Journal of Business Chemistry

Introduction to Innovation Management

Application of Kuhn's theory of scientific revolution to the theory development of disruptive innovation

Marabel Riesmeier*

* Institute of Business Administration at the Department of Chemistry and Pharmacy, WWU Münster, m_ries11@uni-muenster.de

DOI: 10.17879/22139477049; URN: urn:nbn:de:hbz:6-22139477663

The aim of this article is to review the theory of disruptive innovation over the course of its development and analyze its theory building process. The analysis is framed through the theory of scientific development proposed by Thomas S. Kuhn (2012). The novel application of Kuhn's framework highlights crucial developments and faults. It is assessed how the development of disruptive innovation matches the four stages of scientific development: crisis, revolution, normal science and the accumulation of anomalies. It is demonstrated that this framework is a successful means of conceptualizing the development of disruptive innovation. The theory is currently at the stage of normal science. The two potential anomalies are evaluated. It is concluded that controversies surrounding definitions are not an essential threat to the theory. Establishing predictive value on the other hand is a critical point in future development of the theory. It is shown that the future of the theory depends on whether the latter point is resolved.

1 Introduction

Theory building is an essential but challenging activity in innovation management research (Sutton and Staw, 1995). It facilitates the development of a field, provides angles for theoretical analysis and ultimately leads to theories that are applicable in the real world (Wacker, 1998).

The aim of this article is to review the theory of disruptive innovation over the course of its development and analyze its theory building process. The analysis is framed through the theory of scientific development proposed by Thomas S. Kuhn (2012). It will be assessed how the development of disruptive innovation matches the four stages of scientific development: crisis, revolution, normal science and the accumulation of anomalies. The analysis will show that disruptive innovations has gone through Kuhn's stages. It is currently in the stage of normal science. Two potential anomalies are identified, one of which has particularly strong implications for research and practice. Identifying anomalies is of particular importance, because the identification of weaknesses enables targeted research to address challenges within a theory (Carlile and Christensen, 2004). The theoretical and practical implications of the analysis will be discussed. Some predictions regarding future developments of disruptive innovation can be derived.

Disruptive innovation is one of the most influential frameworks for thinking about innovation both in innovation management re-

search (Tellis, 2006) and for practical use in companies and organizations (Butler, 1988). Reviewing the intellectual history of disruptive innovation is of particular interest because it promises much needed direction for future research and clarification of unresolved controversies (Christensen et al., 2018).

Theoretical developments and concerns inform practical application (Mir and Watson, 2000). Based on the identified anomalies, caution is recommended in use in managerial practice. The practical implications may prove very impactful, given the popularity of disruptive innovation (Tellis, 2006).

The implications of analyzing disruptive innovation through the stages of science proposed by Kuhn offers implications not just for business studies, but for history and philosophy of science, albeit in a more modest way. Application to the development of a particular theory puts it to the test. The peculiarities of the dynamic and practically oriented field of innovation management research promise a novel and interesting field of application. Furthermore, this article showcases how Kuhn's theory can be used as a framework for analysis for deriving practical implications and predictions.

2 Theoretical framework

Conceptualizing the development of disruptive innovation within a theoretical framework fosters understanding of the theory building process and the theory itself. Furthermore, it may help determine the present state of the theory and identify areas in which further investigation is necessary.

In the following, the theory of disruptive innovation will be understood and analyzed through the terms of Kuhn's theory of scientific revolutions first introduced in 1962 (Kuhn, 2012). The theory is widely accepted and used in both philosophy of science and practical analysis. It has even been utilized by the main thinker behind disruptive innovation to categorize cycles of theory building in management research (Carlile and Christensen, 2004). Moreover, it has been used to conceptualize certain moments in theory development of disruptive innovation (Christensen, 2006). Yet, a broader analysis of the overarching theory development to contextualize these comments is lacking. In this article, an attempt will be made to understand the overarching narrative of the development of disruptive innovation through Kuhn's theory. It is first necessary to briefly introduce the theory as a means of analysis in the following.

