Entrepreneurship in the large corporation: A longitudinal study of how established firms create breakthrough inventions. *Strategic Management Journal*, *22*(6–7), 521–543. <https://doi.org/10.1002/smj.176>
- Arts, S. (2012). *Path dependency and recombinant exploration: How established firms can outperform in the creation of technological breakthroughs*. Leuven.
- Arts, S., Appio, F. P., & Van Looy, B. (2013). Inventions shaping technological trajectories: Do existing patent indicators provide a comprehensive picture? *Scientometrics*, *97*(2), 397–419. <https://doi.org/10.1007/s11192-013-1045-1>
- Arts, S., Cassiman, B., & Gomez, J. C. (2018). Text matching to measure patent similarity. *Strategic Management Journal*, *39*(1), 62–84. <https://doi.org/10.1002/smj.2699>
- Arts, S., & Veugelers, R. (2015). Technology familiarity, recombinant novelty, and breakthrough invention. *Industrial and Corporate Change*, *24*(6), 1215–1246. <https://doi.org/10.1093/icc/dtu029>
- Ansari, S., Garud, R., & Kumaraswamy, A. (2016). The disruptor's dilemma: TiVo and the US television ecosystem. *Strategic Management Journal*, *37*(9), 1829–1853.
- Audretsch, D., Fornahl, D., & Klarl, T. (2021). Radical innovation and its regional impact—a roadmap for future research. *Small Business Economics*, (2003). <https://doi.org/10.1007/s11187-021-00463-y>
- Ayres, R. U. (1988). Barriers and breakthroughs: an “expanding frontiers” model of the technology-industry life cycle. *Technovation*, *7*(2), 87–115. [https://doi.org/10.1016/0166-4972\(88\)90041-7](https://doi.org/10.1016/0166-4972(88)90041-7)
- Berends, H., Vanhaverbeke, W., & Kirschbaum, R. (2007). Knowledge management challenges in new business development: Case study observations. *Journal of Engineering and Technology Management - JET-M*, *24*(4), 314–328. <https://doi.org/10.1016/j.jengtecman.2007.09.006>
- Bergek, A., Berggren, C., Magnusson, T., & Hobday, M. (2013). Technological discontinuities and the challenge for incumbent firms: Destruction, disruption or creative accumulation?. *Research Policy*, *42*(6-7), 1210–1224.

- Birkinshaw, J., Bessant, J., & Delbridge, R. (2007). Finding, forming, and performing: Creating networks for discontinuous innovation. *California management review*, 49(3), 67-84.
- Bower, J. L. & Christensen, C. M. (1995). Disruptive Technologies - Catching the Wave. *Harvard Business Review* 73(1), 43-53.
- Büschgens, T., Bausch, A., & Balkin, D. B. (2013). Organizing for radical innovation - A multi-level behavioral approach. *Journal of High Technology Management Research*, 24(2), 138-152.
<https://doi.org/10.1016/j.hitech.2013.09.004>
- Chang, Y. C., Chang, H. T., Chi, H. R., Chen, M. H., & Deng, L. L. (2012). How do established firms improve radical innovation performance? the organizational capabilities view. *Technovation*, 32(7-8), 441-451. <https://doi.org/10.1016/j.technovation.2012.03.001>
- Christensen, C. M., Johnson, M. W., & Rigby, D. K. (2002). Foundations for growth - How to identify and build disruptive new businesses. *MIT Sloan Management Review*, 43(3), 22-31
- Colombo, M. G., Franzoni, C., & Veugelers, R. (2015). Going radical: producing and transferring disruptive innovation. *Journal of Technology Transfer*. <https://doi.org/10.1007/s10961-014-9361-z>
- Cooper, L. G. (2000). Strategic Marketing Planning for Radically New Products. *Journal of Marketing*, 64(1), 1-16. <https://doi.org/10.1108/eb058038>
- Dahlin, K. B., & Behrens, D. M. (2005). When is an invention really radical?: Defining and measuring technological radicalness. *Research Policy*, 34(5), 717-737.
<https://doi.org/10.1016/j.respol.2005.03.009>
- Della Malva, A., & Riccaboni, M. (2015). (Un)Conventionality in Combinations: at the Origins of Breakthrough Inventions. *Academy of Management Proceedings*, 2015(1), 16226-16226.
<https://doi.org/10.5465/ambpp.2015.16226abstract>
- Dewar, R. D., & Dutton, J. E. (1986). The Adoption of Radical and Incremental Innovations: An Empirical Analysis. *Management Science*, 32(11), 1422-1433.
<https://doi.org/10.1287/mnsc.32.11.1422>
- Dijk, M., Wells, P., & Kemp, R. (2016). Will the momentum of the electric car last? Testing an hypothesis on disruptive innovation. *Technological Forecasting and Social Change*, 105, 77-88.
<https://doi.org/10.1016/j.techfore.2016.01.013>
- Downs, G. W., & Mohr, L. B. (1976). Conceptual Issues in the Study of Innovation. *Administrative Science Quarterly*, 21(4), 700-714.
- Ettlie, J. E., Bridges, W. P., & O'Keefe, R. D. (1984). Organization Strategy and Structural Differences

