Each chapter and longer case study also provides a number of questions for discussion, which encourage you to review and apply the knowledge you have acquired and test your understanding of the theories and points covered.

All references are listed at the end of the book, but selected further reading is highlighted after each chapter.

There are a number of good general textbooks on technology and innovation management. They provide very useful background on the key concepts that underpin thinking in the field. Those I have found useful in preparing this book are by Smith (2010), Bessant and Tidd (2007), Tidd and Bessant (2014), and Dodgson *et al.* (2008).

Among the leading academic journals that focus on technology and innovation management, and economics are: *Research Policy, Technovation, International Journal of Innovation Management, Technology Analysis and Strategic Management, R&D Management, Industry and Innovation, Journal of Product Innovation Management, European Journal of Innovation Management.*

## Selected further reading

Britnell M (2015) *In Search of the Perfect Health System.* United Kingdom: Palgrave.

Howitt P, Darzi A, Yang G-Z, Ashrafian H, Atun R, Barlow J, *et al.* (2012) Technologies for global health. *The Lancet Commissions.* http://dx.doi.org/10.1016/S0140-6736(12)61127-1

CHAPTER 02

# TECHNOLOGY AND INNOVATION MANAGEMENT: THE NUTS AND BOLTS

**THIS CHAPTER WILL HELP YOU TO:**

- Understand what we mean by technology.
- Understand the nature of innovation and be able to distinguish between invention and innovation.
- Distinguish between the different forms that innovation can take, such as product, process and service innovation.
- Distinguish between different types of innovation such as radical and incremental innovation.
- Understand the links between innovation and technology performance improvement.
- Describe the main activities associated with innovation.
- Understand the ways in which innovations are adopted and diffused.

*Both in research and in popular imagination, 'technology' and 'innovation' are often seen as something related to new products coming out of creative companies. Words like 'R&D', 'entrepreneurship', 'competitiveness' — and faster, better, cheaper products — are all conjured up in our minds when we talk about innovation. But what do we actually mean when we think of technology and innovation? It is important to have a grounding in the core concepts from the extremely large and diverse literature on technology and innovation management if we are to understand how they can be applied to the healthcare sector.*

*Fundamentally innovation is both an outcome and a process. It involves the act of turning an idea or invention into something that can be sold to customers or somehow made practical use of. Lewis Duncan, former Dean of Engineering at Dartmouth University, succinctly described innovation as 'the ability to convert ideas into invoices.' Innovation is also sometimes associated with individuals who have particular characteristics — inventors, entrepreneurs, risk takers. Taking a risk and failing is seen as an essential part both of the innovation process and entrepreneurship. Many commentators believe that to successfully innovate it is necessary to take risks, make mistakes and occasionally fail.*

*There is a wealth of research and experience on managing technology and innovation. This chapter discusses the nuts and bolts — the most important lessons that provide insight into how innovation works. Most of the research and debate about technology and innovation management has been rooted in the manufacturing and service sectors. We pick up the reasons why these lessons cannot always be directly applied to healthcare in the rest of the book. But lessons from other sectors of the economy are still very useful for pointing us towards explanations for particular innovation phenomena in healthcare. As you read this chapter, bear in mind the reasons why healthcare is different from manufacturing and service industries, summarised in Box 2.1 — Chapter 3 discusses them in more detail. Let us start with some definitions.*

**Box 2.1 SUMMARY: Some reasons why innovation processes in healthcare might be different from other sectors**

- Healthcare is a system and it is very complex — there are many organisations involved, with many professional and financial silos and entrenched cultures.
- Healthcare is always evolving because of constant change in its underlying science and the development of new technologies, and because policymakers like to tinker with its funding and institutional arrangements.
- Healthcare is heavily regulated — 'taking a risk' by trying out something new does not necessarily go down well with healthcare managers, politicians or patients.
- Healthcare is usually highly politicised — for instance we may know that the most rational option to improve services might be to close a hospital or hospital department that is no longer needed, but this is almost guaranteed to result in angry voters and anxious politicians.



