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Competing technologies, competing forces: The rise and fall of the floppy disk, 1971–2010

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ABSTRACT

The study examines the rise and fall of the floppy disk as a common data storage device from 1971 to 2010. The analysis led to the identification of three stages in the rise and fall of the floppy disk, i.e. the "new dawn", 1971–1990s, the decline stage in the 2000s and then the phase-out period. From the 1970s to the 1990s, the floppy disk gained dominance and became a leading storage device propelled by its superior features and capacity relative to the old-fashioned punch cards and magnetic tape. Yet, by the early 2000s, it was on a path to terminal decline precipitated by the emergence of competing storage devices and limitations of the floppy disk. The study highlights the effects of the technological revolution which ultimately led to the floppy disk being superseded by more reliable, high-capacity and robust storage devices such as CD-ROM, DVD/Blu-Ray disks, USB memory stick and cloud computing. The study charts the transitions from the floppy disk to CD-ROM and then to cloud computing and the underlying drivers. The study led to the identification of multiple competing technologies and competing forces punctuated by events which, over time, helped to precipitate the decline. The implication for theory and practice is identified and examined.

1. Introduction

Since the last quarter of the twentieth century, technology obsolescence and technological revolutions have become increasingly common as technological breakthroughs have ushered in the introduction of new products, thereby rendering many existing or old technology products obsolete (Bartels et al., 2012; Christensen, 1997; Afuah and Tucci, 2003; Sarpong et al., 2016). In today's globalised world, many industries are increasingly shaped by these forces (Eggers, 2012, 2014; van de Kaa and de Vries, 2015; Amankwah-Amoah and Sarpong, 2016). In spite of frequent occurrences of technology obsolescence and technological revolutions, there has been little research into either what factors precipitate these shifts or how the underlying processes of obsolescence unfold in the face of changes in the wider environment (see Sandborn, 2007, 2015; Bartels et al., 2012). In the past few years, research has suggested that technologies often chart different life courses before becoming obsolete (see Bartels et al., 2012). Nevertheless, our understanding of the processes inherent in a technology becoming obsolete remains limited.

The purpose of this study is to examine why and how some technologies become obsolete. For the present study, our focus is confined to the case of the floppy disk, a technology which was one of the most widely used storage devices in the last quarter of the twentieth century before eventually becoming obsolete in the first decade of the twenty-first century. By the end of the first decade of the twenty-first century, the floppy disk was on a permanent path of decline and had largely disappeared as a common data storage device. Generally speaking, computers required a floppy disk drive (FDD) to be able to read the content of a floppy disk (BBC, 2015). As such, although our analysis focused mainly on the floppy disk, the analysis touches on developments in the FDD industry.

In developing our arguments, the study makes two main contributions to innovation, strategy and business history literature. First, although multiple arrays of technologies have been rendered obsolete, innovation and strategy scholars who have traditionally examined such issues have sidestepped them. The paper builds on and extends prior scholarly works by developing a sequential framework to explicate the rise and fall of the floppy disk. In so doing, the paper adds to the growing body of research which demonstrates that technological revolution stems from the introduction of new technologies punctuated by multiple milestones, shifts and revolutionary breakthroughs (Bartels et al., 2012; Suarez, 2004; Kuhn, 1970). This is a departure from much of the existing literature on innovation and technological revolutions, which has focused on shape and competitive dynamics (Sood and Tellis, 2005; see also Amankwah-Amoah, 2016a, 2016b).

Second, although scholars have suggested the need to examine why and how technologies become obsolete, our understanding of the driving forces behind it remains limited (Bartels et al., 2012). The paper develops a framework of factors which, over time, precipitated the demise of the floppy disk. Furthermore, the historical approach adopted helped to respond to the growing calls to bring historical perspective into the

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study of industrial change and firm behaviour (see van de Kaa and de Vries, 2015).

The remainder of the article proceeds as follows. In the next section, a review of the literature on technology obsolescence and technology revolutions is presented. This is then followed by a review of the case-based approach to data collection and analysis. In the final section, the implications of the findings and directions for future research are examined.

2. Technology obsolescence and technological revolutions: an integrated review

Technology obsolescence in this context refers to a situation where an existing technology is seen to have reached the end-of-life stage (Bartels et al., 2012). This relates to technological revolution which is the process of one technology superseding another to gain dominance (new technologies displacing their predecessors) (Bartels et al., 2012; van de Kaa and de Vries, 2015). Ample theoretical and empirical works have demonstrated that both technology obsolescence and technological revolutions can be precipitated by performance of a given technology relative to the available alternatives (Pecht and Das, 2000). A stream of research rooted in technology trajectories (Dosi, 1982) has long attributed the displacement of technologies by new technologies to superior features and performance offered by the new alternatives designed to accomplish the same objective (Adner, 2002; Schilling, 2013). Technological superiority refers to a technology's performance vis-à-vis competing alternatives which then determine its ability to gain dominance (Suarez, 2004). A line of research indicates that technological superiority, where a format outperforms alternatives, can contribute to the demise of the non-performing or underperforming format (van de Kaa and de Vries, 2015).

