Disruptive Technological History: Papermaking to Digital Printing

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Disruptive technologies have been crucial to the shaping of publishing history. Paradoxically, while each of the technologies—specifically, the evolution of papermaking in Europe starting in the late thirteenth century, Gutenberg's printing press and type-casting from metal in the fifteenth century, lithographic offset printing in the twentieth century, and digital printing in the twenty-first century—has, on its own, been indeed revolutionary in nature, together they have served their role in the evolution of the publishing industry. Simply put, the present publishing industry would not be where it is without them.

Keywords: disruptive technology, publishing history, printing, digital printing

INTRODUCTION

Disruptive technologies provide customers with new products or services with attributes different from those of their competitors in the mainstream market who are interested in sustainable technologies. Such products and services are disruptive because they do not seek to meet the present needs of customers, and, therefore, are considered revolutionary in nature. In addition, disruptive technologies tend to be initially lower in quality than their established, sustaining counterparts and thus underperform when introduced; however, their success lies in the fact that they tend not only to be cheaper, smaller, and more convenient to use but also—because of these attributes—to be considered unattractive by the leading, established companies who pursue high profit margins.

To delineate the publishing industry's disruptive technological history, I review the evolution of papermaking in Europe starting in the late thirteenth century, Gutenberg's printing press and type-casting from metal in the fifteenth century, lithographic offset printing in the twentieth century, and finally digital printing in the twenty-first century.

PAPERMAKING IN EUROPE IN THE LATE THIRTEENTH CENTURY

Before papermaking was introduced into Europe in the late thirteenth century, parchment and vellum were the principal materials used in book manufacture; such manufacture was restricted to the scriptoria of the monasteries and the universities.[1] Parchment was mainly made from sheep or goat skins, whereas vellum originated from newborn calfs, kids, and lambs.[2] Their preparation was a time-consuming and costly enterprise:

> The preparation of parchment or vellum involved the cleaning and removal of hair mechanically by scraping the skin. This was followed by desiccation of the skin using sodium or potassium chloride, adjustment of the pH by treatment with ammonium chloride or sulfate with lime and a fluid application of potash alum with flour and egg yolk to give a final suppleness to the skin in preparation for the artistic decoration or literary work.[3]

It was also costly, according to Lucien Febvre and Henri-Jean Martin, for the French market at least:

> At the end of the 14th century, the price of skins varied between 12 and 20 deniers in Paris. The average area of a skin being about ½ a square metre, ten to twelve were needed to make a volume of 150 leaves measuring 24 cm × 16 cm, typical dimensions of a manuscript book in the 14th–15th centuries. The raw material from which such a book was made could thus be worth anything from 10 to 20 sous in its crude state, and to this we would have to add 4 to 6 deniers for preparing it, i.e. clearing the surface of the remaining bristles and of other blemishes to render it fit to write on.[4]

For paper to be considered a disruptive technology, it needs to satisfy five criteria: It needs to be cheaper, smaller, more convenient to use, initially worse in quality than competing products (and so will underperform when introduced) and thus deemed undesirable to the leading established manufacturers. In comparison to parchment and vellum, paper was considerably cheaper:

> At about the same time Treasury accounts show that the price of paper was 2 sols 6 deniers for a quire of 'petite forme' (i.e. about 50 cm × 30 cm), which would be a denier and a half for a leaf measuring 0.15 metres square, while vellum, as we have seen, was worth a maximum of 24–26 deniers for a skin measuring 0.5–0.6 metres square, including the cost of shaving and preparation.[5]

In addition, paper was lighter and had the potential to produce unlimited copies of books.[6] That is, the supply of rags to produce paper was more abundant than the number of skins available, and the length of time required to prepare each for book manufacture was less. The Gutenberg Bible exemplifies this: Each volume printed on vellum needed 175 skins, thirty or more copies would have required more than five thousand, and one hundred copies would have needed more than fifteen thousand skins.[7] Moreover, while books made from either paper or parchment were of comparable size, the preparation of the former from rags tended to be less time consuming and hands-on because a single process generated simultaneous, multiple reams of paper, thus foreshadowing its future industrialization:

