CHAPTER 2

Digital Is Different?

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LEARNING OBJECTIVES

By the end of this chapter you will have an understanding of:

- The nature and origins of digital innovation.
- The case for seeing it as a transformative technology with pervasive impacts across all sectors.
- The role it can play in innovation management by providing powerful new tools to support the process.
- The wider management implications, especially in learning to operate at a system level.

A quick glance at any kind of media and it won't be long before you'll find reference to the challenge of 'digital transformation' or 'digital disruption'. Reports and studies abound offering insights into why and how organizations need to think about their strategies in this turbulent world – and the dire consequences if they don't. 'Digitalize or die' is the underlying innovation challenge.

But is it a revolution? Is it new? And what does it mean for managing innovation? In this chapter we will explore the nature of 'digital innovation' and review the case for seeing it as a revolutionary challenge. We'll examine both its role as enabling radically different outputs from the innovation process and its potential to extend significantly the toolkit available to us in managing the process of innovation. And we'll look at some of the emerging new challenges which innovation managers will need to get to grips with in order to capture value from the significant opportunities which digital innovation opens up.

2.1 WHAT IS DIGITAL INNOVATION?

For all that it is a widely used term there is remarkably little clarity on exactly what 'digital innovation' actually involves. Most definitions centre around the idea of using digital tools and/or exploiting the digital infrastructure to enable innovation. In other words, it is using digital technology to amplify the range of options, to accelerate 'normal' innovation search along pathways which may prove disruptive to more traditional sectors because of the radical performance characteristics they are able to offer. **Research Note 2.1** gives a review and summary definition which captures this essence.

RESEARCH NOTE 2.1 Defining Digital Innovation

In an extensive literature review Schallmo and colleagues explored the emergence and definition of the concept of 'digital innovation' [1]. They drew from academic research, practitioner and policy reports and consultant studies to create the following definition:

'(Digital innovation) . . . includes the networking of actors such as businesses and customers across all value added chain segments . . . and the application of new technologies . . . As such it requires skills that involve the extraction and exchange of data as well as the analysis and conversion of that data into actionable information. This information should be used to calculate and evaluate options in order to enable decisions and/or initiate activities . . . In order to increase the performance and reach of a company, (it) involves companies, business models, processes, relationships, products, etc . . .'

We can approximately define digital innovation as the suite of technologies around the creation or capture, storage/retrieval, processing and communication of information and their combination into high-level systems with emergent properties.

We can see its considerable potential more clearly if we look at the way digitalization affects a set of key activities. At its most basic level it improves basic functions – for example, the storage and retrieval of information. Such handling can be done using analogue techniques – for example, recording things on paper and then filing them – but using digital technology these functions can be radically improved in terms of speed, space, etc. In a similar fashion, basic control involves sensing activities – counting, timing, weighing, listening, etc. – and acting in some way upon the system generating those inputs – slowing down, speeding up, increasing temperature, etc. These can again be done in an analogue fashion but digital tools are much faster, more accurate, reliable, consume less energy and space, etc.

But it is as we move to the next level in the hierarchy in **Figure 2.1** that the big impacts begin to emerge. By using a common language (all information is eventually reduced to binary digits) and through the use of programs held in software which contain operating instructions it becomes possible to introduce a meta-level. Information can now be analysed, sorted, integrated with stored data – in other words it can be processed, again with radical speed, accuracy, space and other advantages. Control loops can be applied where stored programmes determine what

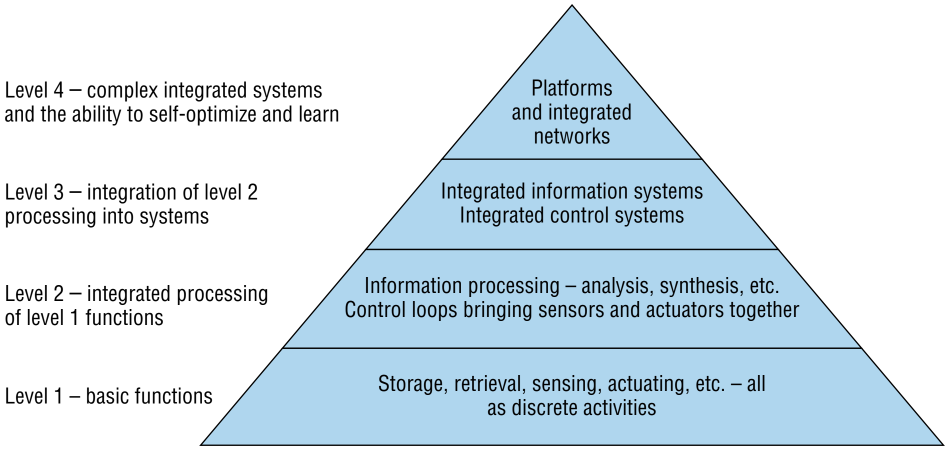

FIGURE 2.1 Simplified hierarchical model of digital technology

action to take dependent on information coming in from sensors and the relevant instructions can be passed to actuators. Such control loops can be applied right across the range of industrial and commercial operations from managing temperature in a distillation column through to regulating the flow of people through a turnstile.

The next level up brings in the power of communication; in digital systems information can be passed between controllers and information processing centres almost instantaneously. And this allows for integration into ever more complex control and processing hierarchies. So in a factory the information processing around ordering, tracking, paying for and storing the thousands of parts needed to make a complex product like a smartphone can be managed by software controlling all of these operations and sharing information between the different elements. In a similar fashion, the robots and automated assembly machines can be co-ordinated with the handling systems to enable the automated assembly of the product. Its despatch and delivery to customers together with the sales processes required to exchange money for goods can all be handled by another suite of software. And in turn the design of the next generation of phone can be undertaken by teams using and sharing their ideas across design systems. The idea of a computer-integrated factory combining design, co-ordination and actual production moves from science fiction to today's reality [2,3].

In services the same pattern becomes possible. A hotel can manage at the operational level the various activities around taking bookings, planning space utilization, billing customers, purchasing provisions, scheduling staff rotas, handling payroll and countless other activities in an integrated fashion, allowing for continuous optimization. Today's banking and finance systems are highly integrated suites of software enabling fast and global transactions across customer bases running into millions of people with different service requirements yet delivering these on a personalized basis. Similar examples can be found across all streams of economic and social activity in both public and private sectors.

Nor is it confined to process innovations; the same also goes for products. Integration and convergence lead to massive improvements in efficiency along many dimensions whilst at the same time enabling completely new or significantly improved functionality. Today's smartphone offers a host of capabilities which go way beyond the simple communication between people that its ancestor in the days of Alexander Bell was able to provide.

Case Study 2.1 gives an example of how such hierarchical potential plays out in the provision of the user experience of streaming movies.