It has been suggested that technologies with sub-standard performance and functionality can be superseded by new ones (Christensen, 1997). Technological superiority can play a pivotal role in determining the fate of an existing technology when there are large variations in the performance or functionality differences between an old technology and its competing alternatives (Suarez, 2004). As such, technology obsolescence stems from the usefulness of a technology relative to the alternatives' reliability, dependability and durability (Bartels et al., 2012; Christensen, 1997). Another stream of research has indicated that technologies, which fail to meet users'/consumers' preferences in terms of functionality, speed, cost and capacity are more likely to be rejected by users over time, thereby becoming obsolete (Shy, 1996).

One line of research has indicated that the pace of technology decline and becoming obsolete is often predicated on the speed of adoption by users of new technology (Shy, 1996). As technology gains traction and the number of users increases, it can exert pressure on existing alternatives, thereby rendering some obsolete (Shy, 1996). A well-established body of research has attributed technological revolutions to factors such as incumbent technology's inherent limitation and superior features, and performance of the new technology (Bartels et al., 2012; Christensen, 1992, 1997; Levinthal, 1998). These factors over time eventually cause the old technology to lose its appeal as more consumers switch to the alternative. Prior research has attributed the technology revolutions to firms' incentives to finance and develop superior technologies to enable them to carve out a segment of the market and ultimately develop a unique source of competitive advantage (Shy, 1996). Prior research has demonstrated that technology revolutions may stem from limited functionality, slow speed and limited accuracy of the existing technology which force users, individuals and companies to switch to the available alternatives (Afuah, 2009; Bartels et al., 2012).

The arguments thus far suggest that technology-specific functionality relative to the alternatives played a pivotal in sealing it's fate. Offering a different theoretical argument, some scholars have suggested that technology becoming obsolete is often driven by market forces, which occurs when it becomes uneconomic for the product manufacturer to continue production (Bartels et al., 2012). Taken together, technology-specific factors, user preferences and requirements, and market forces interact to trigger the process of decline leading to obsolescence. Prior scholarly works have demonstrated that some technologies can pass through stages before becoming extinct (Pecht and Das, 2000). Technology obsolescence can be viewed as life cycle, which entails phases such as introduction, growth, maturity, decline and phase-out and obsolescence (Pecht and Das, 2000; Solomon et al., 2000). Technology obsolescence is treated here as a sequential stage model which delineates the interactions and effects of technology-specific and external factors. The technological revolutions can be viewed as a stage-model, punctuated by a series of events which reflect emergence of alternatives, dominance battle and eventual demise of uncompetitive technology, as illustrated in Fig. 1. The contention here is that technology obsolescence can be viewed as a technological revolution process that unfolds over time, punctuated by environmental and technology-specific factors. One notable absence from the existing literature is the lack of examination of the precipitating factors and how they manifest over time. The purpose of this article is to begin to fill this void in our understanding.

3. Data collection and analysis

The context for the study is the case of the floppy disk. A case-based research method was adopted to help provide a much deeper understanding of the rise and fall of the floppy disk (Yin, 2003). This approach is in line with prior scholarly works which considered the single-industry approach as being suitable for building theory (Sandström, 2016; Yin, 2003). As Christensen (1993) observed a few decades ago, studying the history of the floppy disk has the potential to enrich our understanding of technology revolutions and competing technologies. Given that much of the accumulated knowledge on such old technology and its historical trajectory are in an archival form, the study adopted the archival approach to data collection (see Amankwah-Amoah and Durugbo, 2016). The analysis focused on the period from 1971 (when the device was introduced) to 2010 when many analysts declared "the floppy is dead" (Ulanoff, 2010), "RIP Floppy Disk" (Thomas, 2010), "a fond farewell to the floppy disk" (Grossman, 2010) and "floppy disks are officially dead" (Fiegerman, 2010). The data collection began by assembling secondary reports, videos and news articles on floppy disk from various organisations such as IBM, BBC, *The New York Times*, *The Economist* and the *Financial Times*. The sources yielded data in forms such as video recordings, documentaries and reports. Furthermore, governments and industry reports on the technology were also examined. The company-specific information, such as reports and press releases from pioneering firms in the floppy disk industry such as FUJI and IBM, was identified and examined. The data sources included government reports and academic publications on capacity of the floppy disk. The sources yielded an array of materials on the history of data storage devices.

The analysis started with a familiarisation of past news stories on the floppy disk. The data were organised into an "event history database" (Van de Ven and Poole, 1990). This entailed organising the materials around the key themes at the time which then formed the basis of our findings. In order to analyse the data, a narrative account (Maguire and Hardy, 2013; Eisenhardt and Bourgeois, 1988) was developed which entailed identifying the milestones, key events and emergence of technologies that have shaped the industry and influenced the rise and fall of the floppy disk. An event history from the industry databases was constructed, charting the developments in data storage devices. From this insight, a clearer narrative of how the floppy disk emerged and eventually became extinct in modern technology stores was developed, which formed our "discursive-event history database" (Maguire, 2004). Based on this, the information was classified to help establish the chronology of events. Fig. 2 depicts three distinct periods in the