> Two factors assisted in the development of the industry in [Fabriano, Germany], the same factors which were to aid the spread of papermaking in the whole of western Europe. The first was technical. As early as the 11th century, if not before, there had existed a device to transform the rotary action of a mill into a reciprocal movement by means of levers. At Fabriano it allowed the papermakers to replace by mallets the old grindstones which the Arabs used to pulverise rags and so to increase output, reduce costs, and produce paper to superior quality. The second factor was the extended cultivation of flax and hemp at the close of the Middle Ages. . . . This made for a rag base in paper that was less costly and more plentiful just at the time when paper was coming into general use.[8]

Febvre and Martin and Frederick G. Kilgour agree that the only pertinent advantages that paper had over parchment and vellum were its abundance and low cost.[9] As befitting its initial disruptive nature, the quality of paper was inferior to that of parchment and vellum. It was more 'fragile, had a rough surface, "drank" the water-based ink, and was not hospitable to the pigments of illuminators.'[10] Furthermore, customers — the monasteries and universities — were not requesting its production and thus the established manufacturers continued to supply parchment and vellum (which is not surprising since the production of paper would have diminished or eradicated their business). Febvre and Martin provide two examples of such resistance to paper in Europe:

> Occasionally the new material was in use at the Chancelleries of various European states. But fear of its fragility and the risk of it perishing made rulers proscribe its use for the making of charters. Roger of Sicily in 1145 ordered that all charters on *carta cuttanea* made in the time of his predecessors were to be recopied on parchment and then destroyed, and in 1231 the Emperor Frederick II forbade the use of paper to record public Acts.[11]

However, the predominance of paper and its use in book manufacture became assured in the fourteenth century because of improvements to the drying process, accomplished by making the paper more amenable to inks and pigments,[12] and because of the coming of Gutenberg's printing technology.[13]

GUTENBERG'S PRINTING PRESS AND TYPE-CASTING FROM METAL IN THE FIFTEENTH CENTURY

The study of the evolution of printing and its impact on society is extremely well researched, notably by Elizabeth Eisenstein,[14] S. H. Steinberg,[15] Stephan Füssel,[16] Lucien Febvre and Henri-Jean Martin, Frederick G. Kilgour, and Warren Chappell and Robert Bringhurst. It is therefore not my purpose here to add to this history (though some discussion will be required to place my argument into context); rather, it is my intention to discuss briefly the disruptive nature of this technology.

The scriptoria of the monasteries monopolized book production during the monastic age (from the fall of the Roman Empire to the twelfth century), copying books for their own use or that of other monasteries and, on the rare occasion, producing books for sale.[17] However, the founding of universities during the secular age (starting from the late twelfth and early thirteenth centuries) encouraged a democratization of literature and language, both giving rise to the establishment of workshops of craftsmen employed by the universities and promoting literacy. The latter in turn resulted in a greater demand for books by the populace.

While the scriptoria gradually yielded to paper (though opposition certainly did not disappear, as will be shown immediately below) and adopted a simpler writing style in the secular age in an attempt to speed up book production, the core facets of this production remained unchanged: Each book was hand-copied and individually proofread—an extremely demanding and protracted procedure.[18] Such determination

to retain traditional book-production methods can be explained by a number of factors. John F. Zeigler emphasizes the elitism and autocratic nature of royalty in regard to the advent of the printing press and thus the dissemination of knowledge:

> Knowledge has always been power. Suggesting to the powerful that they ought to give up or share power has never been popular. Suggesting to the information haves that they share the information with the have-nots wasn't a popular argument in Gutenberg's day, and it still isn't.[19]

