A Kuhnian Analysis of Revolutionary Digital Disruptions

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Abstract

Disruption has become a term of fashion. While overused, disruption refers to an important phenomenon; how certain new technologies bring about profound changes to markets and society, thereby devaluing established business practices. Since the dominant theory, Christensen's theory of disruptive innovation, focuses only on one narrow aspect of the disruption phenomenon, alternative approaches are needed to theorise how digital technologies bring about revolutionary changes to industries and society more broadly. We propose to consider disruption akin to a Kuhnian revolution. By drawing direct parallels between paradigmatic shifts in scientific fields and technology-induced industry disruptions, we come to understand disruption as a shift in understanding that fundamentally alters what counts as customer value or product quality and as a result puts the industry on a new trajectory. We draw on the music industry to illustrate our line of argument.

Keywords: Disruption, innovation, Kuhn, paradigm shift, music industry, mp3

1 Introduction

In this essay we investigate how certain technological innovations bring about far-reaching, revolutionary market changes, captured in the term "disruption". Disruptive change is said to challenge and devalue established business models, putting at risk organisations that have been competitive for decades (e.g. Capgemini 2012). At the same time disruption has become a term of fashion, applied to a wide range of phenomena and at risk of losing its distinctive power (Yglesias 2013). Disruption is quickly becoming a synonym for change itself. However, such use of the term ignores that there are differences between "normal" evolutionary change and the kinds of technological disruptions that prove transformative for an entire industry and its business practices.

We argue that we still lack a proper understanding of how technology-led disruptions unfold. The theory most widely employed to explain disruption is Christensen's (1997) theory of disruptive innovation. However, we will show that this theory by its very focus is ill-suited to making sense of how new technologies frequently induce wide-spread changes that are revolutionary for existing markets and business practices. We will show firstly that as a micro-economic theory that views disruption from the vantage point of the incumbent firm it can only deal with the surface-layer implications of a broader phenomenon. Thus, given its focus on the strategies of particular market actors, it is ill-suited to study revolutionary change that is transformative for entire industries and their business practices. Secondly, we will demonstrate that the theory treats both technologies and customer needs as exogenous and given, and is thus unable to see how what technologies offer and what customers come to desire change over time. As a result, it cannot make sense of the paradoxical way in which technological innovations are frequently dismissed and misunderstood initially, yet appear entirely inevitable and self-evident with hindsight once now a normal part of life.

As a case example we outline how the emergence of the file compression format mp3 initiated a wave of disruptive change in the music industry that overthrew established business practices. In the course of this disruption, music production and consumption, initially organised around the 'record', became fully digital and famously led to the failure of many businesses associated with the older, CD-based way of doing business. We demonstrate that, while Christensen's theory fits certain aspects of this phenomenon, it operates at a different level of analysis and by its nature is ill-suited to capture the revolutionary nature of the changes that ensued in the industry.

Instead, we draw on Kuhn's (1962) account of scientific revolutions and his notion of paradigm shift to show that technology-induced industry disruptions progress analogously to scientific revolutions. The parallel nature of the two processes indicates similarities at the level of the underlying change processes; changes to collective practices and the accompanying understanding of what counts as important and worthwhile in each case.

Our Kuhnian analysis adds to the literature and public discourse a new account of disruption, one that provides a richer and more nuanced understanding of how new technologies bring about changes to collective understanding of the industry and its business practices. Our findings are important to Information Systems because disruption challenges the basis on which businesses use and organise through IT. A better understanding of what happens during disruption is thus urgently needed.

2 Background: Christensen's theory of disruptive innovation

Christensen's theory of disruptive innovation was first published as a Harvard Business Review paper (Bower and Christensen 1995) and as a book (Christensen 1997), but later refined and extended in various subsequent articles (Christensen and Overdorf 2000; Christensen 2006). While the theory has shot to prominence recently on the back of the 'digital disruption' phenomenon (e.g. Deloitte 2013), and monopolised the discourse surrounding disruption (Denning 2015), Christensen himself bemoans that "many researchers, writers, and consultants use "disruptive innovation" to describe *any* situation in which an industry is shaken up and previously successful incumbents stumble" (Christensen et al. 2015, 46), whereas he stresses that the theory focuses on one particular kind of innovation only.