- for Radical versus Incremental Innovation. *Management Science*, 30(6), 682–695.
- Forés, B., & Camisón, C. (2016). Does incremental and radical innovation performance depend on different types of knowledge accumulation capabilities and organizational size? *Journal of Business Research*, 69(2), 831–848. <https://doi.org/10.1016/j.jbusres.2015.07.006>
- Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *The Journal Of Product Innovation Management*, 19, 110–132.
- Gatignon, H., Tushman, M. L., Smith, W., & Anderson, P. (2002). A structural approach to assessing innovation: Construct development of innovation locus, type, and characteristics. *Management Science*, 48(9), 1103–1122. <https://doi.org/10.1287/mnsc.48.9.1103.174>
- Germain, R. (1996). The role of context and structure in radical and incremental logistics innovation adoption. *Journal of Business Research*, 35(2), 117–127. [https://doi.org/10.1016/0148-2963\(95\)00053-4](https://doi.org/10.1016/0148-2963(95)00053-4)
- Gopalakrishnan, S., & Damanpour, F. (1997). A review of innovation research in economics, sociology and technology management. *Omega*, 25(1), 15–28. [https://doi.org/10.1016/S0305-0483\(96\)00043-6](https://doi.org/10.1016/S0305-0483(96)00043-6)
- Govindarajan, V., Kopalle, P. K., & Danneels, E. (2011). The effects of mainstream and emerging customer orientations on radical and disruptive innovations. *Journal of Product Innovation Management*, 28(s1), 121-132.
- Green, S. G., Gavin, M. B., & Aiman-Smith, L. (1995). Assessing a Multidimensional Measure of Radical Technological Innovation. *IEEE Transactions on Engineering Management*, 42(3), 203–214. <https://doi.org/10.1109/17.403738>
- Hao, B., & Feng, Y. (2016). How networks influence radical innovation: the effects of heterogeneity of network ties and crowding out. *Journal of Business and Industrial Marketing*, 31(6), 758–770. <https://doi.org/10.1108/JBIM-09-2012-0165>
- Henderson, R. (1993). Underinvestment and Incompetence as Responses to Radical Innovation: Evidence from the Photolithographic Alignment Equipment Industry. *The RAND Journal of Economics*, 24(2), 248. <https://doi.org/10.2307/2555761>
- Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation : The Reconfiguration of Existing Product Technologies and the Failure of Established Firms Author (s): Rebecca M . Henderson and Kim B . Clark Source : Administrative Science Quarterly , Vol . 35 , No . 1 , Special Issue : Tech. *Administrative Science Quarterly*, 35(1), 9–30. Retrieved from <http://www.jstor.org/stable/2393549>