Much the same could also be said of the monasteries. A compounding reason for such a conclusion is that any exceptional change can engender fear and opposition, particularly from those who resist and are reluctant to inform themselves about such change. Simply put, the scriptoria were fearful of the potential loss of standards, quality, and knowledge: 'To them, the introduction of mass-produced books must have looked like the death of all that was dear.'[20] Other arguments against print, most notably expressed by Johannes Trithemius in his book *In Praise of Scribes*, which was written in 1423, included the claims that 'parchment will last longer than paper,' 'not all printed books are easily accessible or inexpensive,' and 'the scribe can be more accurate than the printer.'[21]

While the monasteries monopolised book production, they believed it was unnecessary to modify production methods. In terms of disruptive technology theory, why produce something that established customers do not understand or desire? Moreover, in an effort to retain their monopoly on book production, the scribes and illuminators—within the framework of disruptive technology, they are the established entity intent on continuing to supply products that are sustaining in nature—politically manoeuvred to curtail new methods of reproduction.[22] However, the dissemination of knowledge primarily via the universities and the production of texts by independent workshops employed by the universities, particularly in the vernacular, prevented this from occurring. To come full circle, this was further exacerbated by papermaking: The more efficiently and less expensively books were produced, the more the demand for books increased.[23]

Printing with moveable type using handset metal or ceramic type first appeared in China and Korea in the eleventh century; however, it was not successful because of the thousands of different characters required.[24]

Johann Gutenberg's inventions in the fifteenth century—casting and setting metal types (or founts) and employing them in his letterpress—laid the groundwork for an industry that would remain virtually unchanged until the nineteenth century.[25] So without moving tangentially and discussing the mechanics both of casting and setting type and of Gutenberg's press,[26] it is sufficient to say that such inventions can be considered both revolutionary—that is, disruptive—and evolutionary in nature.

These inventions were revolutionary because the mechanics of book production would never be the same. No longer would books be individually hand-copied and proofread; rather, in combination with papermaking, an unlimited number of copies of a text could be produced from a printing press after setting the type, and it would only need to be proofread once.[27] Language started on its journey toward standardization.[28] In this way, book production and distribution became more efficient, thereby making texts both more accessible to the general public and more affordable—that is, a mass-market enterprise.[29] Such improvements satisfy two of the basic criteria of disruptive technology theory; other criteria, such as being undesirable to the leading manufacturers and initially being of worse quality, were dealt with earlier during the discussion on the opposition of the scriptoria to the technology. Frederick G. Kilgour is in agreement, though not within the disruptive technology framework:

> By 1448 Gutenberg had advanced to the second of the three stages of successful mechanical invention. The first is an intellectual event wherein the invention is conceived and thought through; the second is an area of development in which a prototype is constructed to demonstrate that the new machinery will run; the third is building the machine that will work, in the sense that it will put out a product that is successful in the marketplace. Most of the time the sequence yields a product that is better and cheaper than existing ones for which there is already a well-established market. In Gutenberg's case there was no market mechanism available in which a pent-up demand for books could express itself.[30]

In addition, the reading public grew in number: such a literate community existed, possibly reading the same text simultaneously, in the same town and elsewhere, most certainly in different cities across the country and potentially across the world. (Without doubt, if an error in

text was overlooked before going to print, this would affect not just a single copy, but hundreds of copies — though such scenarios constantly haunt editors to this day.)

While revolutionary, these inventions were also evolutionary because the form of the content would remain essentially unchanged, except with the addition 'of graduated types, running heads … footnotes … tables of contents … superior figures, cross references … and other devices available to the compositor.'[31] The craftsmen in the fledgling printing shops sought to imitate — or, more precisely, mirror — the texts produced by the scriptoria in terms of page layout, letterform, and format.[32] For example, Gutenberg imitated the contemporary scribal manuscripts when deciding on a script to cut. He decided on gothic, which, it turns out, is easier to cast than roman.[33] The codex form in which content was delivered persists to this day; the next revolutionary step in modern communication and technological progress will involve recasting this mindset.