Christensen's theory targeted the surprising observation "that technologies with inferior performance can displace established incumbents" (Adner 2002, 667). Whereas incumbent businesses are said to succeed through a series of incremental "sustaining innovations" to their products that maintain their market-share, disruptive innovations are understood as "a new kind of product or service, one that's actually worse, initially, as judged by the performance metrics that mainstream customers value" (Christensen and Overdorf 2000, 72). Because such innovations are initially not valued by mainstream customers and "promise lower margins" they are dismissed by the incumbent (Christensen 1997). However, disruptive innovations "take root in undemanding tiers of the market and then improve at

such a rapid rate that they can squarely address mainstream market needs in the future" (Christensen et al. 2002, 961), while at the same time maintaining their cost advantage (Wessel and Christensen 2012). This motivates mainstream customers to switch from the incumbent to the new entrant, who now offers good enough utility at a lower price, causing the incumbent to fail.

Since its inception Christensen has extended and clarified his theory (Christensen 2006), while vigorously defending its focus on disruption from below (Christensen et al. 2015). Notably, he shifted the theory from disruptive technologies (Bower and Christensen 1995) to disruptive innovations (Christensen 1997). This allowed him to both broaden the range of potential causes of disruption, such as innovations in business models, products or sales channels (Markides 2006), arguing that disruptive innovation doesn't have to be based on new technology (see Govindarajan and Kopalle 2006), and to narrow his focus on the firm as the main unit of analysis after realizing that particular technologies are never under the sole jurisdiction of one business (Baiyere and Salmela 2013).

An interesting point of ensuing discussion concerns why incumbents overlook or dismiss the disruptive innovation initially. Christensen himself points out that incumbent executives are not unaware of the innovation, but that they "stay close to their customers" (Bower and Christensen 1995). Termed the "innovator's dilemma" (Christensen 1997), the incumbent acts rationally by listening to their existing customer base but as a result "overshoots" in developing the product because the "trajectory of technological progress almost always outstrips the abilities of customers to utilize the improvement" (Christensen et al. 2002, 961). By contrast, Danneels (2004) argues that incumbent executives fail to understand their customers: "If they had a deep understanding of their customers' needs they would have known that their customers actually did have a broader range of product selection criteria than those upon which products competed before the disruptive technology. A truly customer-oriented firm understands the latent and unexpressed needs of its customers" (Danneels 2004, 255). On this account, firm executives act irrationally because they are "blinded by their existing mental models" (Henderson 2006, 7) and exhibit a lack of "visionary leadership" (Tellis 2006). Similarly, Lucan and Goh (2009) argue that it is often middle managers who fail to see the significance of the disruptive innovation, paralysing the incumbent to react to the unfolding disruption.

Finally, criticisms of the theory include: that it was derived from a small number of cases (Lepore 2014; King and Baatartogtokh 2015) cherry-picked in hindsight (Danneels 2004); extension of the theory beyond disruptive technology to include business models, products, sales channels, thus failing to account precisely for the role of technology in disruption (Markides 2006); lack of predictive power (Danneels 2006) because it includes its own outcomes (incumbent failure) as part of the definition of disruptive innovation (Tellis 2006); failure to predict the trajectory of some of the most disruptive technologies, e.g. Apple's iPhone (Gans 2015); and that 'disruption' and the theory reflect a 'high modernist' ideology (Lepore 2014).

3 Case example: disruption of the music industry

In this section we first present as a case example the disruption of the music industry, set off by the release of the music compression algorithm mp3. We then demonstrate that Christensen's theory, due to its particular focus and underlying assumptions, is unable to account for the revolutionary nature of this disruption phenomenon. This insight motivates a re-examination of the phenomenon by drawing on the parallel between technology-led market disruptions and scientific revolutions (Kuhn 1962).

While typical of disruptive, revolutionary changes brought about by new technology, our music industry example is by no means unique. Other contemporary cases include the iPhone and digital photography, and earlier ones are the personal computer, the automobile, electricity, or the steam engine. Note also that disruption does not have to play out at a broad societal or industry scale: new technologies can equally disrupt particular sectors or parts of daily (business) life.

3.1 How mp3 disrupted the music industry

Mp3 is a normal part of life today and synonymous with how music is consumed. Technically, it refers to the algorithm that converts music into digital files used by digital music players (e.g. the iPod), smartphones (e.g. the iPhone), and streaming services (e.g. Spotify). While subsequent standards have refined the original work (e.g. MPEG-4, AAC), mp3 has become iconic of the digital music revolution.

Mp3 originated from decade-long psychoacoustics research carried out at the University of Hannover and the Fraunhofer Institute of Integrated Circuits in Germany, as well as later standardisation by the Moving Pictures Experts Group (MPEG) (Milner 2009). While the underlying music compression algorithm was developed prior to 1992, the year 1993 marked the official publication of the standard.

In 1994 Fraunhofer Institute released its encoder I3enc. 1993 saw the creation of the mp3 file format and the WinPlay3 software that enabled end-users to create their own mp3 files for the first time.