The power of digital is that it has emergent properties – as we climb this hierarchy so the whole becomes greater than the sum of its parts. In addition it uses a common language which means that interoperability is possible, linking ever more complex systems. The Internet of Things

CASE STUDY 2.1 Unravelling Netflix

Netflix began life as a video rental company in the days when the format available for this transaction was physical DVD discs which had to be picked up and then returned to a shop. Angry at having to pay late return fees on his films Reed Hastings began thinking about how he might change the business, setting up the company with his business partner Marc Randolph in 1997. Their business model at that time was to offer a web-based rental service, posting discs to users; this enabled them to offer a wider range of choice than any physical store might, building on Amazon's experience of bookselling. But in the following 20 years the company has grown to be the biggest entertainment provider in the world with over 150 million subscribers in 190 countries around the world. It has pioneered the world of entertainment streaming and now has extensive activity in content creation as well as distribution.

But the success of their model owes a great deal to the digital revolution. It is worth looking at what actually has to come together to bring a movie to the screen of a typical user. At the outset content is created using digital tools – audio and video cameras and other devices. That product is then available for distribution but instead of using the old model of copying it to disc and then renting it out Netflix streams the content directly. To do this involves an immensely complex architecture of microservices each of which 'talks' to the other via structured APIs – application programming interfaces. These microservices deal with various parts of the user experience and transaction – for example, storing the shows which have been watched, deducting fees from the user's credit card, one monitoring watching habits to feed the recommendations algorithm and so on.

The real power of digital technology becomes apparent when the permutations needed to deliver these to individuals are taken into account. Netflix runs about 700 microservices but these are constantly being updated and adapted around millions of users. The company originally ran this on their own servers but as they grew they moved this to work in the cloud, bringing in further complexity and also the need to interface with Amazon Web Services as key suppliers of cloud storage and server capacity. (Significantly one of Netflix's biggest competitors is Amazon's Prime service, but like Apple using Samsung components in its phones the arrangement suits both parties.)

Netflix's consumer base watches on thousands of different devices – TVs, tablets, phones, etc. and so the system needs to detect which platform is being used and supply the content in the correct format for that device. Again software enables 'transcoding' to adapt to individual users whilst also managing the digital rights to ensure unlicensed copying or sharing is prevented. Other software driving Netflix's Content Delivery Network detects bandwidth and routing of the content across the internet, breaking the film up into packets and then reassembling them as they arrive from different sites into an integrated stream which gives the viewer a seamless presentation.

Source: Based on Nair, M., 'How Netflix works: The (hugely simplified) complex stuff that happens every time you hit Play', Medium, 17-Oct-2017. [Online]. Available: https://medium.com/refraction-tech-everything/how-netflix-works-the-hugely-simplified-complex-stuff-that-happens-every-time-you-hit-play-3a40c9be254b

(IoT) is already a reality because the intelligence and basic functionality can be embedded in any household device (or in any other location) and then linked together in complex networks [5].

Three other key features are worth mentioning. First, digital technologies allow for easy updates to the core controlling programs because they require only software revision. There is no need to replace physical components in many cases, so systems are renewable and progressive. Wikipedia's model is based on continuing updates and many physical products – smartphones, for example – undergo regular improvements to speed, performance, functionality and security all delivered via software updates. Tesla's complex cars are designed on a similar model; rather than having to drive to a workshop for improvements most updates can be delivered via software versions.

The second important feature is associated with what has been called 'Moore's Law' – an observation which has largely proved correct that the power of electronic devices increases exponentially whilst their cost falls. This enables a continuing stream of innovation delivering expanding functionality without high cost.

At the same time the modularization of software and the development of programming languages which enable assembly of complex systems and their interoperability means that increasingly complex arrangements become possible (see Case Study 2.1 for an example).

So digital technology offers an immensely powerful platform on which to build a wide variety of applications relevant to any sector of the global economy.

2.2 IS IT NEW?

Digital innovation is not new. Despite the hype around the disruptive potential of this technological wave the reality is that it's been building for the past 70 years, ever since the invention of the transistor back in Bell Labs in 1947 [6]. And there's a good argument for seeing it date back over a century to when John Fleming and Lee DeForest began playing around with valves and enabling simple electronic circuits.

And programmable control was evident in the early days of the Industrial Revolution with mechanical devices increasingly substituting for human skill and intervention. Not for nothing did the Luddites worry about the impact technology would have on their livelihoods. Textile manufacturers were able to translate complex designs into weaving instructions for their looms through the use of punched card systems, an innovation pioneered by Joseph Marie Jaquard. And we should remember that it was in the nineteenth, not the twentieth century that the computer first saw the light of day in the form of the difference and analytical engines developed by Babbage and Lovelace.

So the potential of using digital technology to control and communicate is not new. Nor is the sense of its potential game-changing capacities. In 1920, the Czech playwright Karel Capek wrote a satirical play entitled 'R.U.R' which stood for Rossum's Universal Robots, which imagined a conflict between automatons and humans. (This gave us the term 'robot' as a programmable automaton.) Science fiction began imagining the ways in which advanced control technologies could impact our lives long before the enabling technologies emerged. Images of the factory of the future emerged, automated to the point where it needed no lights and was staffed only by one man and a dog (The job of the dog to protect the factory from trespassers and that of the man being to feed the dog!). Or George Orwell's 1948 frightening image of a society with a device in every room able not only to display but also to receive information about citizens [7].

Research Note 2.2 gives an example of a major futures study looking at the potential implications of digital technology for society.

RESEARCH NOTE 2.2 IT Futures

A major study into the long-term future with information technology was undertaken in response to requests from the UK National Economic Development Office (NEDO), a quasi-governmental agency which brought together employers, trade unions and policy-makers. NEDO had established a Long-Term Perspectives Committee in the belief that the market would not automatically sense and deal with long-term problems. This Committee commissioned a series of studies to help inform their deliberations about the impact of various factors on social and economic development, including the role of new information technology (IT). These led to two publications summarizing the work of this research which used a Delphi (polling expert views and synthesising them) approach. One was a literature review *(IT Futures)* and the other a forecast *(IT Futures Surveyed)* and these were later brought together in a book *Information Horizons* [8]. A retrospective review of the forecasting exercise was carried out 25 years later and published in a review of service sector productivity [9].

Given the accelerating pace and the increasing investment in IT research, it was difficult to anticipate many developments, especially those involving competition between several technological solutions for the same basic problems (optical media? magnetic storage? solid-state devices? etc.) and those involving user adoption and reinvention of products. But the study did manage to recognize and capture some of the key underlying trends which would shape the future. At the time they were seen as including:

- Major improvements in the power and reductions in the cost of microelectronics and intelligent processors;
- Growing roll-out of fibre optical cable enabling high bandwidth applications;
- Increasing use of satellite-linked communications;
- Improvements in data storage and manipulation capabilities;
- Increasing range of software to support sector-specific applications.