Kuhn stresses that science revolves around paradigms. A paradigm is an accepted model or pattern that shapes the way in which research is conducted (Kuhn, 2012, p. 23). It is important to note that a paradigm does not need to apply to a large field such as physics but may shape fields and sub-fields of any scale. Especially in humanities and social sciences, several paradigms may coexist to an extent. Transitions may be rather fluid. (Kuhn, 2012, pp. 6-8)

An essential concept introduced by Kuhn is the division of the process of scientific change into phases. Once a field has been established, it progresses into a phase called normal science. Normal science revolves around the present paradigm. Questions resulting from it and phrased in terms of it are solved with means prescribed by it. Scientists typically turn towards relatively detail-oriented questions in this phase. Experiments are designed to expand the depth of knowledge and understanding through the paradigm (Kuhn, 2012, p. 7).

Through the process of normal science, anomalies may be revealed. The paradigm can initially withstand these anomalies or may be adapted to accommodate them. However, over time anomalies accumulate and become increasingly hard to ignore. This leads to the next phase, a period of crisis. Crises may be resolved within normal science, but if normal science continues to fail to account for the anomalies, a scientific revolution must follow (Kuhn, 2012, p. 52).

A scientific revolution is characterized by a

paradigm shift. Underlying assumptions are challenged in a radical way. A new paradigm replaces the previous one. Once the new paradigm has been established, normal science resumes (Kuhn, 2012, p. 92).

3 What is disruptive innovation?

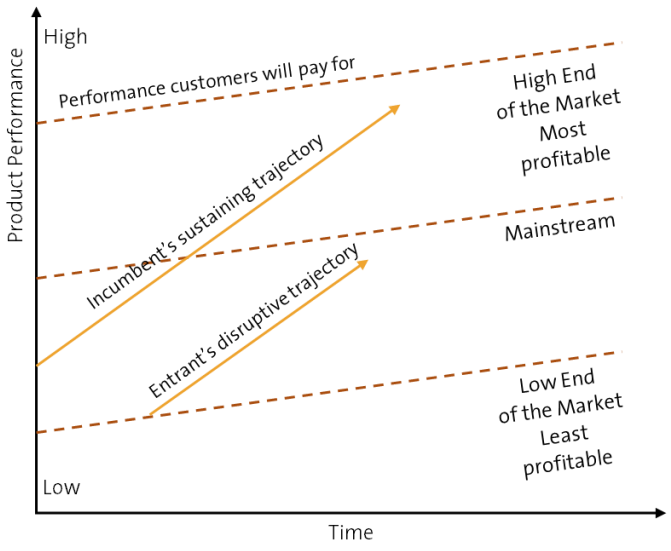
First, a brief overview of the theory of disruptive innovation is provided, introducing the stages and assumptions of the model. The thus established groundwork is the basis for the chronologically structured analysis in the following.

The theory of disruptive innovation is based on the observation that some incumbent firms fail despite good management (Christensen, 1997). To explain this, a distinction is introduced: sustaining versus disruptive innovation. In contrast to sustaining innovations, which are introduced by incumbents to improve existing solutions, disruption is defined as "a process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses" (Christensen et al., 2015).

Initially named disruptive technology, the broader phrase disruptive innovation has replaced that term since 2003 (Christensen and Raynor, 2003). A disruptive innovation may occur, when incumbents focus on existing, high reward customers, but leave others underserved. An entrant then takes advantage of the situation and targets the underserved customers by offering a more suitable, often less expensive product. The disruptive technology initially underperforms compared to previous solutions and thus does not immediately threaten the incumbent. The incumbent continues to focus on their core, high-value customers, introducing sustaining innovations to meet their demands. When successful, the entrant begins to move upmarket towards the mainstream, overcoming initial limitations of value and potentially making the incumbent obsolete eventually (Christensen, 1997).