At the time, music was normally distributed and consumed via Compact Disc, which had replaced vinyl records in the decade earlier[1]. However, this prior change had been merely evolutionary compared to the revolutionary changes unleashed by mp3. Mp3 allowed music to be 'freed' from its original medium (the 'LP' or 'CD') and stored digitally in large quantities. For the first time it was also possible to copy music at near zero cost and to distribute it via computer networks nearly instantaneously. But it was the launch in 1999 of the file sharing software Napster that enabled computer users to share music directly from their own hard drives with a large group of anonymous others easily (Winter 2013).

The first mp3 player was launched in 1996, but it was the launch of the iPod in 2001 that brought awareness of mp3 players to the wider public. We are quite familiar with how things progressed since: mp3 players - and later smartphones using the technology - became the normal way to consume music. Streaming technology has added to this a new quality, further 'freeing' music and giving instant (and almost everywhere) access to the world's entire (mainstream) music history[2].

Consider now how this disruptive change unfolded. Firstly, when mp3 was released, the reaction was quite subdued. Experts and music industry insiders were dismissive of its music quality because mp3 is a lossy compression format. Secondly, when Napster later emerged using mp3, it was not initially regarded as a threat to the industry but rather seen as a nuisance and interpreted exclusively in terms of the legality of its model, as a copyright infringement (The_New_York_Times 2014). Thirdly, even the now famous iPod was dismissed by many initially[3] – after all, who needed "1,000 songs in your pocket", given that the "Walkman" and "Discman" were doing a good job already, and weren't CDs much more practical to handle[4]? While widely praised by technology insiders, it took the general public a while to warm to the idea of using mp3 players and sales were comparatively sluggish in the first years before the iPod became a wide-spread success.

Today such scepticism seems foolish. Owning CDs has become a thing of the past; music is naturally purchased and consumed using digital devices of various sorts. What is more, the music industry has been disrupted fundamentally. Record companies that resisted and grappled with the changes for a long time and then attempted unsuccessfully to set up their own online distribution, today have to live with the reality that a former computer company is now the world's largest music distributor[5]. And music retailers selling CDs, such as Tower Records, have famously been bankrupted in the process[6]. New start-up businesses, such as Pandora and Spotify, are now household names. In sum, changes underpinned by mp3 have been wide-spread, profound and irreversible.

3.2 Analysis of the case with Christensen's theory

At face value the mp3 story falls within the scope of Christiansen's theory of disruptive innovation. The emergence of mp3 fits the notion of disruption "from the bottom". Mp3-based music consumption was initially not relevant to mainstream customers because of mp3's inferior music quality. Mp3 originated outside of the music industry (in the IT field) and was introduced into the industry as a cheaper alternative to the CD (as an initially free alternative via Napster and later as a cheaper way to buy music via iTunes). The incumbent record companies did work to improve their offerings incrementally by improving sound quality (Milner 2009) by developing new recording media which eventually overshot the level of quality sought by consumers (e.g. with the unsuccessful Super Audio CD – SACD). The disruptive innovation (mp3-based music sales) over time gained market share and eventually leapfrogged and invalidated the incumbents' business models (those based on the CD).

[1] The CD had 0.1% market share in 1983, 51.8% in 1993, and 93.4% in 2003; the LP went from 36.6% to 0.1% between 1993 and 2003; the Cassette persisted longer but disappeared by 2003: http://blog.thecurrent.org/2014/02/40-years-of-album-sales-data-in-one-handy-chart/

[2] For a comprehensive account of the history of the music industry see (Albright 2015).

[3] http://macdailynews.com/2005/01/17/dismissive_dell_ceo_not_impressed_with_apple_mac_mini_calls_ipod_a_one_prod/

[4] http://www.wired.com/2001/10/apples-breakthrough-ipod/

[5] Apple's iTunes Music Store launched in 2003 and became the world's largest music retailer in 2010, see https://en.wikipedia.org/wiki/ITunes_Store.

[6] In the US, CD World was bankrupted in 2003, Tower Records and Media Play were both liquidated in 2006, see: https://en.wikipedia.org/wiki/List_of_defunct_retailers_of_the_United_States.