LITHOGRAPHIC OFFSET PRINTING IN THE TWENTIETH CENTURY

Lithographic offset printing is a chemical process in which the '*chemical* separation of both the image and non-image [is] achieved'.[34] Flexible plates, traditionally made from metal, are 'wrapped around a cylinder which runs against a second, rubber-covered cylinder (the *blanket*). The image is *offset* or transferred from the printing plate to the blanket and from there transferred to paper. The printed image lies upon the surface of the paper instead of being driven into the paper as it is with the letter-press'.[35] Simply speaking, the chemical process involves the image area attracting the greasy ink, whereas the non-image area attracts water. The water roller, called the dampener, first covers the plate with water, thus leaving the non-image ink-resistant; next, the ink roller covers the plate, coating the image area only.[36]

Lithographic offset printing superseded the letterpress in the last quarter of the twentieth century;[37] however, the technology itself is thought to have 'accidentally' originated in 1799 by Alois Senefelder[38]:

> I took a cleanly polished stone, inscribed it with a piece of soap, poured thin gum solution over it and passed over all a sponge dipped in oil colour. All the places marked with fat became black at once, the rest remaining white. I could make as many impressions as I pleased; simply wetting the stone after each impression. …[39]

Up until the mid-nineteenth century, lithographic offset printing continued to use a stone for transferring text and images onto tin, such as biscuit and tobacco tins[40]; however, from that point on, zinc plates were used. Simultaneously, offset lithography moved from its manually operated form to being power driven.[41] Lithographic offset printing onto paper began in the early years of the twentieth century.

From this very brief discussion on the history of lithographic offset printing, it is apparent that this printing form has journeyed an evolutionary path; its impact has been nonetheless disruptive, albeit—and paradoxically—in a fashion similar to that of its predecessor, the letterpress, and to papermaking.

To place offset lithography in sharp relief, let us compare it with its immediate letterpress predecessors, the linotype and monotype machines, paying particular attention not only to the design of the machines but also the composing of type. Invented in the 1880s, the linotype machine, which was operated by one person, featured two mechanisms in the one unit. The first was a composing mechanism, to which a typewriter-like keyboard was attached, that cast entire lines of type called 'slugs.' The second was the casting mechanism that correctly justified the text, after which it was cast. The monotype machine was introduced the following decade and differed from the linotype machine in two ways. First, it consisted of two units, each of which was operated by a different person: the keyboard and the caster. Second, rather than set entire lines of text, the monotype cast individual types and then gathered them into lines. The linotype produced less expensive first-page proofs, whereas the monotype reduced 'the cost of subsequent corrections.'[42] Because it cast entire lines of running copy, the linotype had a built-in inflexibility in its type design: Since both roman and italic forms of a letter occupied the same matrix, they needed to have a similar width. The monotype was certainly less restrictive owing to its casting of individual letters, thereby giving operators the ability to kern individual letters, whether roman or italic.[43] While certainly more efficient than Gutenberg's printing press, both were still extremely labour intensive when compared with lithographic offset printing.

From the outset, lithographic offset printing was prime disruptive technology in that it was cheaper and easier to use; moreover, the books produced were initially considered to be of inferior quality to those

manufactured on the letterpress. Lithography was by far cheaper and easier because the printing plates were not as expensive to produce as those for the letterpress; they were also more durable and easier to store.[44] Instead of creating and casting the type either line by line (linotype) or letter by letter (monotype), offset lithography relies on filmsetting techniques to produce lightweight metal printing plates[45]:

> Light-sensitive photographic film is used to prepare negatives and positives. If photographs or illustrations are used, continuous tones or halftones are prepared. Lithographic printing relies on a system of printing dots. A photograph is converted to a series of thousands of dots using a grid pattern of a halftone screen so it can be reproduced. If a photo contains color, then a color separator works on the image to insure that all colors are reproduced accurately.[46]