This process of disruptive innovation has typically been symbolized in variations of Figure 1. Incumbents tend to focus increasingly on higher value customers. In turn, they leave room for entrants to place their product or service at the lower, less profitable end of the market. The product performance trajectories show that the entrant firm increasingly challenges

Figure 1 The trajectories of customer demands and companies in the market over time (source: Christensen et al., 2015).



the incumbent and takes over the mainstream from there (Christensen et al., 2015).

It must be pointed out, that disruptive innovation as a theory and as discussed in the context of this article is tied to the mechanism rather than properties of the products or service. The colloquial use of the term disruptive sometimes obscures the distinction. The term radical innovation is used instead to refer to a product or service that fundamentally changes and redefines a market, because it is so novel and different (Christensen, 2006). It can be introduced by either incumbents or entrants.

The theory views innovation from a market-based perspective of technology demand (Adner, 2002). This is illustrated by the emphasis put on establishing the concept of value networks early in theory development. Value networks are "the context within which a firm identifies and responds to customers" needs, solves problems, procures input, reacts to competitors, and strives for profit' (Christensen, 1997, p. 32). Market-based in essence, the concept also highlights how a company's actions and internal structures are shaped by the market.

The theory of disruptive innovation was first proposed by and remains closely linked to Clayton M. Christensen. In view of the extraordinary influence it has had on academia and managerial practice alike (Tellis, 2006), it has arguably become the most important theory in innovation management research in the last two decades (King and Baatartogtokh, 2015).

4 Development of the theory of disruptive innovation

4.1 Crisis of the previous paradigm in Innovation theory

Since in the terms of Kuhn, the history of disruptive innovation necessarily begins at a point of crisis of the previous paradigm (Kuhn, 2012), the question arises: Had the previous stage of normal science in innovation management research disintegrated to an extent which can be conceived of as crisis prior to the introduction of disruptive innovation?

Preceding disruptive innovation, the state and direction of innovation management research has been described as neither consistent, nor conclusive (Wolfe, 1994). Several theories and distinctions were competing; disorder in the field and disagreements over even the most basic terms and approaches were prevalent (Gopalakrishnan and Damanpour, 1997).

At the time, multiple theories were competing in the field of innovation management research. Theoretical angles such as the resource-dependent view of the firm (Pfeffer and Salancik, 2003), continuous and discontinuous technological change (Dosi, 1982) and architectural innovation (Henderson and Clark, 1990) among others were popular and did establish useful and influential angles for thinking about innovation. Arguably, neither of them managed to establish itself as the dominant framework because each had specific shortcomings in capturing innovation. A detailed analysis of the shortcomings of each theory is beyond the scope of this work, which is why the focus will be on the S-curve theory of innovation. This theory in particular catalyzed the development of disruptive innovation.

The S-curve theory of innovation was widely used in innovation management at the time (Foster, 1986). The theory established, that the development of technological innovation follows the shape of S-curves. When a technology is first introduced, development begins slowly. It then accelerates when more competitors jump onto the technology. Development begins to slow down when the technology approaches its limit and only incremental improvements are possible (Asthana, 1995; Brown, 1992).

Major limitations of S-curve model of innovation have been pointed out by Christensen. He criticized the way it is causally structured and its lack of predictive power, calling special

attention to the specific discrepancies between market entrants and incumbent firms (Christensen, 1992a) as well as the narrow focus on technology that disregards architectural and market innovation (Christensen, 1992b).

It can be concluded, that the field of innovation management research was indeed going through a time of crisis pre 1997. Observations not consistent with the S-curve model of innovation paved the way for a new paradigm.

4.2 The revolutionary character of disruptive innovation

The scientific revolution is a key element of Kuhn's theory. Therefore, it needs to be assessed whether disruptive innovation has in fact revolutionized the field.

The beginning of the theory of disruptive innovation is Christensen's (1993) extensive historical observation of the quickly evolving disc drive industry between 1956 and 1990, where he first proposed the distinction between sustaining and disruptive technologies. The concept was gradually expanded to describe phenomena previously unaccounted for in other industries such as printing and department stores (Bower and Christensen, 1995).