Importantly however, we identify certain "anomalies" (Christensen 2006) that challenge the efficacy of the theory, as well as crucial aspects of the phenomenon that fall outside of its scope. In particular, the theory fails to fully answer the following two questions:

1. What exactly changes during disruption? According to the theory a disruptive innovation is initially inferior but improves in performance over time until it is "good enough" for the incumbent's existing customers. However, the case shows that mp3 did not improve in quality: its sound quality is still technically inferior to the CD, *but this no longer matters today*. What has changed is not the *quality* of the product, but what *counts as quality* in the eyes of music consumers. However, both the world of the consumers and the technology are exogenous to Christensen's theory, represented merely through discrete variables - 'needs and price sensitivity' and 'utility and quality'. Therefore, any changes in collective understanding of music by consumers or of products by the industry are beyond the scope of the theory.
2. Why does the disruption look inevitable in hindsight, yet incumbents (dis)miss the disruptive technology initially? We have already shown that there is disagreement in the literature about whether or not incumbents act rationally in dismissing the disruptive innovation. According to Christensen, incumbents would have acted rationally in dismissing mp3 because it did not satisfy mainstream customer needs. However, others would argue that music industry executives should have seen the change to digital music consumption coming. After all it is now a normal, taken-for-granted part of the industry and of daily life, to the extent that early naysayers look foolish, and we ask with hindsight "How could they not see this?".

This brief analysis demonstrates that Christensen's theory is ill-suited to make sense of large scale revolutionary changes brought about by disruptive technologies, exemplified by the case. Firstly, as a micro-economic theory it focuses on the decisions of incumbent actors: it thus operates at a narrower level and is not suited to explain how new technologies change whole markets, and the world more broadly. Secondly, the theory assumes that customer needs, while multi-faceted, are exogenous and pre-given, and that the improvements to both the sustaining and disruptive innovations are deterministic, as evidenced in Christensen's notion of "trajectory" (Christensen 2006). As a result, any revolutionary, "trajectory-breaking" changes, brought about by collective changes in understanding through the interplay between what technologies offer and what customers come to desire, are beyond the scope of the theory.

A different approach is thus needed, one that moves beyond the "business as usual" logic embodied in Christensen's theory. We find such an approach in Kuhn's influential account of scientific revolutions which analogously theorizes revolutionary change, albeit in the field of scientific discovery. We will show that despite different problem settings, revolutionary changes in business practices and "what counts as normal" parallel how scientific revolutions unfold, suggesting deeper underlying similarities.

4 Kuhn's scientific revolutions

In this section we introduce Thomas S. Kuhn's seminal work in *The Structure of Scientific Revolutions*. Kuhn (1962) challenged the view accepted at the time that science presents a linear story of progress and accumulation of new insights through discoveries. Instead, he demonstrated that science tends to go through periods of continuity, referred to as 'normal science', interspersed with disruptive periods of revolutionary science.

We will argue that his account of how scientific fields progress can illuminate how industries are transformed by disruptions. By drawing direct parallels between scientific revolutions and technology-induced disruptions we are able to see more precisely how new technologies induce disruptive shifts and what changes as a result of such shifts. We acknowledge that Kuhn's work does not apply directly, and thus cannot *explain* disruption: direct applications outside of the natural sciences, such as in sociology, have been challenged previously (Bryant 1975). However, by drawing *parallels* between change in scientific fields and change in business fields (industries) we argue that both are underpinned at a deeper level by similar principles, even though the actual enterprise and its objects of interest are quite different.

We begin by providing a brief introduction to Kuhn's notion of paradigm before we outline his account of revolutionary change in four stages: 1) normal science, 2) emergence of anomalies, 3) paradigm change and crisis, 4) post-revolutionary normalisation.

4.1 Paradigm

Under normal circumstances any scientific field engages in what Kuhn terms "normal science" in which scientists follow an on-going process of "puzzle-solving", advancing the field by solving its known problems by employing methods and tools in ways that are commonly understood by members of the field. This shared understanding and the common ways of going about the field's work are referred to as a 'paradigm'. In Kuhn's original work, paradigm had a rather broad meaning (Masterman 1970) and referred to both the explicit rules, tools, methods, activities, and goals employed by the field, but also the tacit skills, beliefs, and ways in which the world makes sense to the scientist as the basis for normal science. Novice scientists are inducted into a paradigm both by learning from textbooks and by way of practical apprenticeship.

Following criticism for his loose usage of the term (Masterman 1970), Kuhn (1977) later distinguished two notions, one broad and one more specific. The *broad* notion refers to "all the shared commitments of a scientific group" (*ibid,* 294), which Kuhn also came to refer to as *the disciplinary matrix*. This disciplinary matrix encompasses beliefs, activities, values, particular kinds of equipment shared by members of the field; as such, it is quite similar to the technical notion of a *practice* (Schatzki 2002; Nicolini 2012). The *specific* notion of paradigm refers to the "exemplars [which] are concrete problem solutions, accepted by the group as, in a quite usual sense, paradigmatic" (Kuhn 1977, 298). Kuhn emphasised the latter aspect of paradigm thereafter. He demonstrates that it is through exposure to exemplars that the science student acquires an important skill of distinction-making, as a way of understanding the problem space, which cannot be captured by explicit rules. After being confronted with a certain number of exemplars the scientist comes to see "the situations that confront him as a scientist in the same gestalt as other members of his specialists' group" (Kuhn 1970, 189).