Offset lithography also incorporated a wholly rotary-style design, whereas the letterpress machines were one of three types: platen, with two flat surfaces; flatbed cylinder, with a flat and a cylindrical surface; and rotary, with two revolving cylindrical surfaces.[47] So while the rotary style was present in some of the letterpress machines, what set offset lithography apart was the new technology of web offset,[48] which meant that the offset printing machines could be fed continuous rolls of paper rather than separate sheets.[49] Web presses could operate at such fast speeds that more than twenty-five thousand impressions could be created per hour,[50] thereby significantly out-producing the letterpress machines.

In regard to output quality, it has been indicated that opposition to offset lithography and its inferior quality existed. It was believed that offset lithography would be appropriate only for mass-market, commercial titles, while the superior quality of the letterpress was suitable for academic books and journals.[51] Presumably, the reason for this opposition involved the belief that more hours of labour, intellectual precision, and creativity in the form of casting types and manually setting pages were evident in the letterpressed pages and distinguished them from pages mindlessly mass produced by offset lithography. Warren Chappell and Robert Bringhurst further this argument by indicating that offset printing succeeded in divorcing printing from the intellectual impetus of publishing:

> In the 1970s and 1980s, the practitioners of photocomposition and offset printing were, like Gutenberg, engaged in a simultaneously innovative and imitative act. But they were not imitating writing; they were imitating *printing*—and were doing so in a world where reading had become, for most, a passive, cerebral act, unconnected with any physical sense of the making of letters, and unconnected with any sense of the intellectual urgency of publishing. Reading had become more and more a passive act, and printing had become more and more just a form of mass production.[52]

After the Second World War, the demand for books increased; while the impact of the war on industry was such that the letterpress remained dominant until the last quarter of the twentieth century, the disruptive offset lithography was gaining ground as mentioned above. No one could deny the fact that metal type would wear from use—and consequently create poor copy—and needed to be regularly replaced. As foundries started to close, letterpress printers realized it would become more difficult and more expensive to replace their type.[53] The dominance of lithographic offset printing was assured and proven in 1971, 'when the Association of German Typefounders voted to dissolve itself.'[54]

DIGITAL PRINTING IN THE TWENTY-FIRST CENTURY

When digital printing is discussed, what is usually of interest are the modern services that the technology provides—namely, print-on-demand and short-run digital printing—and how they impact on the literary and cultural landscape,[55] not how digital printing differs technically—and, for the purposes of this study, disruptively—from lithographic offset printing.

Since the late twentieth century, lithographic offset printing has been computer controlled;[56] recent innovations, such as computer-to-plate technology, have reinforced this. Computer-to-plate technology is basically an amalgam of 'traditional' offset and digital printing—that is, it 'allows all page, text and image composition to take place on a computer and the creation of a printing plate directly from the digital file'.[57] Where digital printing differs technically from offset printing is the use of toner rather than ink in a process called electrophotographic imaging, a technology that was originally used in laser printers and photocopiers.[58] John B. Thompson summarizes this process well:

> Most digital printers are toner-based printing devices in which toner particles adhere to a photoconductive drum in patterns that are determined by laser beams or light-emitting diodes; the toner is then transferred to paper and fused in place, usually by hot roller.[59]

By the nature of its digital immediacy, digital printing has many disruptive advantages over lithographic offset printing in terms of cost, efficiency, and convenience. First, every text is an original produced directly from the digital source rather than a copy printed from a plate. Second, there are 'flat economies of scale': the digital source could be likened to an entire plate, which means no set-up and plate costs need to be amortized across the print run. And third, such advantages potentially free the industry from bias toward mass markets over niche markets[60] and provide independents — even self-publishers — opportunities to publish at low cost.