In parallel, groundwork for a larger theoretical framework was laid by developing the concept of value networks in collaboration with Rosenbloom (Christensen and Rosenbloom, 1994, 1995). The concept of value networks was an attempt to theorize the abstract space in which firms act in a novel way. Although too narrow a term to become a new paradigm in itself, the concept was crucial for conceptualizing the contingencies of disruptive innovation.

The essential feature of a scientific revolution is the establishment of a new paradigm, such as a consistent and comprehensive scientific theory. Until 1997, theoretical terms that should later become the theory of disruptive innovation had been used to explain specific phenomena, but these descriptors had not been established as a general theory.

Disruptive innovation was fully established as a comprehensive theory with the book "The Innovator's Dilemma" (Christensen, 1997). It quickly gained critical acclaim and notoriety among managers and academics alike (Thomond et al., 2003). At this stage, disruptive innovation became a dominant paradigm of innovation management research.

It can be concluded that the field indeed went through a stage of revolution. In the next section, it will be assessed whether a stage of normal science has followed its establishment as a dominant paradigm.

4.3 Disruptive innovation arriving in normal science

Following a scientific revolution, a phase of normal science revolving around the new paradigm of disruptive innovation is entered. In practice, this phase is characterized by the following aspects: use of the theory as a means of analysis, exploration of its practical application, and refinement of the theory by adding nuance. This results in a large body of research being produced.

The first defining aspect of normal science is the use of the theory as a means of analysis. Disruptive innovation is indeed being applied successfully to new contexts to gain insights into innovation in specific fields. So disruptive innovation has been used to analyze phenomena as diverse as Airbnb and the rise of informal tourism accommodation (Guttentag, 2015), the response of newspapers to the internet (Gilbert, 2001), and the impact of genomics on treating rare diseases in biopharmacology (Ahn et al., 2019). Christensen's more recent books very clearly fit this sense of normal science, too: the concept of disruptive innovation is applied to further removed subject areas such as health care (Christensen et al., 2009), education (Christensen et al., 2016) and higher education (Christensen and Eyring, 2011).

Another characteristic of normal science is the refinement by adding nuance and theoriz-

ing details. In recent years, there have been numerous examples of this in disruptive innovation, such as an analysis of the peculiarities of micro entrants (Markman and Waldron, 2014), how threat perception impacts the reaction of an incumbent (Gilbert, 2006) and characterizing systemic disruption (Ansari et al., 2016).

The practical applications of the theory are discussed in "Seeing What's Next" (Christensen et al. 2004) and "The Innovator's DNA" (Dyer et al., 2011). Disruptive innovation is often used to give practical guidance to managers for identifying and dealing with disruption (Butler, 1988).

In normal science, a large body of research is produced, since relatively few publications are necessary to establish a theory, but rising acceptance of the paradigm produces an increasing number of publications. As can be seen in Figure 2, researchers' interest in disruptive innovation has indeed been on the rise. The large and growing body of research serves to confirm that the theory has entered normal science (Clarivate Analytics, 2019).

It has been demonstrated, that disruptive innovation currently clearly fulfils the criteria of normal science. The next step is to investigate whether anomalies have become prevalent.

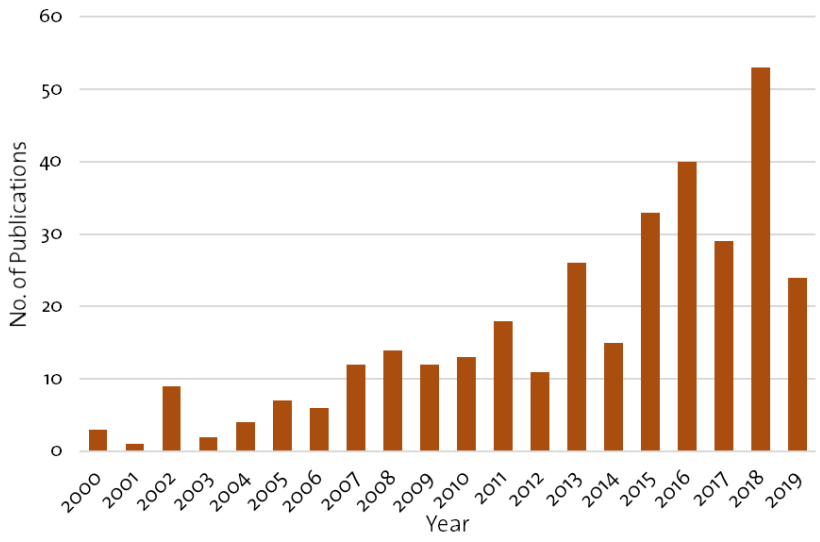
4.4 Consideration of controversies as anomalies