In summary, what unites both notions is not so much what exactly a paradigm *is*, but what it *does*: "it refers to that thing which allows scientists to go about solving the puzzles they continually generate" (Eckberg and Hill 1979, 929). More specifically, a paradigm governs at once how the world shows up (in terms of known exemplary cases), and how to respond (governed by the disciplinary matrix).

4.2 How scientific revolutions unfold

1) Normal science: When a scientific field operates effectively it will be guided by a paradigm in picking out and solving problems relevant to its core problem space working towards scientific truth. As such, normal progress in the field takes place on the background of the current paradigm in an incremental fashion, because "normal science does not aim at novelties of fact or theory and, when successful, finds none" (Kuhn 1962, 52). At the same time there are always certain anomalies, nagging puzzles, empirical findings or counter instances that rub up against the expectations of the field. However, during periods of normal science those anomalies are routinely set aside. In fact, it is only later and in hindsight that they take on significance *as* 'anomalies': during periods of normal science they do not present against the paradigm as legitimate concerns of the scientific endeavour and are largely dismissed as not worthy of attention.

2) Emergence of Anomalies: It is when nagging puzzles and unexpected outcomes can no longer be ignored that they appear as 'anomalies' that challenge the concrete situations, experiments and paradigmatic problems (Eckberg and Hill 1979). This recognition that nature has 'violated' the paradigm-induced expectations that govern normal science is what triggers a scientific revolution. However, it is initially only at the fringes of the orthodox scientific field that some scientists begin approaching these problems differently, experiment with new procedures and devise novel, tentative theories. Only when those alternative theories begin competing with existing theories, as recognised by the dominant paradigm, does a 'paradigm shift' begin unfolding, plunging the field into crisis.

3) Paradigm shift and crisis: The emergence of successful alternative explanations for the anomalous results brings about a scientific revolution that presents as a crisis for the established field. Different camps emerge, some advocating new ways of doing things, others staying with the established ways. Dealing with this tension soon becomes the all-consuming task for the broader field, and it is only resolved over quite some time once a revolutionary shift in paradigm has occurred. Such a shift is always transformative, not cumulative, because paradigms cannot be reconciled – the rejection of a paradigm requires the rejection of its fundamental assumptions and practices for doing science. A 'paradigm shift' amounts to a "*reconstruction of the field from new fundamentals"* (Kuhn 1962, 85), a gestalt shift that changes the disciplinary matrix including tools, methods, rules, purpose, activities as well as the identities of the scientists involved. Eventually, the formerly incomprehensible approaches of the fringe become the new exemplars of the transformed field. While it is a source of excitement to those advocating change, it is experienced by those still committed to the old paradigm as an

existential crisis. In fact, the old paradigm, which was the basis for normal science earlier, now presents as an "immense restriction of the scientist's vision [leading] to a considerable resistance to paradigm change" (Kuhn 1970, 64). Increasingly, people committed to the old paradigm become discontent, they experience the change as an identity crisis, and failure to account for anomalies is often seen by others as a failure of the scientist and not of the theory. As a result, some quit the profession altogether.

4) Post-revolutionary normalisation: Once the paradigm shift has occurred a new phase of normal science is entered. Initially many aspects of the new scientific practice are still being changed to fit the new understanding of the world: textbooks are being rewritten, new methods and tools are being developed. Most significantly however, a fundamental shift in understanding has transformed how the world is seen: "It is rather as if the professional community had been suddenly transported to another planet where familiar objects are seen in a different light and joined by unfamiliar ones as well" (Kuhn 1970, 111). The shift thus amounts to a transformation of worldviews: the field not only changes inwardly, but what makes sense, what questions to ask and how to pursue them have changed: "A scientific revolution results in a more or less total transformation of the scientists' conception of the world such that their very data, the facts of their science, are transformed by the paradigm shift" (Urry 1973, 464). Moreover, a form of historical reconstruction takes place in which the current understanding of the world is applied retrospectively to make sense of the past (Pickering 1984; Latour and Woolgar 1986): now the revolution shows up as an inevitable correction of mistaken understanding. Aspects of the prior paradigm may become integrated into the new one but in the process they will change their meaning: "Though an out-of-date theory can always be viewed as a special case of its up-to-date successor, it must be transformed for the purpose. And the transformation can be undertaken only with the advantages of hindsight, the explicit guidance of the more recent theory" (Kuhn 1970, 102f).