However, it is widely acknowledged that the cost savings incurred in digital printing generally apply to print runs of less than approximately one thousand copies;[61] for larger print runs, offset lithographic printing remains more economical because once the plates have been created, the price per page reduces as the print run increases: 'The unit cost of offset printing 2000 copies of a 300-page paperback might be $2.00; produced digitally in a run of 200, the book would cost $3.00 to $5.00.'[62] Moreover, as per the disruptive technology framework, despite the fact that digital printing creates an original copy each time, its quality of output has yet to equal that of lithographic offset printing.

Reviewing this disruptive journey therefore provides readers with a historical and lay technical view of how these revolutionary technologies have contributed to the evolution of the publishing industry. Moving from parchment and vellum to paper provided those involved — namely, the scriptoria of the monasteries and universities — with a cheaper, lighter material that was more convenient to manufacture and made use of abundant raw materials. Gutenberg's inventions of the printing press and type-casting from metal in the fifteenth century marked a momentous turning point in the history of publishing: he succeeded in mechanising and speeding up the production of books, thereby making the process less laborious and more efficient. As a consequence of the universities' democratization of language and literature, society's demand for books was unprecedented. Gutenberg's printing press ensured that

supply was better able to satisfy demand, simultaneously assisting language's journey to standardization. The domination of Gutenberg's printing press emphatically ended in the final quarter of the twentieth century with the rise of lithographic offset printing. Moving from casting type from metal, either manually or mechanically, to using photography to manufacture printing plates, incorporating the rotary-style in the machine design, and using web-offset printers rather than sheet-fed ones further enhanced the efficiency of book production, enabling thousands of page impressions to occur within an hour. Making books became a commercial, mass-production enterprise. And lastly, digital printing's emergence in the first decades of the twenty-first century has not served to supplant lithographic offset printing; rather, it has enabled short print runs to be economically viable and assisted in freeing the market from past bias against niche publishing. Furthermore, printing straight from digital sources has provided an unparalleled immediacy of information.

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NOTES

1. Eugene F. Provenzo, Jr., *Beyond the Gutenberg Galaxy: Microcomputers and the Emergence of Post-typographic Culture* (New York: Teachers College Press 1986), 11. See also Lucien Febvre and Henri-Jean Martin, *The Coming of the Book: The Impact of Printing 1450–1800*, trans. David Gerard (London: NLB 1976), 15, 19. Febvre and Martin state that the scriptoria and their ecclesiastical affiliates monopolized book production from the fall of the Roman Empire to the twelfth century (the monastic age) but that the founding of universities encouraged a democratization of literature and language from the late twelfth and early thirteenth centuries onward, giving rise to the establishment of workshops of craftsmen employed by the universities (the secular age).
2. Warren Chappell and Robert Bringhurst, *A Short History of the Printed Word* (Vancouver: Hartley and Marks 2000), 5
3. Howell G. M. Edwards and Fernando Rull Perez, 'Application of Fourier Transform Raman Spectroscopy to the Characterization of Parchment and Vellum. II — Effect of Biodeterioration and Chemical Deterioration on Spectral Interpretation,' *Journal of Raman Spectroscopy* 35 (2004): 754–60, 754
4. Febvre and Martin, *The Coming of the Book*, 17