Thus far, it has been firmly established, that the theory of disruptive innovation is in the phase of normal science. But can this be expected to continue or is normal science on the verge of collapse? To answer this, it needs to be examined whether anomalies are present and if so, how many and how severe a threat they are to the theory. To investigate anomalies and their implications, a detailed look at the two main controversies surrounding the theory is necessary: definition and predictive value.

4.4.1 Definition

An issue that has repeatedly been raised by critics is one of definition. Danneels (2004) alleges, that the definition of disruption is neither precise nor consistent, arguing mainly that the characteristics for recognizing disruptive

Figure 2 Number of publications containing the phrases ‚disruptive innovation' or ‚disruptive technology' in the fields of management, business and operations research management science published between 2000 and 2019, source: Clarivate Analytics, 2019).



innovation are not specific enough and fail to account for radical innovation by incumbents. The scope and specificity of the definition is addressed by Tellis (2006): He asserts that it is unclear, whether the claim, that a disruptive innovation after having conquered more niche customers goes on to outperform incumbents and eventually overtakes their core customer base, is part of the definition, raising the question of whether disruptive innovation can only be identified in hindsight.

The confusion surrounding the definition may be related to the term "disruptive". It is rich in connotation and prompts numerous associations that are not part of the scientific definition. Thus, it is often understood as less specific than intended. One issue is the confusion with radical innovation. Danneels (2004) concludes that disruptive innovation fails to account for observation that radical innovation is often introduced by incumbents (Chandy and Tellis, 2000). In fact, the dichotomy of radical versus incremental innovation is completely distinct from sustaining versus disruptive innovation. Sustaining innovation in Christensen's sense may well be radical.

Tellis' (2006) criticism serves to illustrate another common misconception: disruptive innovation is often understood as referring to a product or service at a fixed point in time, but is actually intended to refer to a process instead (Christensen et al., 2015). If the former was the case, disruptive innovation could only be identified post hoc. This is not the case: Disruption of the market, implying that the entrant succeeds in taking over significant portions of it, is one of the predictions the model makes for the process of disruptive innovation, not part of its definition. From Kuhn's framework, it can be predicted that the issue hence will not be critical for the future success of the theory.

Christensen himself concurs that a different name such as "Christensen effect" may have prevented misunderstandings, which arise from the carious connotations of "disruptive" (Christensen, 2006).

In conclusion, the controversy regarding definition of disruptive innovation is not so much an anomaly, but rather a misunderstanding being framed as such.

4.4.2 Predictive Value

As laid out above, allegations that the theory has little to no predictive value because the concept can allegedly only be applied post hoc, are unfounded. The predictive aspects may still fail for other reasons, this will be examined in the following.

There is comparatively little statistical data supporting the predictive value of disruptive innovation (King and Baatartogtokh, 2015). Rather, the theory is largely built on case studies and in-depth qualitative analysis. Qualitative techniques often evoke skepticism (Shah and Corley, 2006) but narratives can in fact be essential for building theory that is novel and interesting – Eisenhardt and Graebner (2007) argue that since it is "deeply embedded in rich empirical data, building theory from cases is likely to produce theory that is accurate, interesting, and testable".