5 Reinterpreting disruption through a Kuhnian lens

In this section we re-tell the music industry case employing Kuhn's account of paradigm shift and phases of scientific revolutions. This illustrates that industry disruptions resemble scientific revolutions in nature and structure; we visualise the parallel nature of the two processes in table 1.

5.1 Business as usual: the record industry

In the late 1990s both the music industry and music consumption were paradigmatically organised around the 'record'. The production, distribution and sale of records underpinned the industry: activities, tools, machinery, supply chain structure, company strategies, incentive structures, and job titles in the industry all intersected with the record. Accordingly, music production companies at the time were known simply as "record companies". Moreover, the 'record' as its core product defined how the industry engaged with and viewed its customers. Correspondingly, purchasing, curating and displaying records as part of one's personal record collection were normal activities for many people, even to the extent that it was supported by specialised record-holding furniture.

In the decades prior, evolution of the industry had occurred incrementally and exclusively within this paradigm, by improving its products, processes and business models. For example, music had come to be recorded and distributed successively on a variety of different media, most notably Vinyl, Cassette, and then the CD. Importantly, neither the switch from analogue to digital recording, nor any of the media innovations had challenged the paradigm and central status of the 'record' in significant ways.

Developed in academic research, mp3 found its first application very much at the fringes of society. People in computer hacking culture began tinkering with new software algorithms to create digital music files from CDs. This so-called 'ripping' divorced music from its physical medium and allowed storage on computer hard disks, self-production of music CDs ('burning'), and sharing via computer networks such as the Internet. However, at this stage the technology did not register with the music industry in any significant way, as it was simply not intelligible as an aspect of 'record production'.

5.2 Emergence of anomalous competition: Napster and free music download

It was the wide-spread success and media-publicity of the digital music sharing service Napster, that focused significant attention in the industry on mp3 for the first time (Winter 2013). Napster was relevant because it engaged a significant customer group (young people), but at the same time it was an anomalous form of "competition" because it did not "play by the rules" (The_New_York_Times 2014). Against the existing paradigm, mp3 and Napster were anomalous because they did not appear directly relevant to matters of record production and distribution.

While experienced by many users as an exciting new way to discover new music on the hard drives of users globally, underpinned by freedom of information ideals of the early hacker culture, for incumbents in the industry Napster showed up quite differently; as a platform for "stealing" music and part of the music piracy phenomenon that threatened the established order (Winter 2013; Witt 2015). Accordingly, the industry honed in on the aspect of "free music" (The_New_York_Times 2014) yet (dis)missed other aspects important to its new users, particularly sharing and discovering new music. Many customers were also sceptical of mp3 initially: after all mp3-based music required a computer, was cumbersome and inferior to CDs. Creating mp3 collections on computers was not as satisfying as owning a well-curated CD collection, and how could mp3s be used in the car?

5.3 Industry disruption: From music ownership to sharing and instant access

Over time digital music consumption made inroads into the wider society. After being initially confined to 'nerd' culture, the release of the iPod increased visibility of mp3, making it 'cool' and catapulting it into public pop culture. In the process it enrolled many more people into the new practices and possibilities of digital music. New business models were shaped, new actors entered the market often from the computer industry (e.g. Apple), and new tools and devices were developed; together they articulated a more coherent new business paradigm of digital music distribution.

This emerging new digital music model now openly competed for customers against the traditional CD-based model. Yet for the incumbents committed to the old paradigm, mp3 still did not make sense because it broke with their understanding of what was important about and counted as quality in a product. After all, mp3 as it is a lossy compression format had technically much inferior sound quality. What is more, digital music challenged the old 'ownership' model of music distribution and consumption. Not surprisingly, the incumbents reacted strongly to protect their model by litigating against music sharing ("piracy") and by forcing digital music distributors, such as iTunes, to adopt digital rights management (DRM) solutions to prevent sharing of purchased music (Witt 2015).

Ultimately however a fundamental gestalt shift in understanding of music and its role in everyday life and the wider society occurred. It was this paradigm shift that made visible *both* what the new value proposition was, and what was the basis of the incumbent model: sharing of music, mobile consumption and instant access anywhere and anytime underpinned the new model, whereas the old model was organised around "ownership" of recorded music.

This shift in understanding fundamentally disrupted the industry and with it incumbent businesses, whose value propositions looked increasingly "old-world", were unable to compete on the new understanding of what was important about music consumption. A full-blown crisis ensued putting in jeopardy the economic viability of CD-based distribution and business models. Not surprisingly, this was experienced as an existential crisis by many in the industry (Cummings 2013); businesses failed and people quit.