In general, these trends did follow the trajectories anticipated, although in some cases the rates of change were faster than might have expected (leading to a leapfrogging over some of the short-term horizon developments); and the drivers of change often came from unexpected sectors — for example, the growth of communications satellite use being driven by entertainment (and particularly sport) channels. There was also another interesting leapfrog effect: some countries with less developed infrastructures (like South Korea) took advantage of the emerging technologies to roll out new fibre optic networks, which then supported new volumes of traffic and proliferation of applications, which in turn fuelled further technological development. In that country, and in many others, policy also played a key role as governments continued to get a better grasp on the considerable potential of 'the wired society'.

2.3 IS IT REVOLUTIONARY?

Although there is little in the way of a tight definition of digital innovation there is certainly a sense of its disruptive potential. Much of the discussion in the popular media links digital innovation with terms such as 'disruptive', 'revolutionary', or 'transformational'. So it is worth asking the question whether or not there are features of digital innovation which qualify it for that label.

The answer is a mixture. In terms of the pace of its arrival the above description of its history suggests that it is a very slow-paced change, although there has been rapid acceleration in the application of it over the past 30 years. In many ways it has more in common with a number of other 'revolutions' like steam power or electricity where the pattern is what Hargadon calls 'long fuse, big bang' [10]. That is to say the process towards radical impact is slow but when it converges there can be significant waves of change flowing from it.

Considerable interest was shown back in the 1980s (when the pace of the 'IT revolution' appeared to be accelerating) in the ideas of a Russian economist, Nikolai Kondratiev [11]. He had observed patterns in economic activity cycles which seemed to have a long period (long waves) and which were linked to major technological shifts. The pattern suggested that major enabling technologies like steam power or electricity which had widespread application potential could trigger significant movements in economic growth. The model was applied to the idea of information technology and in particular Chris Freeman and Carlota Perez began developing the approach as a lens through which to explore major innovation-led changes [12]. They argued that the role of technology as a driver had to be matched by a complementary change in social structures and expectations, a configuration which they called the 'techno-economic paradigm' (TEP) [13].

Importantly the upswing of such a change would be characterized by attempts to use the new technologies in ways which mainly substituted for things which already happened, improving them and enhancing productivity. But at a key point the wave would break and completely new ways of thinking about and using the technologies would emerge, accelerating growth. (A parallel can be drawn to research on the emergence of electricity as a power source; for a sustained period it was deployed as a replacement for the large central steam engines in factories. Only when smaller electric motors were distributed around the factory did productivity growth rise dramatically. Essentially the move involved a change in perspective, a shift in paradigm [14].)

Whilst the long wave model has its critics, it offers a helpful lens through which to see the rise of digital innovation. In particular, the earlier claims for revolutionary status seemed unfounded, reflecting the 'substitution' mode of an early TEP. Disappointment with the less than dramatic results of investing in the new wave would slow its progress – something which could be well observed in the collapse of the Internet 'bubble' around 2000. The revolutionary potential of the underlying technologies was still there but it took a while to kick the engine back into life; this time the system-level effects are beginning to emerge and there is a clearer argument for seeing digital innovation as transformative across all sectors of the economy.

This idea of learning to use the new technology in new ways underpins much of the discussion of what is sometimes called the 'productivity paradox' – the fact that extensive investment in new technologies does not always seem to contribute to expected rises in productivity. Over time the pattern shifts but – as was the case with electric power – the gap between introduction and understanding how to get the best out of new technology can be long, in that case over 50 years.

The example of Netflix (Case Study 2.1) shows how digital technology was first used to substitute, replacing direct shopping in a video store with online rental and delivery via the postal system. But in the same way as Amazon began to learn how to leverage the system potential of the technologies becoming available the Netflix model moved from online retailing to a much more highly integrated and economically powerful ecosystem. Today we can see a growing number of examples of such platforms and ecosystems; indeed the rise of the so-called FANG companies (Facebook, Apple/Amazon, Netflix and Google) and their equivalents in China, Korea, India and beyond can be directly linked to their exploitation of system-level emergent properties.

There is now plenty of evidence that such models can be applied to traditional sectors as well as defining new business areas [15]. Examples might include Airbnb and its impact on the accommodation sector where it is the largest provider of rooms without owning any property directly, or Uber and Lyft trying to disrupt the transportation sector. The automobile industry is moving into a new fluid phase of innovation with radically different business models and product concepts based on exploiting digital controls and systems. Indeed the competitive dynamics are change with the entry of new players such as Tesla from the software industry, with others such as Google and Apple indicating their strong interest.

It is important to insert a note of caution in this discussion. Whilst digital technologies undoubtedly have the potential to disrupt traditional sectors the evidence is that they are not necessarily destroying the established incumbents. Rather there is a process of absorbing and working with the new technologies to strengthen core competencies – a phenomenon noted in earlier studies of radical innovation by Tushman and Anderson [16]. As Birkinshaw points out digital disruption is a more nuanced phenomenon than much of the current popular discussion suggests [17]. But it does require innovation managers to adapt their response and upgrade the ways in which they work with this new toolkit, and we turn to this question in the next section.

2.4 WHAT DOES IT MEAN FOR INNOVATION?

So while it's been a long time coming there's a lot to suggest that the revolution has finally arrived. The real question is how can we manage it? To get close to answering this we need to split the question into two parts, seeing innovation both as a noun and as a verb. The former is all about the *outcomes* of innovation – the products, processes, services, new organizational forms, etc. which are enabled by digital technologies. And this is where so much of the discussion has focused. The management challenge here is one of exploration – for any organization the question should be '*have we looked at how digital might change what we do?*'

Table 2.1 Some Key Features of Digital Technologies

Low cost leading to widespread application potential
Common language – digital code – enabling communication and interoperability of software
Fast easy communication – connectivity was the barrier back in the 1980s, even with advanced protocols like ISDN (Integrated Services Digital Network) and similar
Increasing wireless connection potential
Low cost enables intelligent functionality to be built into a wide range of devices and then connected into systems – the 'Internet of Things'
Learning via machine (artificial intelligence)
Potential to collect and work with big data – massive increases in the volume, variety and velocity of collection allows for pattern recognition and the exploitation of network-level effects

Table 2.1 summarizes some of the key features of digital technologies which may open up new innovation opportunities for any organization.

And as we have already seen the application of such power to any sector opens up significant innovation opportunities. **Case Study 2.2** gives an example of its application in the humanitarian sector, building on the enabling framework offered by mobile phone network technology.