- Henkel, J., Rønne, T., & Wagner, M. (2015). And the winner is - Acquired. Entrepreneurship as a contest yielding radical innovations. *Research Policy*, 44(2), 295–310.
<https://doi.org/10.1016/j.respol.2014.09.004>
- Hervás-Oliver, J. L., Albors-Garrigos, J., Estelles-Miguel, S., & Boronat-Moll, C. (2018). Radical innovation in Marshallian industrial districts. *Regional Studies*, 52(10), 1388–1397.
<https://doi.org/10.1080/00343404.2017.1390311>
- Hill, C. W. L. ., & Rothaermel, F. T. (2003). The Performance of Incumbent Firms in the Face of Radical Technological Innovation. *The Academy of Management Review*, 28(2), 257–274.
- Jugend, D., Jabbour, C. J. C., Alves Scaliza, J. A., Rocha, R. S., Junior, J. A. G., Latan, H., & Salgado, M. H. (2018). Relationships among open innovation, innovative performance, government support and firm size: Comparing Brazilian firms embracing different levels of radicalism in innovation. *Technovation*, 74–75(March), 54–65. <https://doi.org/10.1016/j.technovation.2018.02.004>
- Kaplan, S. (1999). Discontinuous innovation and the Growth Paradox. *Strategic Leadership*, March/April, 16–21.
- Kaplan, S., & Vakili, K. (2015). The double-edged sword of recombination in breakthrough innovation. *Strategic Management Journal*, 36, 1435–1457. <https://doi.org/10.1002/smj>
- Kassicieh, S. K., Kirchhoff, B. A., Walsh, S. T., & McWhorter, P. J. (2002). The role of small firms in the transfer of disruptive technologies. *Technovation*, 22(11), 667–674. [https://doi.org/10.1016/S0166-4972\(01\)00064-5](https://doi.org/10.1016/S0166-4972(01)00064-5)
- Kemp, R. (1994). Technology and the transition to environmental sustainability. The problem of technological regime shifts. *Futures*, 26(10), 1023–1046. [https://doi.org/10.1016/0016-3287\(94\)90071-X](https://doi.org/10.1016/0016-3287(94)90071-X)
- Kim, D., Cerigo, D. B., Jeong, H., & Youn, H. (2016). Technological novelty profile and invention's future impact. *EPJ Data Science*, 5(1), 1–15. <https://doi.org/10.1140/epjds/s13688-016-0069-1>
- Kostoff, R. N., Boylan, R., & Simons, G. R. (2004). Disruptive technology roadmaps. *Technological Forecasting and Social Change*, 71(1–2), 141–159. [https://doi.org/10.1016/S0040-1625\(03\)00048-9](https://doi.org/10.1016/S0040-1625(03)00048-9)
- Kovacs, A., Marullo, C., Verhoeven, D., & Van Looy, B. (2019). *Radical, Disruptive, Discontinuous and Breakthrough Innovation: more of the same? FEB Research Report* (Vol. MSI_1904).
<https://doi.org/10.5465/ambpp.2019.272>
- Lettl, C. (2007). User involvement competence for radical innovation. *Journal of Engineering and Technology Management - JET-M*, 24(1–2), 53–75.