5.4 Post-disruptive normalisation: Digital music as a normal part of life

Today, digital music production, distribution and consumption are entirely normal: it is what young people who newly join this market as customers encounter. The new paradigm has taken hold and is fully taken-for-granted. Accordingly, former 'fringe' and 'pirate' activities have become the new exemplars that guide activity in the industry: ripping of CDs to create mp3s, sharing of mp3s online (with Napster), buying of music through instant download (e.g. from iTunes), listening to music 'on the go' (e.g. with the iPod or iPhone) or streaming music straight to the living room or car (e.g. with Pandora). Distribution on physical media such as CDs or Vinyl still exist but is now confined to certain niches, and takes on a different significance in fringe identities such as the 'audiophile', or simply as "what old people do".

Finally, given that the new paradigm has now become normal and taken-for-granted, it makes the industry's past trajectory intelligible retrospectively in a new light: disruption becomes valorised as a story of inspired invention (of the mp3 technology) and linear progress toward better technology. While stories about business failures in the wake of the shift from CD to mp3 persist as industry folklore, the path-breaking nature of the shift in understanding of music becomes largely covered up, and the change is now understood as an inevitable progression of technology. With it the gradual evolution of shared social consumption and production practices within the disrupting community is replaced by a more simplistic story of disruption brought about by mp3 as a technological causal agent.

Phases	Kuhnian Scientific Revolution		Revolutionary disruption in the Music Industry		Phases
	Emerging new paradigm	Established scientific paradigm	Emerging new business paradigm	Incumbency industrial paradigm	
1. Normal Science		Working towards the "truth" through ongoing problem/puzzle solving guided by the dominant paradigm (scientific progress)		Continuous improvements to maximise product value, guided by the "record" paradigm, e.g. innovations in recording media.	1. Business As Usual
	Focus on observations or phenomena that do not fit the expectations of the paradigm.	Certain nagging problems are ignored because they do not make sense within the dominant paradigm	Tinkering with technology & software discloses new possibilities to digitally store and transmit music (mp3).	Initially mp3 does not register as relevant to the industry at all.	
2. Emergence of anomalies	Novel way of dealing with nagging problem (e.g. new theory, new techniques) emerges.	Nagging problem is recognised as an anomaly because the new approach is successful in some way that is understood by the orthodoxy.	Mp3 sharing services (e.g. Napster) emerge and gain a large user base and wide media coverage.	Free music sharing is noticed as relevant "competition" only because it engages existing customers.	2. Emergence of anomalous competition
	Novel approach breaks in important ways with the existing paradigm	While recognised, the new approach is not accepted as "scientific" on existing standards	New services offer new-to-the-world ways to discover new music and share music with others globally.	Fail to see what is novel about Napster; focus is on "free music offering", stealing and piracy.	
3. Paradigm shift and crisis	Novel approach crystallises a fundamentally new understanding of what the problem is and what counts as "truth" (new paradigm)	New approach does not (fully) make sense to scientists committed to the old paradigm; old paradigm restricts understanding the new one.	New value proposition crystallises: "music sharing and instant access" instead of "record ownership". Music takes on different significance.	Incumbents understand mp3 narrowly as a threat to ownership, fail to see novelty of the new value propositions.	3. Industry disruption and crisis
	New disciplinary matrix begins to emerge: new configuration of tools, ways of experimenting, theories.	Old ways of doing science now openly compete with the new ways.	New business models, actors (e.g. Apple), tools (e.g. iPod, iTunes), ways of using music emerge, organised around digital distribution of music.	CD and digital music compete, mp3 is dismissed for inferior sound, ownership paradigm is imported into digital music through DRM.	
	Novel approach sets field on a new trajectory, offers exciting new directions, draws in increasing number of, often young, scientists.	Arguing for the legitimacy of the orthodoxy becomes all-consuming; scientists committed to old paradigm are in existential crisis, many quit.	Digital music opens up a new world of possibilities for both new businesses and for consumers. Digital music becomes part of pop culture.	Incumbents experience existential crisis, businesses fail as they are unable to adapt and thus quit the industry.	
4. Post-revolutionary normalisation	New way of doing science is now normal: student scientists learn the new paradigm	Old ways of doing science persist at the fringes, disappear as old generation of scientists retire.	Today, digital music consumption via streaming or download is entirely taken-for-granted by young people.	CD, Vinyl still exist but takes on new significance for audiophile niche customers; might disappear.	4. Post-disruptive normalisation
	Formerly illegitimate solutions become the new paradigmatic exemplars.	Old exemplars become moral tales of wrong turnings in the history of the field.	Practices and technologies such as ripping of CDs, sharing on Napster, buying from iTunes, listening with iPod or Pandora are new exemplars.	Buying records is a "thing of the past", what "old people do", superseded by "progress" and "innovation".	
	The history of the revolution is retold as an inevitable and linear story of incremental scientific progress toward the (new) truth.		Disruption is valorised as a story of great invention and progress toward better technology, path-breaking quality of disruption is covered up.		
	Theories of the old paradigm might find a place in the new one, but central concepts are reinterpreted.		Former "record" companies are now understood as having always been "music production" companies.		