CASE STUDY 2.2 Exploiting Digital Innovation in the Humanitarian Context [18]

When Haiti was hit by a devastating hurricane in 2010 much of the city of Port-au-Prince lay in ruins. Within a very short time aid workers and locals began to piece together makeshift solutions to their problems, using resources such as mobile phones and a cellular connection. Solutions co-created and diffused included:

- Creating an 'instant' banking system across which aid agencies could distribute cash to buy food, medicines and other essentials [19]
- Open street mapping to provide up-to-date information about affected populations, damaged infrastructure, key emergency locations, etc. [20]
- Reuniting displaced persons using the phone network as a database and communications centre
- Crisis mapping and emergency communications
- Creating online access to key information but also to provide employment opportunities
- Providing resilient and fast voice-based communication.

Source: Based on J. Bessant, A. Trifilova, and H. Rush, 'Crisis-driven innovation; The case of humanitarian innovation', *International Journal of Innovation Management*, forthcoming 2016.

The difficulty in making the transition to deploying digital technology is that it is rarely a case of 'plug and play'. Systems need to be rethought not simply at the technological level but in terms of the underlying business models – the ways in which the new ideas can create and capture value. Part of Kodak's problem as an early entrant to the digital world was not the technology of digital photography (they held patents for the first digital camera and had a good base on which to develop products). It was the difficulty of finding a relevant business model, not least because their current market was a poor predictor of the ways in which the technology might find application [21].

This experience is beginning to emerge in a variety of studies. **Research Note 2.3** presents the results of two studies in Germany which emphasise the need to rethink business models.

But even when there is a compelling business model there remain difficulties in implementing the innovations, not least because of a mismatch between the skills and capabilities needed and those actually possessed. The studies in Research Note 2.3 highlight the skills gap even in a country like Germany with a significant flow of graduates in relevant digital disciplines. **Case Study 2.3** indicates the long timescale needed for building and assimilating such capabilities.

RESEARCH NOTE 2.3 Skills Challenges in Digital Innovation

In a study of 69 electrical engineering firms in Germany Arnold and colleagues found major implications for the way in which the 'Internet of Things' was being exploited [22]. They identified a number of factors which acted as rate limiting steps to the effective adoption and exploitation of the technology including:

- The changing role of the workforce from operators to problem-solvers with a consequent demand for higher level and different skills profile
- The need to build strategic networks and collaborations outside the enterprise, creating and managing ecosystems including customers and suppliers
- Data security and safety
- Learning to develop alternative business models better able to capture the potential value of IoT application

In another study involving extended literature review and a survey of 284 employees across multiple organizations in the high-technology consumer goods market Butschau and colleagues found that there were a number of hurdles slowing the rate of adoption and successful exploitation of digital technology [23]. These included:

- Cognitive competencies – skills and knowledge to support new digital approaches
- Social competencies – ability to work effectively in teams to support higher levels of networking, communication capabilities and reliability
- Processual competencies – learning to work with new systems and structures enabled by digital technology

CASE STUDY 2.3 Competence Building in Electronics – the Long Road

Hella is a German company, founded in 1899 and a major supplier of headlights and other accessories to the automotive industry. Its business is heavily dependent on electronics which now accounts for the lion's share of its turnover and which has helped position it well for dealing with the emerging move to highly automated and possibly driverless vehicles.

Its ability to play in this field is not an accident; it relies on having laid the foundations 40 years ago with strategic investment into what was at the time a risky unknown field.

By the 1980s the auto industry had begun to recognize the significant potential of electronics and there was an acceleration towards their widespread adoption to improve comfort, safety, emissions and security. Possibilities were also opening up for electronic diagnosis and for the potential replacement of whole systems of mechanical components. All of this created strong demand from the customer side but also a big challenge for Hella; they needed to think carefully about the major strategic shift into this field.

In 1982 Hella's product range was essentially based around simple electronics – electro-mechanical equipment such as relays, horns, water pumps for windscreen wipers, vacuum pumps and various sensors. And they had a few software-driven applications, especially the speed regulator. It was clear that if they were going to ride this new wave in the industry they would need to expand and focus their competence.

The swing towards integrated electronics led to considerable expansion across Hella's workforce. But it was not simply expansion in numbers; there was also a big shift in the skills and content of work involved. This was especially apparent in the design area where the long traditions of mechanical design were being replaced by electronics and circuit design. And software became an increasingly important area. For each new product there was a need for a minimum of two software developers who could work on both hardware and software. But at the start this was precariously underpinned – only between 15 and 20 young engineers were available who had these skills and the external labour market was already empty. So Hella had no alternative but to train young people from scratch by recruiting straight from universities and technical colleges – a 'grow-your-own' philosophy.

The challenge was not just to find somewhere to work, it lay also in the ways in which these young staff worked. In fact the organizational structure helped enable a unified development process which was fast and bridged effectively across different functions. A lack of space and facilities meant that they were all working closely together and shared ideas and information quickly and easily. And the acute skills shortage forced new staff to learn both hardware and software – unlike in larger organizations where these functions would have been managed separately. The Hella approach meant that development was parallel rather than serial and the idea of systems thinking became embedded early on.

ASICS – application specific integrated circuits – became increasingly important in the game.

One problem with this hardware approach was that it locked the design 20 weeks or more ahead so changes weren't possible – reducing new product development freedom. But customers often wanted last minute adjustments which were difficult to implement except via complex workarounds. Moving to a digital, software-based approach gave Hella the time needed and the flexibility to accommodate this.

Their approach was essentially to adopt a platform – pick a family of processors and then develop standard training, libraries of routines, standardized modules, etc. which gave flexibility and speed.

Another important input was the early adoption of structured programming techniques. These were introduced originally using an external coach who spent a great deal of time training and supporting Hella's acquisition of such capability. After two years it became standard Hella practice and brought with it advantages of higher quality and faster development of software.

The next milestone on the journey lay not in the electronics themselves but in the connecting cables between them. As cars and the electronic systems became more complex and widespread so that the problem of cabling rose to prominence. The solution lay in the idea of a BUS – using software to encode and decode different packets of information travelling along a single channel.

From an early start in the 1980s Hella moved to a position of strength in electronics. By the mid-1990s over 1.8 million electronic modules per day were coming off Hella production lines. Their progress has continued with major expansion of the division and activities now involve complex sensors and actuators to support autonomous vehicle controls. In an echo of their early days in moving into electronics they are now making a similar strategic bet on the future by investing heavily in machine learning skills and capabilities.

2.5 WHAT DOES IT MEAN FOR INNOVATION MANAGEMENT?

As we will see in Chapter 3 innovation is a process which enables value to be created and captured from ideas. It is a journey with many variants but with a common set of phases through which those ideas must pass. The model we introduced at the end of Chapter 1 provides a generic roadmap and it is worth bringing this to mind in considering the second set of implications of digital technology (**Figure 2.2**). How can it support or enhance the way we manage this process?