<https://doi.org/10.1016/j.jengtecman.2007.01.004>

- Lettl, C., Herstatt, C., & Gemuenden, H. G. (2006). Users' contributions to radical innovation- evidence from four cases in the field of medical equipment technology. *R & D Management*, 36(3), 251–272.
- Linton, J. D. (2009). De-babelizing the language of innovation. *Technovation*, 29(11), 729–737.
<https://doi.org/10.1016/j.technovation.2009.04.006>
- Lundvall, B.-A. (2016). From the Economics of Knowledge to the Learning Economy. In B.-A. Lundvall (Ed.), *The Learning Economy and the Economics of Hope* (pp. 133-153). Anthem Press.
- Lynn, G. S., Morone, J. G., & Paulson, A. S. (1996). Marketing and Discontinuous Innovation: The Probe and Learn Process. *California Management Review*, 38(3), 7–38.
- Magnusson, T., & Berggren, C. (2011). Entering an era of ferment - radical vs incrementalist strategies in automotive power train development. *Technology Analysis and Strategic Management*, 23(3), 313–330. <https://doi.org/10.1080/09537325.2011.550398>
- Markides, C. (2006). Disruptive innovation: In need of better theory. *Journal of Product Innovation Management*, 23(1), 19–25. <https://doi.org/10.1111/j.1540-5885.2005.00177.x>
- Mewes, L. (2019). Scaling of Atypical Knowledge Combinations in American Metropolitan Areas from 1836 to 2010. *Economic Geography*, 95(4), 341–361.
<https://doi.org/10.1080/00130095.2019.1567261>
- O'Connor, G. C. (1998). Market learning and radical innovation: A cross case comparison of eight radical innovation projects. *Journal of Product Innovation Management*, 15(2), 151–166.
[https://doi.org/10.1016/s0737-6782\(97\)00078-7](https://doi.org/10.1016/s0737-6782(97)00078-7)
- O'Connor, G. C., & Ayers, A. D. (2005). Building a radical innovation competency. *Research Technology Management*, 48(1), 23–32. <https://doi.org/10.1080/08956308.2005.11657292>
- Pandit, D., Joshi, M. P., Gupta, R. K., & Sahay, A. (2017). Disruptive innovation through a dynamic capabilities lens: an exploration of the auto component sector in India. *International Journal of Indian Culture and Business Management*, 14(1), 109-130.
- Phene, A., Fladmoe-Lindquist, K., & Marsh, L. (2006). Breakthrough innovations in the U.S. biotechnology industry: The effects of technological space and geographic origin. *Strategic Management Journal*, 27(4), 369–388. <https://doi.org/10.1002/smj.522>
- Qi Dong, J., McCarthy, K. J., & Schoenmakers, W. W. (2017). How central is too central? Organizing interorganizational collaboration networks for breakthrough innovation. *Journal of Product Innovation Management*, 34(4), 526-542.

- Rosenkopf, L., & Nerkar, A. (2001). Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. *Strategic Management Journal*, 22(4), 287–306.
<https://doi.org/10.1002/smj.160>
- Schoenmakers, W., & Duysters, G. (2010). The technological origins of radical inventions. *Research Policy*, 39(8), 1051–1059. <https://doi.org/10.1016/j.respol.2010.05.013>
- Schoenmakers, W., Duysters, G., & Vanhaverbeke, W. (2008). *Radical versus non-radical inventions. UNU-MERIT Working Paper Series*. <https://doi.org/10.1111/j.1467-629X.1980.tb00220.x>
- Shahin, A., Barati, A., & Geramian, A. (2017). Determining the critical factors of radical innovation using an integrated model of fuzzy analytic hierarchy process-fuzzy Kano with a case study in Mobarakeh steel company. *Engineering Management Journal*, 29(2), 74-86.
- Song, M., & Di Benedetto, C. A. (2008). Supplier's involvement and success of radical new product development in new ventures. *Journal of Operations Management*, 26(1), 1–22.
<https://doi.org/10.1016/j.jom.2007.06.001>
- Sood, A., & Tellis, G. J. (2005). Technological evolution and radical innovation. *Journal of Marketing*, 69(3), 152–168. <https://doi.org/10.1509/jmkg.69.3.152.66361>
- Srivastava, M. K., & Gnyawali, D. R. (2011). When do relational resources matter? Leveraging portfolio technological resources for breakthrough innovation. *Academy of Management Journal*, 54(4), 797-810.
- Steenhuis, H. J., & Pretorius, L. (2017). The additive manufacturing innovation: A range of implications. *Journal of Manufacturing Technology Management*, 28(1), 122–143. <https://doi.org/10.1108/JMTM-06-2016-0081>
- Tripsas, M. (1997). Unraveling the process of creative destruction: Complementary assets and incumbent survival in the typesetter industry. *Strategic Management Journal*, 18(SPEC. ISS.), 119–142.
[https://doi.org/10.1002/\(sici\)1097-0266\(199707\)18:1+<119::aid-smj921>3.3.co;2-s](https://doi.org/10.1002/(sici)1097-0266(199707)18:1+<119::aid-smj921>3.3.co;2-s)
- Tushman, M., Smith, W. K., Wood, R. C., Westerman, G., & O'Reilly, C. (2010). Organizational designs and innovation streams. *Industrial and Corporate Change*, 19(5), 1331–1366.
<https://doi.org/10.1093/icc/dtq040>
- Uzzi, B., Mukherjee, S., Stringer, M., & Jones, B. (2013). Atypical combinations and scientific impact. *Science*, 342(6157), 468–472. <https://doi.org/10.1126/science.1240474>
- Verhoeven, D., Bakker, J., & Veugelers, R. (2016). Measuring technological novelty with patent-based indicators. *Research Policy*, 45(3), 707–723. <https://doi.org/10.1016/j.respol.2015.11.010>

Verona, G., & Ravasi, D. (2003). Unbundling dynamic capabilities: an exploratory study of continuous product innovation. *Industrial and corporate change*, 12(3), 577-606.