## What is 'technology'?

The term 'technology' tends to be closely associated with 'innovation'. We talk of firms introducing a new technology in the same way that we talk of firms being innovative. But technology and innovation are not the same. It is important to develop a working understanding of technology and its various dimensions. Most writers come to the conclusion that technology is a slippery concept (Roberts and Grabowski, 1996; Orlikowski, 1992). The consensus is that technology is concerned with the application of knowledge to solve problems. Mitcham (1994) argues that technology has four dimensions: knowledge, activity, objects and volition. Some define it very broadly. For example, Schon (1967) described technology as 'Any tool or technique: any product or process, any physical equipment or method of doing or making by which human capability is extended.' An early edition of the OECD's *Oslo Manual* (on the measurement of scientific and technological activities) suggests that technology is 'the whole complex of knowledge, skills, routines, competence, equipment, and engineering practice' (OECD/EUROSTAT, 2005).

> "*By aggregating task, technique, knowledge, and tools into a single construct — technology — interaction among these constituting components and with humans is ignored. For example, we cannot examine how different assumptions, knowledge, and techniques can be embedded in different kinds of artefacts or practices, and how these have differential consequences for human action and cognition.*"
> (Orlikowski, 1992)

Such definitions have been criticised because of their breadth. Orlikowski (1992) argues that this makes it hard to distinguish the relative impact of new knowledge, physical artefacts or practices. There are also concerns that the words 'technological' and 'technology' are imbued with particular meanings that are associated with physical, manufactured products. These may not be appropriate when used in relation to the study of innovation because many people interpret the word 'technological' to mean 'using high-technology plant and equipment', and thus something that is not applicable to service or process innovations (OECD/EUROSTAT, 2005).

For our purposes, there are some important points to extract from these discussion about technology.

## *Hard and soft technologies*

A distinction is usually made between *hard* technology, tangible artefacts such as computers or mobile phones, and *soft* technology, the knowledge about how those artefacts work (Swamidass and Nair, 2004). Soft technology is defined by Bessant and Francis (2005) as 'systems of thought, practice, and action that facilitate the achievement of explicit aims' — in other words, soft technology enables the application of hard technology to a problem. Orlikowski (1992) argues that a particular technology will be inscribed with ways of working that reflect individual values, world views, and organisational procedures and processes. How we understand a technology such as some software may therefore be heavily influenced by the knowledge encoded within it (Kogut and Zander, 1992; Blackler 1995; Fernandes and Melo Mendes, 2003).

There is a large literature on the relationship between knowledge and technology and innovation. This focuses on questions such as how 'explicit', 'tacit' or 'situated' it is, whether it is 'codified' or 'embodied', what capabilities organisations need to select, adopt or abandon technology, or support performance improvement (Box 2.2). Some knowledge — such as software to operate a device — is explicit, but tacit or situated knowledge may also be present and will influence its adoption and use (Suchman, 1987). This type of knowledge develops as the result of learning about a technology as it is used in a specific context, and is therefore hard to capture or transfer to another individual or context or organisation (Lave and Wenger, 1991; Sole and Edmondson, 2002).

### Box 2.2 CONCEPTS: Types of knowledge

- **Explicit knowledge** can be readily articulated, codified and accessed.
- **Tacit knowledge** is the opposite of explicit knowledge; it cannot be adequately articulated by verbal means.
- **Codified knowledge** is tacit knowledge converted to explicit knowledge in a usable form.
- **Embodied knowledge** is the routines, habits, tasks, and information we understand without conscious thought.
- **Situated knowledge** is knowledge affected by the history, language, and values of the person knowing it.



*"The tools themselves are not the technology; it is the use to which they have been put that marks them out as a technology, and it is people who do the putting to some use for some purpose."* (Teich, 2003)

It is important to recognise that hard and soft technologies are not simply two ends of a continuum with physical artefacts at one end and intangible artefacts at the other. They are distinct types of technological entity, but entities which are bound together to a greater or lesser extent. An important implication of this is that human agency influences our actions and understanding of technology. We use technology both in a habitual and unconscious, and in a planned and deliberative way. We also make strategic choices about the application of technology and its future development. In short, we affect the way technology is used and evolves, and thus the factors that enable or inhibit technological innovation. The consensus is that technologies are not neutral in how they relate to both human agency and to the institutions in a society.