It is important in particular to recognize that whilst there is a core process for innovation our views on how it operates have become increasingly refined. As Rothwell pointed out we can identify several generations of thinking about how we organize innovation, each building on lessons from an earlier time. In other words, there is scope of 'innovation model innovation'. This is certainly the case with the world of digital technologies; whilst innovation has long been recognized as a distributed multi-player process it is through digital infrastructures that the significant

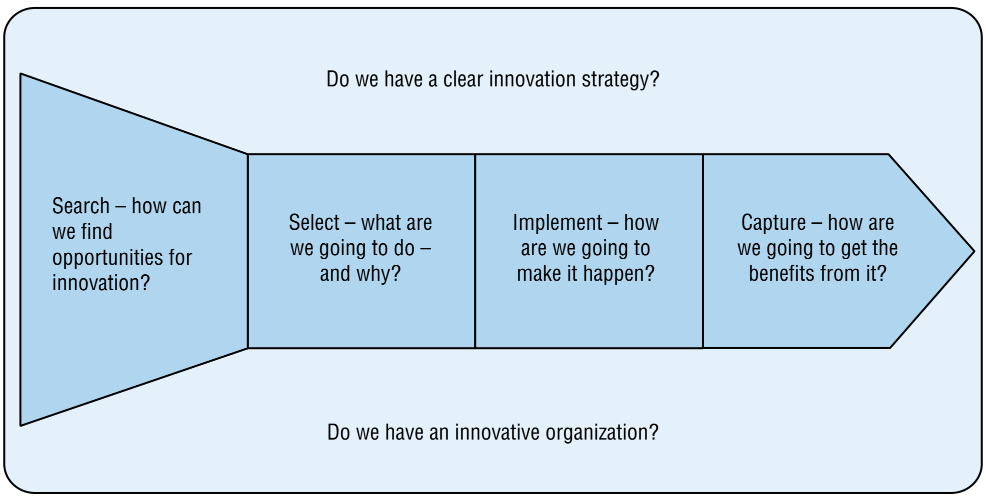

FIGURE 2.2 Simplified model of the innovation process

gains offered by a networked model become available. 'Open innovation' (a theme we will return to repeatedly in this book) is predicated on the idea of extensive networking and collaboration but while the principle has been understood for some time the enabling technology and infrastructure is only now maturing. This raises a number of new challenges for innovation managers in terms of learning how best to work with these opportunities.

In this section we will look at two core themes. First, how does digital technology add to or enhance our toolkit for working through the core innovation process? And second, what are the new challenges which emerge at this networked system level around which we need to develop new innovation management capabilities?

THE NEW DIGITAL TOOLKIT

As **Research Note 2.4** indicates we have a number of tasks to accomplish in the innovation process and organizations build behaviour patterns – routines – around executing these. A variety of tools – frameworks, structures, programs, etc. can help this happen. **Table 2.2** sets out an overview of the ways in which digital technology can enhance this toolkit.

We will highlight a few of these here but more detailed discussion can be found in the relevant chapters later in the book.

A key characteristic of the digital infrastructure is that it enables both 'richness' (high quality/content) and 'reach' (accessing a large population) in its communication possibilities [25]. So the challenge of search can be opened up to many more participants through various

RESEARCH NOTE 2.4 Innovation-Enabling Digital Technologies

In work with colleagues at the University of Erlangen-Nuremburg in Germany and at the Centre for Leading Innovation and Change at Leipzig Business School, Kathrin Moeslein has developed a framework for viewing such developments [24].

They suggest five complementary sets of tools which enable networks to be built and operated drawing on inputs from the crowd:

- ***Innovation contests*** – not a new idea (Napoleon's offer of a prize led to the development of margarine as a substitute for butter whilst in the United Kingdom the development of the maritime chronometer was as a result of an open contest won by Thomas Harrison). The basic principle is to offer a prize and then invite ideas via a Web 2.0 portal on which others can vote, make comments, etc. A twenty-first century example is the $20m prize Lunar X competition to develop a robot which can explore the surface of the moon; it must travel at least 500 m and send pictures back to earth. Many public and private sector organizations are using versions of innovation contests to increase the front-end flow of ideas, ranging from jewellery design (Swarovski), car design (Smart) and even public service design (Bavarian State government).
- ***Innovation markets*** – these essentially work by bringing 'seekers' and 'solvers' together via an eBay-style marketplace enabled by Web 2.0. The pioneer of this approach and still widely used is InnoCentive.com (which brings together 165,000 innovators from 175 countries) but many others now exist. Research suggests that such markets are particularly valuable in dealing with persistent problems which internal innovation teams have been unable to solve.
- ***Innovation communities*** – unite interested and often experienced and skilled innovators sharing common interests. User groups and online communities are examples and such groups are often a rich source of co-operative innovation in which ideas from one member are built on by others. Linux is a good example of this process, as is the growing developer community around Apple's iPhone platform.
- ***Innovation toolkits*** – enable users to engage with developing their ideas – for example, through configuration and self-build toolkits. Lego Factory offers a good example of this approach where users are encouraged to create their own designs which software on the Web helps them work with.
- ***Innovation technologies*** – offer tools to realise design and production by user creators, for example, through online computer-aided design and rapid prototyping technologies. Examples include Quirky (www.**quirky**.com) and Ponoko (www.**ponoko**.com).

Table 2.2 Digital Tools Application Across the Innovation Process

Stage in innovation process	Digital tools
Search	Broadcast search/crowdsourcing Cross-sector pattern matching Patent mining Innovation contests Innovation markets User communities Netnography Internal collaboration platforms
Select	Idea markets Voting via collaboration platforms Crowdfunding Decision support tools Machine learning/artificial intelligence (AI) applied as decision tool Simulation and prototyping to extend the exploration phase at low cost
Implement	Simulation and prototyping tools – e.g., 3D printing Collaboration platforms Co-creation communities Virtual teams AI/machine learning
Capture value	Networking and viral marketing to accelerate diffusion Platform models to concentrate and deploy knowledge Ecosystem construction AI/machine learning

tools based on working with those crowds and communities. These can include innovation contests, working with on-line user communities, crowdsourcing of ideas and the deployment of innovation markets in which 'seekers' for solutions to innovation challenges can be matched with 'solvers' [26]. (Chapter 7 explores some of these options in more detail.)