Veryzer, R. W. (1998). Discontinuous Innovation and the New Product Development Process. *Journal of Product Innovation Management*, 15(4), 304–321. [https://doi.org/10.1016/s0737-6782\(97\)00105-7](https://doi.org/10.1016/s0737-6782(97)00105-7)

Appendix (Supplementary material)

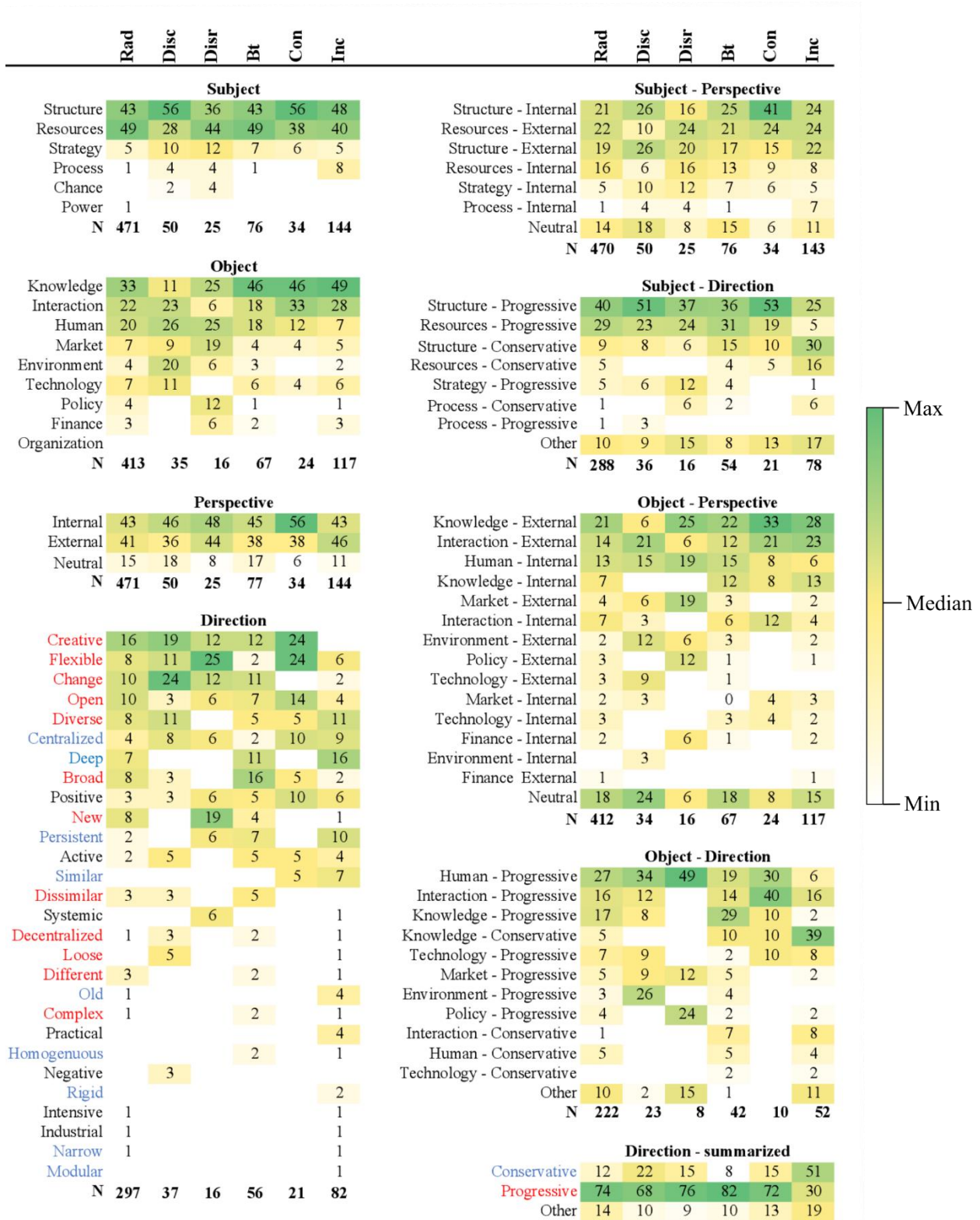


Figure A1: Requirements – by dimension (facet) and innovation label (column)

Note: Values are column-percentages. Blue and red colouring for classification into ‘progressive’ and ‘conservative’