5. Ibid., 17–18
6. Ibid., 16
7. Ibid., 18
8. Ibid., 30–31. The process of papermaking might appear time consuming and incredibly hands-on; however, it must be remembered that such a process might simultaneously produce reams of twenty-five sheets, which were collected into bundles of twenty reams (34). The description provided above by Howell G. M. Edwards and Fernando Rull Perez relates to the preparation of each skin.
9. Febvre and Martin, *The Coming of the Book*, 16; Frederick G. Kilgour, *The Evolution of the Book* (New York: Oxford University Press 1998), 79
10. Kilgour, *The Evolution of the Book*, 79
11. Febvre and Martin, *The Coming of the Book*, 30
12. Kilgour, *The Evolution of the Book*, 79
13. Nicole Howard, *The Book: The Life Story of a Technology* (Baltimore: Johns Hopkins University Press 2009), 39
14. See, for example, Elizabeth Eisenstein, *The Printing Press as an Agent of Change: Communications and Cultural Transformations in Early Modern Europe*, 2 vols. (Cambridge, UK: Cambridge University Press 1979) and Elizabeth Eisenstein, *The Printing Revolution in Early Modern Europe*, 2nd ed. (New York: Cambridge University Press 1983).
15. S. H. Steinberg, *Five Hundred Years of Printing* (Hammondsworth, Middlesex: Penguin 1955)
16. Stephan Füssel, *Gutenberg and the Impact of Publishing*, trans. Douglas Martin (Burlington, VT: Ashgate 2005); and Stephan Füssel, 'Gutenberg and Today's Media Change,' *Publishing Research Quarterly* 16, 4 (Winter 2001): 3–10
17. Kilgour, *The Evolution of the Book*, 70. Other copying completed by the scriptoria, particularly in the secular age, included that of missals, antiphonaries, and breviaries (see Febvre and Martin, *The Coming of the Book*, 18–19).
18. John F. Zeigler, 'Gutenberg, the Scriptoria, and Websites,' *Journal of Scholarly Publishing* 29 (October 1997): 36–43, 37
19. Ibid., 38
20. Ibid., 39
21. Naomi S. Baron, *Alphabet to Email: How Written English Evolved and Where It's Heading* (London: Routledge 2000), 44
22. Chappell and Bringhurst, *A Short History of the Printed Word*, 5
23. Provenzo, Jr., 1986, 11. Between 1200 and 1400, the collection of books into libraries, notably in both the homes of the wealthy and universities, became common (see Howard, *The Book*, 19–23).
24. Chappell and Bringhurst, *A Short History of the Printed Word*, 5

25. Füssel, *Gutenberg and the Impact of Publishing*, 7
26. Much information already exists. For example, see Chappell and Bringhurst, *A Short History of the Printed Word*, 43–46; Füssel, *Gutenberg and the Impact of Publishing*, 15–18; Howard, *The Book*, 34–38; and Kilgour, *The Evolution of the Book*, 86–92.
27. John Arnold discusses how the use of linotype machines to manufacture newspapers in the 1890s in Australia resulted in significant redundancies in the industry. See John Arnold, 'Printing Technology and Book Production' in Martyn Lyons & John Arnold (eds.), *A History of the Book in Australia 1891–1945: A National Culture in a Colonised Market* (St. Lucia: University of Queensland Press 2001, 107).
28. This is supported by Jane Gleeson-White, 'The Book: A Revolutionary Tale', *Meanland* (blog), 8 February 2010, http://meanland.com.au/articles/post/the-book-a-revolutionary-tale/; David Crystal, 'World English: How? Why? When? Where? Which? Whither?,' *English Language Teaching News* 31 (1997): 52–75, 15; and Dennis Freeborn, *From Old English to Standard English: A Course Book in Language Variation across Time*, 2nd ed. (London: Macmillan 1998), 260.
29. Howard, *The Book*, 59
30. Kilgour, *The Evolution of the Book*, 90–91
31. Steinberg, *Five Hundred Years of Printing*, 28
32. Füssel, *Gutenberg and the Impact of Publishing*, 7
33. Chappell and Bringhurs, *A Short History of the Printed Word*, 43
34. Rob Dunn, Ray Hester, and Andrew Readman, 'From Letterpress to Offset Lithography,' in Bill Cope and Diana Kalantzis (eds), *Print and Electronic Text Convergence* (Altona, Victoria, Australia: Common Ground 2001), 89
35. Chappell and Bringhurst, *A Short History of the Printed Word*, 252
36. Dunn, Hester, and Readman, 'From Letterpress to Offset Lithography,' 90–91
37. It should be noted that printing by letterpress was by no means static. Innovations in the form of the linotype and monotype machines occurred in the 1880s and 1890s respectively; however, such technological improvements are incremental and can thus, within the disruptive technology framework, be considered sustaining in nature. Interestingly, an elitist preference for the traditional hot-metal letterpresses meant that, initially, the linotype and monotype machines were employed for mass-market type texts, while the former was used for finer, higher-quality works.
38. Howard points out, however, that Senefelder sought to deny that his invention was accidental. He wrote the following: 'I have told all these findings fully in order to prove to the reader that I did not invent stone-printing through lucky accident, but that I arrived at it by a way pointed out by industrious thought' (Howard, *The Book*, 131). Howard's citation originates from Senefelder's *The Invention of Lithography* (New York: Fuchs & Lang Manufacturing Company, 1911).