Inside organizations there is growing use of various kinds of collaboration platforms, essentially matching the potential of suggestion schemes with the community building and sharing functionality of social networks such as Facebook [27]. Organizations are able, in this way, to access thousands of ideas quickly from a workforce which may be distributed widely across the planet. Innovation management software of this kind has matured rapidly; typically today's platforms offer support for:

a. ***Finding ideas***
- Ideation support – open gateway for people to contribute their ideas
- Database to store and keep track of all ideas submitted
- Comment facility so others can add their responses and reactions – a kind of 'Facebook' 'like' and comment feature
- Shared idea development in which different comments can be used to refine and improve the idea
- Grouping – so that ideas (and the people suggesting them) can be linked together

b. ***Selecting ideas***
- Giving users of the system a chance to rate and evaluate ideas, again both with simple scores and with comments and refinements
- Engaging multiple perspectives – for example, evaluation by users, by experts of various kinds and even by 'investors' – people with notional money to invest who help manage a 'stock market' for ideas
- Feedback and status – transparency so that everyone can see what is going on and what happened to their ideas, where they are in the process

c. *Implementing ideas*

- Providing online meeting places where teams can take their ideas further forward and develop them for full evaluation
- Offline support for teams to work up their ideas
- Online and offline pitching events at which ideas are judged and decisions about formal backing and support are taken

d. *Targeting ideation*

- Using campaigns of various kinds to target and focus ideation along key strategic directions

e. *Knowledge management*

- Capturing and synthesizing all information from the platform and looking for patterns, mining for linkages, helping redeploy the knowledge held within and across the organization

Table 2.3 gives some examples of the benefits offered by such applications.

In the select phase the various options for innovation projects need to be assessed and assembled into a portfolio for further development. This involves various decision tools, qualitative and quantitative (as we will see in Chapter 9) and digital technology offers a variety of ways in which this decision making can be enhanced. The 'wisdom of crowds' can be quickly mobilized in the form of online voting, mobilizing virtual 'idea markets', or opening up crowdfunding platforms (which give an indication not only of support but also of the likely market potential of an innovation). Selection decisions are normally made under conditions of uncertainty and digital tools provide ways in which more information to reduce this can be made available at low cost and early in the process – for example, through the use of prototypes and simulations. And where selection criteria are well-defined there is an increasing role for AI/machine learning tools to support the process. **Research Note 2.5** gives an example.

Table 2.3 Benefits Offered by Collaborative Platforms for Innovation [27]

Function	Characteristics
1. Simple front end ideation	Automating the suggestion box, providing a mechanism to 'crowdsource' ideas and collect them
2. Interactive front end	Engaging other people in reviewing, refining, commenting on ideas
3. Targeted interactive front end	Using targeted campaigns and challenges to draw out ideas in a particular direction of strategic importance. Requires an 'owner'/sponsor of the challenge
4. Ideation and judgment	Adds in possibility for others to evaluate and judge, contribute to selection of 'good' ideas. Can bring in specialist/expert judges. Also possibility of 'investors' – mobilising 'idea markets' to get a sense of which ideas achieve popular support
5. Building communities of practice	Enables teams to form and interact in the further development of their ideas after selection in the early rounds. May involve off-line/physical meeting to develop ideas. May involve training inputs of various kinds to help strengthen the core idea and make it ready for 'pitching' in final selection rounds.
6. Connection to mainstream innovation system	Involves some kind of 'pitch' of entrepreneurial idea to senior managers who will elect and allocate development resources to take the idea forward. At this point the team may be augmented with specialists to help move the idea forward. The results are measured using organization KPIs and reward systems linked to those.
7. Integration into the innovation system	This pattern of innovation becomes part of the culture, running in parallel with other activities. Knowledge is captured and stored, re-used to support new targeted campaigns and recombined creatively.
8. Extension to players outside the organization	Mobilizing the model to bring in suppliers, users and others as part of co-creation infrastructure.

Source: Bessant, J., 'A maturity model for high involvement innovation', Hype Software, Bonn, White paper, 2018.

RESEARCH NOTE 2.5 Using Artificial Intelligence (AI) to Support Innovation Management [28]

The German software company Hyve carried out a survey of 163 managers exploring the potential and use of AI in innovation. They found examples suggesting companies are increasingly experimenting learning from their experience and establishing AI-driven methods. For example, the German company Beiersdorf, producer of various skin care and body products, used AI and machine learning to generate insights from consumer discussions found online. The experiment confirmed that computer algorithms could identify relevant consumer statements on the internet about products much faster and in greater numbers than was possible with established approaches. The identification of specific consumer needs could also be conducted much more efficiently thanks to machine learning. At the same time however, the immense importance of human innovation researchers was clearly evident when it came to training algorithms and presenting the results through storytelling and visualizations.

The American food company Mondelez used AI in the selection and evaluation stage. This becomes problematic partly as a consequence of crowdsourcing where it becomes possible to access thousands of ideas from external and internal sources. Manually reviewing these ideas for a final selection is a lengthy process that ties up valuable resources within the company and may eliminate many ideas too quickly. In cooperation with HYVE's innovation team, Mondelez decided on a different approach, using AI to identify patterns in the description of ideas and thereby determine the DNA of successful ideas.

The major conclusion of the Hyve study was that the 'biggest obstacle is still a lack of understanding and knowledge. AI is still bewildering for many people; a black box, where you don't know what actually happens'.

Source: Based on Hyve Software, 'Autonomous innovation: How AI and algorithms revolutionize innovation management', Hyve Software, Munich, 2019.

Within the implementation process innovations move from ideas through various stages of concept development, testing, refinement and launch. Each of these can benefit from the use of digital tools – for example, simulations and visualizations can quickly test ideas and rapid prototyping can create early boundary objects around which potential users can co-create better concepts [29]. 'Agile innovation' approaches stress a rapid sequence of build/test/learn and pivot and these can be supported by the use of such a digital play kit [30,31]. Collaboration platforms enable interaction of teams even if they are widely distributed in time and space. And such platforms can also form the nucleus for teams of employees to self-organize around key ideas (especially for internal process innovations) and co-create them. (These applications are discussed in detail in Chapter 10.)

Finally innovations need to be launched and to diffuse to scale and the value created captured in some way for the innovator. Digital tools around networking provide powerful accelerators for the social processes which underpin diffusion and are increasingly used to create communities around innovations. Building platforms (see below) offers a way of using knowledge more efficiently by deploying it in a targeted fashion to multiple users and using feedback from those markets to refine the offering and targeting. Amazon and Google provide good examples of this platform model for market development and growth. And again machine learning/AI offers ways to improve future launch and diffusion campaigns.

There is growing interest in and application of these tools but it is important to note that their effectiveness only comes as a result of learning. The 'productivity paradox' which emerges often in the discussion of new technology application is relevant here too; few of these tools work well on a simple 'plug and play' basis [32]. Instead there is a need to learn how to work with them, to understand not only the mechanics of their operation but also to configure the organization to make effective use of them.

The case of collaboration platforms provides a good example. At first sight their advantages seem obvious – a way of automating the old suggestion box concept and making it possible to tap into the ideas of all employees even in a large and geographically distributed organization [33]. The reality is that making effective use of such tools requires an extended learning and organizational development process before the full gains can be realized [27].