The predictive value of a theory cannot only be called into question on the grounds of quantitative, but also qualitative data. If a theory is based on and explains case data, it is essential for the predictive value that the concepts apply to a variety of cases and fields. The applicability should overall hold up independently of the educated observer if the narratives are indeed universal. This was tested by King and Baatartogtokh (2015), the results call the claims of the theory into question. They surveyed and interviewed experts on 77 cases sourced from previous discussions by Christensen and Raynor, which had been categorized as examples of disruptive innovation. The study revealed, that experts did not agree with their interpretation. There was substantial disagreement over the assertion, that the cases matched four key criteria of disruptive innovation: That sustaining innovation was present to begin with, that in-

cumbent companies overshot customers' needs, that there was a way incumbents could have responded successfully and that incumbents were displaced by new technologies. These criteria are indeed central to disruptive innovation. If there is a flaw here, it does not stem from a misunderstood definition, but a flaw in the theory as a whole.

The question arises, whether the criteria for disruptive innovation are narrow enough to allow for objective categorization. Unambiguous interpretation is a necessary condition for accurate application and reliable prediction. Some evidence for claiming that the theory is intersubjectively valid and does lead to improved prediction has been provided by Raynor (2011, pp. 41–45), who observed greatly improved prediction capability in business students who had learned about disruptive innovation. Although a clear improvement was observed, the results still show that interpretation is anything but obvious and unambiguous.

It follows, that the theory is lacking in unambiguous interpretability and application, which affects its prediction value. In terms of Kuhn, this poses an anomaly. Further research needs to be conducted; time will show, whether the anomaly can be overcome within normal science by narrowing and clarifying the terms of the theory or if it will ultimately lead to a crisis.

Out of the two anomalies discussed, the second has shown to pose a serious threat to the theory. Kuhn's framework is predictive, there are two options for a theory that is challenged by anomalies. Either, they can be resolved by clarifying the terms. Based on this analysis, the prediction is warranted that disruptive innovation will not be fundamentally challenged by questions surrounding definitions. The legacy of the theory rather hinges on its predictive value. The objection is relatively fundamental. As an anomaly, it may be hard to overcome, which is why it is likely that it will be a dominant issue in future debate. Future work is needed to for theory building and to assess the scope of the problem.

5 Conclusion

The analysis has demonstrated, that Kuhn's theory is a useful means of conceptualizing theory development in innovation management research.

It has been shown how theory of disruptive innovation has progressed through the stages of theory development proposed by Kuhn. Disruptive innovation emerged in a time of crisis in the field of innovation management research. It has further been demonstrated that the introduction of the concept can clearly be conceived of as a scientific revolution. Ever since, the research revolving around disruptive innovation has been in a phase of normal science and anomalies have been investigated. Currently, there are two major controversies surrounding the theory: There has been discussion about the definition of disruptive innovation, and the predictive value of the theory has been called into question. The first controversy is based on misunderstandings, and thus is not a critique that threatens the theory. The predictive value on the other hand has indeed been exposed as an anomaly in Kuhn's terms. Specifically, it has been criticized, that cases often do not unambiguously match the theory as well as previously assumed, and varying interpretation even within the realms of disruptive innovation theory may lead to varying results. The latter anomaly may pose a serious threat to the theory of disruptive innovation. In the terms of Kuhn, anomalies may either be resolved within normal science or lead to the ultimate breakdown of a theory. The analysis has shown that the area of predictive value will be a critical point in the future development of the theory.
Predictions and direction for further research can be derived from the analysis through Kuhn's framework. The current stage of dominance is endangered; the future of the theory hinges on whether the pending issues are resolved. The analysis has shown that further

thought must go into if and how predictive claims can be substantiated. The question demands quantitative insights into predictions and theoretical refinement. At this point, the suitability for objective categorization of innovations is questionable. If the theory cannot meet the current challenges, other theories may outcompete it.

The issue of predictive value is especially relevant in practical application: Companies should be aware that concerns have been raised surrounding the use of disruptive innovation to gain accurate and reliable predictions. Supplementation with additional predictive tools for innovation management may be advisable in practice.

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