Table 1: The parallel nature of scientific revolutions and industry disruptions

6 Discussion

Table 1 displays the interplay between incumbent and emerging new practices, in both scientific fields and, using the music industry example, in business fields. This side-by-side comparison demonstrates that the phenomenon of industry disruption bears remarkable parallels to the revolutionary transitions in scientific understanding as theorized by Kuhn. Many other episodes of technological disruption to 'business as usual' follow similar trajectories. We are not claiming that in some way business change can be viewed as a form of scientific enquiry. Rather, we argue that the parallel indicates that there are common principles underpinning the way practical understanding is propagated over time in the two fields, via paradigms. This allows us to revisit the two questions that Christensen's theory was unable to fully answer and show how they can be understood on a Kuhnian account:

1. What exactly changes during disruption? We can now understand disruptive change as resulting from a paradigm shift in the Kuhnian sense. This paradigm shift comprises both how the industry is organised with its tools and taken-for-granted ways of doing things, and how it understands its product and consumers and what is worthy of attention. This brings about a 'new normal' and sets the industry on a new trajectory of incremental innovation governed by a new understanding of what counts as quality, and thus what guides innovation in the next episode of 'business as usual'.
2. Why does the disruption look inevitable in hindsight, yet incumbents (dis)miss the disruptive technology initially? Incumbents are initially unable to 'see' what is innovative or disruptive about a new technology because it does not make sense from within the old paradigm. The dilemma then is not that they listen to their customers too closely, but that the more committed they are to the old paradigm that provided a competitive edge during episodes of 'business as usual', the less they are able to understand the new one and thus react to the change. After the shift however, people in the industry view the world and also the past from within the new paradigm. On this new basis the change toward the new technology now appears entirely rational and deterministic in hindsight, even though it was unintelligible at the time when viewed from within the old paradigm.

For practice we note that a paradigm, in particular the notion of exemplars, is a powerful way to understand how groups within a profession are enrolled into a common understanding or worldview. It shows its members what counts as valid and worthy problems, activities, solutions, concepts and theories. Its great advantage is that it is sufficiently open and non-specific, compared to formal rules and specifications, to deal with entirely new situations within the range of normal activity. However, this efficiency brings with it a great disadvantage also, namely, that while it systematises a certain range of phenomena, it blinds its users to other phenomena – anomalies that do not 'fit' the paradigm. This limits both the ability of incumbents to 'see' disruptive changes building momentum and the extent to which truly innovative products can be created by incremental innovation within the paradigm. This further explains why disruptive change typically originates at the fringes. At the same time it stifles claims of self-proclaimed 'disruptors' who set out to 'create a new paradigm'. It is in the nature of paradigms that they resist being made explicit, let alone being 'designed' or 'engineered'. Paradigms are social and shared and thus beyond the reach of any individual or organisational actors.

7 Conclusion

While Christensen's theory of disruptive innovation is widely used in both the academic literature and public discourse, it explicitly focuses on one narrow aspect of disruption only (disruption of an incumbent business from below). By its very nature and focus, revolutionary technology-induced disruption of entire industries and their business practices, as outlined here, is beyond its scope. It is thus important to explore alternative frameworks to understand how fundamental, trajectory-breaking shifts in practical understanding, brought about by the application of new technologies, disrupt business as usual in existing industries. We have identified such a framework in Kuhn's notion of paradigm.

We are aware that we might be accused of explaining one over-used term (disruption) with another (paradigm). However, we have demonstrated that, firstly, it makes sense to retain the notion of disruption to refer specifically to the revolutionary episodes that set a field or an industry on a new trajectory, distinguishing it from 'innovation' as the practice of evolving business during episodes of 'business as usual'. Secondly, we have demonstrated that when taken in the original Kuhnian sense and applied with precision, paradigms provide a useful and nuanced account of the change processes that underpin this topical phenomenon. Finally, formulating industry disruptions using parallels to Kuhnian revolutions contributes a historical account of the four phases that bring about disruption.

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