39. Dunn, Hester, and Readman, 'From Letterpress to Offset Lithography,' 89
40. Chappell and Bringhurst, *A Short History of the Printed Word*, 212
41. Dunn, Hester, and Readman, 'From Letterpress to Offset Lithography,' 89
42. Chappell and Bringhurst, *A Short History of the Printed Word*, 213
43. Ibid., 213–15
44. Howard, *The Book*, 144
45. Certainly, considerable innovation has driven the development of lithographic plates, such as computer-to-plate technology and direct imaging. For more on this, see Dunn, Hester, and Readman, 'From Letterpress to Offset Lithography,' 99–102.
46. Albert N Greco, *The Book Publishing Industry*, 2nd ed. (Mahwah, NJ: Lawrence Erlbaum Associates 2005), 173–4
47. Greco, *The Book Publishing Industry*, 174–5
48. Chappell and Bringhurst, *A Short History of the Printed Word*, 268
49. Offset lithography did not rely only on web presses: Sheet-fed presses were also employed. However, the increased efficiency provided by lithography meant there were more choices could be made without jeopardizing output. Sheet-fed presses could generate between one thousand and ten thousand impressions per hour, though some could reach as many as fifteen thousand (see Greco, *The Book Publishing Industry*, 175).
50. Greco, *The Book Publishing Industry*, 175
51. Kathleen M. Lyle, 'From Metal to Hard Disc,' *Journal of Applied Probability* 25 (1988): 65–75, 67
52. Chappell and Bringhurst, *A Short History of the Printed Word*, 272–3
53. Ibid., 290–1
54. Füssel, *Gutenberg and the Impact of Publishing*, 195
55. Jason Epstein, 'Reading: The Digital Future,' *New York Review of Books* (5 July 2001), available at http://www.nybooks.com/articles/archives/2001/jul/05/reading-the-digital-future/; Ted Gannan, 'Digital Technology and Publishing I: The Survival of Textbook Publishing,' *Publishing Studies* no. 2 (Autumn 1996): 5–9; Estelle Jobson, 'Digital Printing: Current and Future Applications,' *Publishing Research Quarterly* 10, 1 (2003): 20–30; Edward Nawotka, 'Our Digital Future,' *Publishing Research Quarterly* 24 (2008): 124–8; Hanno Ronte, 'The Impact of Technology on Publishing,' *Publishing Research Quarterly* 16, 4 (2001): 11–22
56. Nick Walker, 'New Technology and the Publishing Firm: Business Development, Culture and Models' in David Carter and Anne Galligan, eds., *Making Books: Contemporary Australian Publishing* (St. Lucia: University of Queensland Press 2007): 151–66, 155
57. Dunn, Hester, and Readman, 'From Letterpress to Offset Lithography,' 101

58. Füssel, 'Gutenberg and Today's Media Change,' 5–6
59. John B. Thompson, *Books in the Digital Age: The Transformation of Academic and Higher Education Publishing in Britain and the United States* (Cambridge: Polity 2005), 421
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