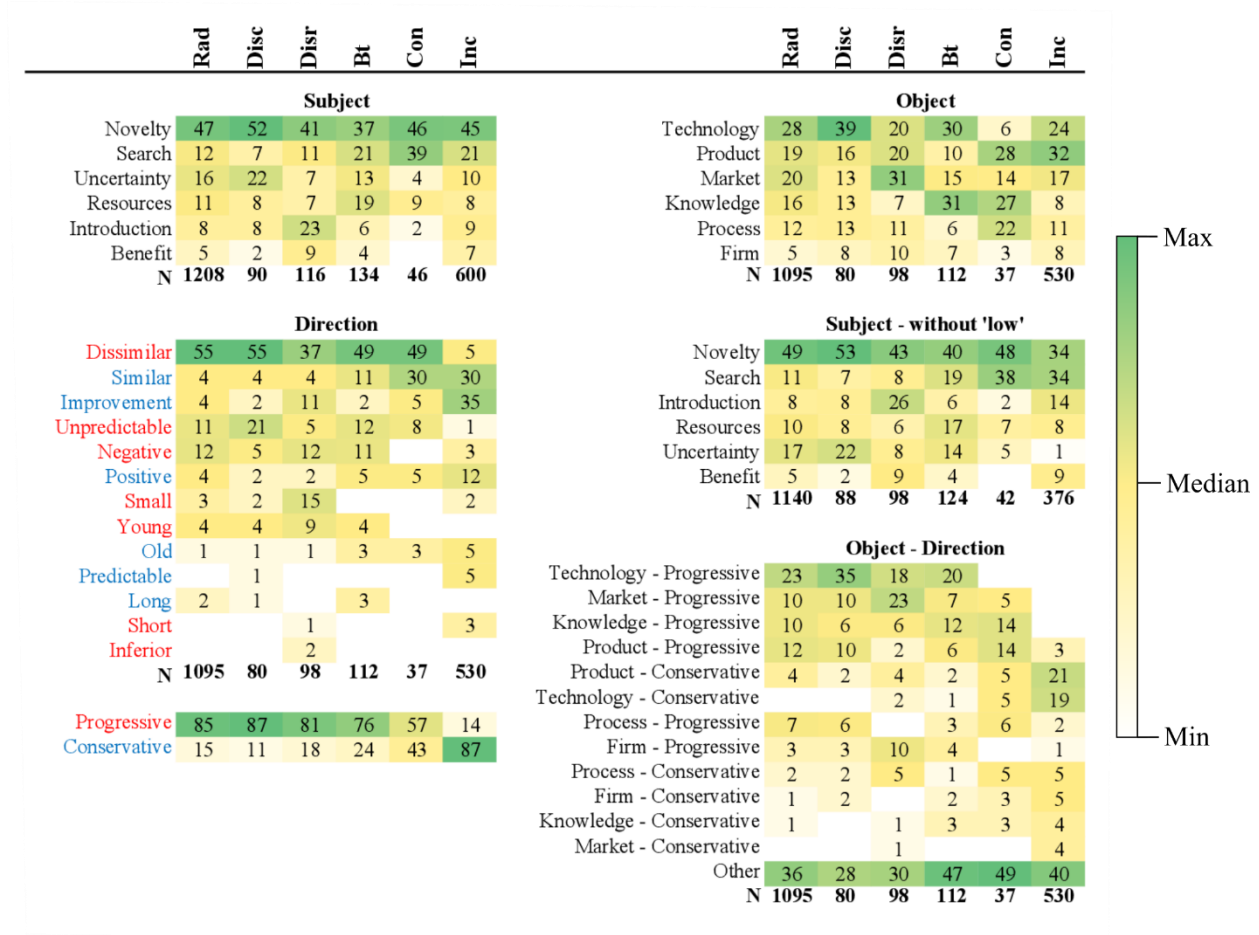


Figure A2: Features - by dimension (facet) and innovation label (column)

Note: Values are column-percentages. Blue and red colouring for classification into ‘progressive’ and ‘conservative’