NEW WAYS OF THINKING ABOUT INNOVATION MANAGEMENT

Deploying the tools described in the above section requires learning new skills and adapting existing innovation structures and routines within organizations to get the full benefit from them. But there is another set of challenges which require the creation of new operating models, building completely new routines to support capturing value from digital technology-based innovation. In particular there is a need for systems-level thinking.

Systems Level Thinking As we have seen in this chapter there is a shift in both the approach organizations take to innovation (open innovation/interactive value creation) and also the available digital technology infrastructure to enable this. Digital enables networking and connectivity on a massively enhanced scale, virtual partnering, online communities, consortia, etc. And successful organizations are able to capitalize on this by creating new networked architectures to create and deliver their innovative solutions – they have deployed 'innovation model innovation'. For example, the north west of Spain was not a traditional textile region yet over the past 50 years the Inditex organization (parent of Zara) has established a hugely successful global business in this field through extensive use of digital tools. It pioneered the concept of fast fashion through rapid co-ordination across a multiplayer design and supply chain. In a similar fashion players such as Amazon and Alibaba have created completely new models building on the emerging IT infrastructure. **Table 2.4** gives some examples of major new businesses which have emerged during the past 20 years, all of which build on new models enabled by digital infrastructure.

The challenge these organizations faced at a strategic level was not simply the deployment of new tools, nor in substitution of better products or processes enabled by digital technology. Instead they took a broad view of the whole system of value creation and worked through the many different elements in their models to enable emergent properties – the whole becoming greater than the sum of its parts. As Gawer and colleagues put it, '*they bring together individuals and organizations so they can innovate or interact in ways not otherwise possible, with the potential for non-linear increases in utility and value*' [34].

This involves moving the innovation management focus from the level of the enterprise or the immediate network with key customers and suppliers. Pitched at a system level it raises questions about governance and control and introduces some fascinating paradoxes. Apple, for example, is in head-to-head competition with Samsung for a share of the global smartphone market – yet some of the key components of its phones are made by Samsung. Netflix depends on Amazon's servers to keep its streaming services running, yet Amazon Prime is one of its big competitors. So the idea of system level collaboration and interaction is more than simply focusing all players on a common goal; it is about finding models which allow for both individual and collective action in an evolving ecosystem.

Looked at through this lens it becomes clear that some major players are less successful on the basis of the individual products or services which they offer than on their ability to act

Table 2.4 Platform Businesses based on Digital Infrastructure

Application field	Organization
Social media	Facebook, Twitter
Smartphones	Apple, Google (via Android platform)
Marketplaces	Amazon, Tencent, Alibaba, Yandex (Russia)
Accommodation	Airbnb
Transportation	Uber, Lyft
Software and games	Microsoft, Valve
Entertainment	Netflix, Amazon

as system architects. Apple's rise, for example, owes a great deal to its ability to put together the ecosystem around iTunes, enabling legal file sharing and digital downloading of music by bringing together all the relevant stakeholders into its network. Google owes a lot to the development of Android and the open system which it created to engage thousands of app writers.

Whilst we hear much of the success stories around platform/ecosystem businesses we should recognize that building such operations is risky and complex and many fail. For example, MySpace was a powerful early entrant in the social media space but lost out to Facebook, Sidecar was the start-up which pioneered ride sharing but was eclipsed by Uber and Airbnb was not the first rental platform for accommodation, being preceded by players like VRBO. The costs of building an ecosystem are significant and there is a high risk of not achieving the scale or the co-ordination necessary to make it work. **Research Note 2.6** gives some insight into key causes of failure in innovation management at this system level.

RESEARCH NOTE 2.6 Platform Leadership

In an influential book Annabel Gawer and colleagues explore the phenomenon of platforms as a system level model for exploiting digital infrastructure [34]. They argue in particular for the need to pay attention to four key areas of strategic action:

Choose the architecture – in particular platforms can be multi-sided bringing different players together. Managing a two-sided platform is difficult, managing a multi-sided one becomes increasingly so. Uber's problems (it has yet to become profitable) may lie in part because of its attempts to build and manage many different sides to its platform and associated ecosystem. There is also the issue of choosing the relevant platform type – they distinguish between *innovation* platforms (such as Windows, Amazon Web Services and Apple's IoS) and *transaction* platforms (such as Facebook, Alibaba's Taobao, Airbnb and Uber), where the former involve the creation of products and services and the latter, as the name suggests, operating as market places. Innovation platforms usually involve building blocks and connectors which enable others to participate – for example, the developer community working across the Android platform.

The 'chicken or egg' problem at launch – for innovation platforms it is important that the provider begin with products/services which do not need a third party complementor. For example, Microsoft's dominance of the PC platform world owed much to having MS-DOS as a core product and making that available easily so as to build volume; Google adopted a similar strategy with Android, offering an operating system into which others could then connect.

Building an effective business model – whilst platforms offer significant network effects which can quickly multiply their reach and potential revenue it still requires careful attention to the underlying business model. Which parts are offered free or at low cost and which will provide revenue – and when? Google's strategy with Android was to give away the core operating system and then generate revenue from the developer and user side. The essence of a platform business model is its scale; Microsoft spent $1bn developing Windows XP but recouped this across its market in three weeks after launch. By contrast Symbian, Nokia's micro-device operating system failed to build sufficient scale for it to become an effective platform.

Establishing and enforcing ecosystem governance – platforms involve, by their nature, players with complementary assets and operate as ecosystem. But there needs to be careful design of the governance and rules to manage issues like quality and conformance to standards. The current concerns about misuse of platforms by app providers has highlighted the responsibilities which platform owners have to ensure that their systems operate legally and in a morally acceptable fashion.

The Changing Role of Knowledge Innovation is about creating value from ideas – and so knowledge creation and deployment is at the heart of the process. But digital technologies open up new opportunities for working with knowledge. In a formal sense 'knowledge management' (KM) did not feature extensively in discussions of innovation until the late twentieth century (although there were some notable exceptions, particularly in thinking about the role of tacit knowledge as a complement to formal knowledge such as generated in R&D) [35]. KM came to focus on the ways that organizations can generate value by improving the ways in which they create, capture/store, distribute/transfer and effectively use/apply knowledge. But at that time the approach taken reflected the 'substitution' view of digital innovation with the emphasis on data and how data management tools could be more effectively applied. Gradually the idea of searching and processing that data emerged with software such as search engines, data mining and pattern recognition. Gradually the concept of converting data to useful knowledge and manipulating that came to dominate.