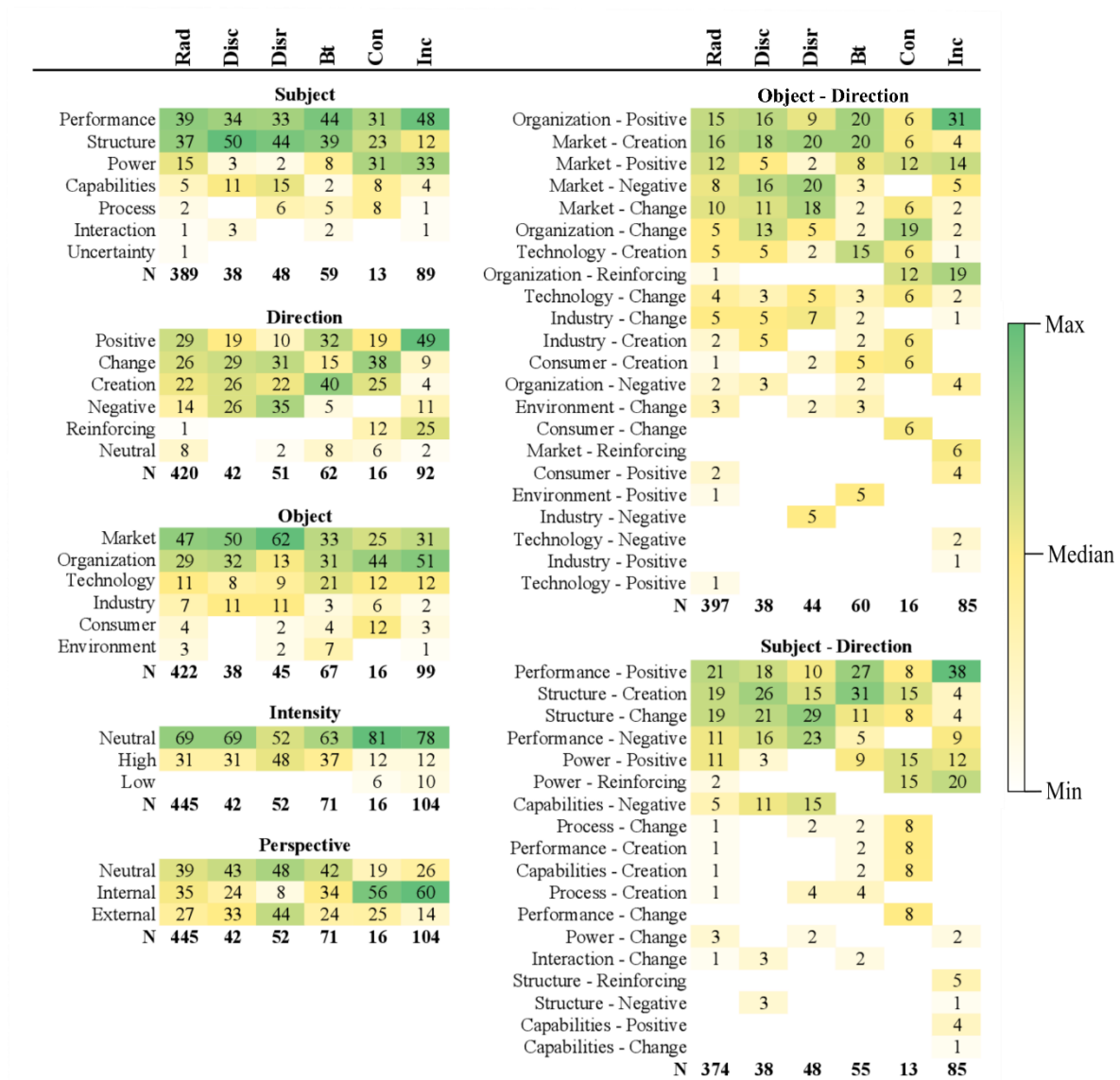


Figure A3: Effects - by dimension (facet) and innovation label (column)

Note: Values are column-percentages

Table A1: Chi-squared test of difference in the distribution between requirements/features and effects

	Rad	Disc	Disr	Bt	Con	Inc
Rad	-	0.556	0.063	0.126	0.38	0.000
Disc		-	0.457	0.702	0.273	0.000
Disr			-	0.728	0.073	0.000
Bt				-	0.12	0.000
Con					-	0.287
Inc						-

Notes: Values indicate p-values of the Chi-squared test of difference in the distribution of codes (350 aggregated codes) between on the one hand the input and content (requirements/features) an on the other hand output (effects) with respect to the calculation in Kovacs et al. (2019)

Table A2: Most frequent first-round codes by phase (columns) and innovation label (rows)

	Requirements		Features		Effects	
	Code	n	Code	n	Code	n
Rad	external knowledge, external learning	34	risks comparably high	66	creating new markets	43
	strategic and organizational flexibility	20	new technology	65	source of competitive advantage	39
	detection of opportunities	18	uncertainty (general)	50	change in markets	28
	cooperation	16	new product(s) and services	45	competence destroying	26
	knowledge breadth	14	exploration	42	cannibalization	25
Disc	cooperation	4	new technology	12	creating new markets	6
	strategic and organizational flexibility	3	uncertainty (general)	7	competence destroying	5
	different skills	3	paradigm shift or change in technological regime	5	failure, destruction of established firms	4
	high organizational autonomy	3	technological uncertainty	5	change in markets	4
	detection of opportunities	2	discontinuity along the path	5	change in the firm	4
Disr	strategic and organizational flexibility	4	new technology	13	failure, destruction of established firms	15
	detection of opportunities	3	cost reduction	13	change in markets	11
	cooperation	2	performance worse (at first)	8	competence destroying	9
	market opportunities	2	new performance features	7	creating new markets	8
	new business model	2	introduced by new entrants or young firms	6	changes the shape of industries	7
Bt	external knowledge, external learning	9	new technology	9	creating new markets	7
	knowledge depth	4	exploration	8	basis for future technology	7
	good management	3	uncertainty (general)	7	source of competitive advantage	5
	knowledge breadth	3	risks comparably high	7	high profitability	4
	strategic alliances	3	new combinations of existing elements	6	source of growth	4
Con	external knowledge, external learning	5	new product(s) and services	4	change in the firm	4
	strategic and organizational flexibility	4	recombination of existing elements	4	source of competitive advantage	3
	high organizational autonomy	2	combination of exploitation and exploration	3	creating new markets	2
	creativity	2	exploitation	3	strengthening market position and control	2
	suppliers (knowledge)	2	uncertainty (general)	2	change in markets	1
Inc	external knowledge, external learning	10	small product modification or improvement	81	strengthening market position and control	15
	cooperation	9	minor improvements to current technology	51	source of competitive advantage	10
	knowledge depth	9	exploitation	38	high profitability	8
	knowledge from customers	7	risks comparably low	32	short-run effect on firm performance positive	8
	high organizational autonomy	7	building on existing knowledge	23	small impact on technology	5

IMPRESSUM

Jena Economic Research Papers

ISSN 1864-7057

Friedrich Schiller University Jena

Faculty of Economics and Business Administration

Carl-Zeiss-Str. 3

D-07743 Jena, Germany

Email: office.jerp@uni-jena.de

Editor: Silke Übelmesser

Website: www.wiwi.uni-jena.de/en/jerp

© by the author