Today's potential is significantly higher. In particular, we have come to recognize the value of 'big data' – the large amounts of data which can be collected by amalgamating things like transaction records or visitor statistics and processing them to find patterns. The key characteristics of such big data opportunities are sometimes summarized in the '3 Vs' – volume, velocity and variety. The data available, for example, from GPS chips in mobile phones give a rich picture of habits and preferences across millions of people. The data can be harvested in a number of ways, to detect generic patterns (and open up new markets) or to personalize and customise. In a similar fashion the growing use of intelligent assistants such as Amazon's Alexa or Apple's Siri generates rich data about lifestyles and preferences across huge numbers of people which can be used to target advertising and customise products and services offered. And the attraction of Amazon, Alibaba and Yandex (Russia) as platforms for retail services is the metadata they generate about shopping and consumption patterns which can be valuable to advertisers.

Big data tools and techniques are increasingly being applied, not just in the commercial sector. In the public sector the value of such data is huge and can be manipulated to help improve provision of key services. It can also help enhance understanding – for example, in healthcare the billions of data points held in the UK's National Health Service can provide a rich laboratory for mapping patterns and trends in disease. A report by the consultants Ernst and Young in 2019 suggested this data had a value of around $10bn [36].

The Red Cross is exploring the use of big data to help in its aid work in refugee camps where the movements and behaviours of hundreds of thousands of people in refugee camps or involved in mass migration can help tailor the timely provision of the right kinds of support services [37].

Responsible Innovation One final theme is important to explore in the context of digital innovation. We have seen in this chapter the significant potential for economic and social transformation through riding this technological wave. Its enabling of richness and reach can address many of the big global challenges in positive ways – for example, the use of big data in refugee camp management (see above), the enabling of cash programming via digital money in humanitarian and development aid contexts, the potential for inclusion of otherwise marginal players into the economic system via mechanisms like the e-Choupal model in rural India or the Alibaba Taobao villages in China. It can offer massive improvements in the efficiency and effectiveness of public services such as healthcare and education. And it can offer a wide spectrum of powerful applications available in handheld or even wearable devices.

But digital innovation also has a dark side. The growing concerns about unmoderated traffic across social media platforms and their emotional and physical health consequences, anxiety about privacy and security, the rising tide of cybercrime and a host of other examples highlight the point that innovation is not always a good thing. This is not a new theme; concerns over the wider implications and unanticipated consequences of technological change have been around for a long time. This field of research and the emerging tools and techniques enable an approach known as 'responsible innovation' (which we will discuss in more detail in Chapter 14) which argues for anticipation of wider consequences and flexibility in design to ensure adaptability and control over technologies in their development and modification as they diffuse.

Arguably the scale of impact which such a transformative set of technologies offers places the challenge of responsible innovation high on the list of priorities for innovation managers in the future.

SUMMARY

- In this chapter we have explored the potential of digital innovation, defined as the suite of technologies around the creation or capture, storage/retrieval, processing and communication of information and their combination into high-level systems with emergent properties.
- We have seen that although not new the momentum behind this technological wave has been building and has reached a maturity in the development of key components and infrastructure that now enables system level solutions to be widely available across all spheres of social and economic activity.
- Such a trend and the accompanying emergent properties of such systems qualify digital innovation for being considered as transformative, having many characteristics associated with long waves of economic and social change.
- Digital innovation has two key implications for innovation management. First in the outputs of the innovation system; there is enormous scope for applying the technology and the challenge is to explore innovation space as effectively as possible to find and exploit these opportunities. At the same time the take-up of the technologies is limited by the availability of skills, structures and business models to enable them and so building these into digital innovation strategies will be important.
- In terms of its implications for the process of innovation itself digital innovation offers a wide range of new and improved tools with which to work right across the process. Once again this has skills and capability building implications.
- There are also new challenges for innovation management emerging from the need to learn to operate at the system level, co-ordinating and orchestrating the efforts of multiple actors and stakeholders in wider innovation ecosystems.
- The transformative potential of digital innovation raises questions about the purposes and consequences of such a trajectory and this underlines the need for a 'responsible innovation' approach.

FURTHER READING

As suggested in the chapter there is a great deal of material being published around the digital technology revolution, but much of it remains at the level of commentary and prescription. Examples include Lindsay Herbert's *Digital transformation* (Bloomsbury, 2017), Anurag Harsh, *Going digital* (Osborne, 2016), Dick Whittington, *Digital innovation and entrepreneurship* (Cambridge University Press, 2018), and David Rogers, *The digital transformation playbook: Rethink your business for the digital age* (Columbia Business School, 2016).

There are a few research-based studies which take a more measured view including several edited collections, allowing wider coverage of this complex field. Examples include Anne-Laure Mention (ed.), *Digital innovation – Harnessing the value of open data* (WSPC, 2019) and Joe Tidd (ed.), *Digital disruptive innovation* (World Scientific, 2019).

Early discussion of the emerging ICT 'revolution' and critical assessment of this can be found in Ian Miles et al., *IT horizons* (Edward Elgar, 1987), John Bessant and Sam Cole, *Stacking the chips* (Frances Pinter, 1985), and Raphie Kaplinsky, *Automation – the technology and society* (Longman, 1984). Long waves and their link to the emerging transformation are discussed in Chris Freeman, Carlota Perez, and Giovanni Dosi, *Structural crises of adjustment: Business cycles and investment behaviour* (Frances Pinter, 1989).

A number of books and articles look in a more critical and systematic fashion at the likely implication for different sectors through digitization; these include Davenport and Westerman, 'Why so many high-profile digital transformations fail' (*Harvard Business Review*, March 2018), Jeanne Ross and colleagues, *Designed for digital: How to architect your business for sustained success* (MIT Press, 2019), Alan Brown, *Delivering digital transformation* (De Gruyter, 2019), and Satish Nambisian and colleagues, 'Digital innovation management: Reinventing innovation management research in a digital world' (*MIS Quarterly*, (41) 1, 2017). Annabel Gawer, Michael Cusumano, and David Yottie, *The business of platforms* (MIT Press, 2019) offers an excellent review of the emergence of platforms as a business model and the challenges in operating such innovation ecosystems. Tatiana Iakovleva and colleagues look at the challenges posed by *Responsible innovation in digital health* (Edward Elgar, 2019).

OTHER RESOURCES

A number of additional resources including downloadable case studies, audio and video material dealing with themes raised in the chapter can be found at locations listed below.

Resource type	Details	Access
Video/audio	David Simoes Brown of 100% Open talking about the challenges of working in open innovation with especial emphasis on digital channels Catharina van Delden talking about her start-up Innosabi which has grown to be a successful business in the field of online community development to support agile innovation	All at https://johnbessant.org/resources/media-resources/the-innovators-media-library/
Case studies	Examples of using digital technologies to enable innovation include: Lego Threadless Liberty Global Lufthansa Systems	All at https://johnbessant.org/case-studies/
Tools	A maturity model for working with online collaboration platforms to support innovation	https://johnbessant.org/tools-for-innovation-and-entrepreneurship/

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