Researchers therefore suggest that technology forms part of a 'socio-technical system' — a system where people, organisations, institutions, and technologies interact (Trist, 1981; Teich, 2003) — and its role is subject to processes of 'social construction', where understandings of the world and shared assumptions about reality are jointly constructed by individuals (Orlikowski, 1992). It cannot be treated as a given (Weick, 2001), nor can its implementation be viewed in a deterministic fashion (see below). Many have studied how technology is 'socially constructed' (e.g. Bijker *et al.*, 1987; Bijker, 1995; Garud and Rappa, 1994). This highlights the way meanings associated with diverse technologies affects their development — for example, trade-offs made between traction, speed, and aesthetics influenced the bicycle tyre.

➔*Go to Chapter 5 to find out more about how this can make it hard to gather and interpret evidence about the impact of some kinds of healthcare innovation*

As we will see in later chapters, these distinctions about hard and soft technology and the nature of knowledge are important for understanding why innovation processes in healthcare are different from other sectors of the economy. In particular, healthcare technology cannot be defined solely in terms of physical artefacts. Its power lies in the soft knowledge associated with technology — in the skills and techniques involved and how these are put to use. This knowledge is adaptable to specific conditions — customised around the needs of individual patients and the local organisational context, such as a specific hospital in a particular national health system. It is also subject to evolution because of the reflexive nature of healthcare professions (i.e. practitioners learn from experience about themselves and their work). It may therefore be shaped by a process of social construction. This is why the implementation and impact of healthcare technology and healthcare innovation can be both challenging and unpredictable.

## Technology determinism

While the implementation of technology cannot be treated deterministically, technology nevertheless has some deterministic qualities, in the sense that once it has started it may not be easy to reverse a particular technology trajectory. The internal combustion engine, developed in the late 19th century, still shapes the motor vehicle industry in the 21st century. A wholly new infrastructure of charging stations and battery recycling needs to be created to support electric vehicles. The continued use of the QWERTY arrangement on keyboards — not necessarily the most efficient for English speakers — is another well-known example (David, 1985).

> "*Technology is built and used within certain social and historical circumstances and its form and functioning will bear the imprint of these conditions.*" (Orlikowski, 1992)

Because technology is socially constructed and forms part of a wider socio-technical system, it is therefore important to recognise that there is nothing inevitable about a technological trajectory. This applies as much to a technology's general direction of travel as it does to the relationship between a technology and society, since there is no guarantee that it will be adopted or its use will result in a specific outcome (Barley, 1986; Edgerton, 1999). How a technology is currently configured — its hard and soft elements, and the assumptions, values and knowledge that are embedded within it — is therefore closely shaped by its starting point and subsequent historical evolution (Clark, 1985).



A technology or technology system will therefore embody legacy elements as well as features associated with contemporary influences. Morison (1966) describes how old practices — soft technology — were embodied in contemporary artillery — hard technology — during the Second World War in the form of a short pause before firing: a routine introduced in the past to 'hold the horses' was followed without question, despite the very different circumstances of modern warfare.

## Why we need to be more precise in our definitions of 'innovation'

> "*Innovation is 'an idea, practice, or object that is perceived as new by an individual or other unit of adoption'.*" (Rogers, 2003)

> "*Innovation is 'the process of bringing inventions into use'.*" (Schon, 1967)

The term 'innovation' is overloaded with meaning. It can refer to an *outcome* — we often implicitly use it in relation to physical objects or products — and it can refer to the *processes* by which these are developed. The outcomes of innovation can be physical objects, but new services or business models can also be described as innovations — the new business model of a low cost airline, for example. Viewing innovation as a discrete product is often characteristic of the research literature on adoption, while viewing it as a process is more associated with research on implementation (Rye and Kimberly, 2007). As we will see later, in healthcare this separation can be somewhat artificial.

Until relatively recently business model or service innovation was generally overlooked in research, debate and teaching. Although things have improved, arguably there is still an overemphasis on the aspects of innovation that relate to the creation of new products and bringing them to a commercial market. There remains relatively little work on public sector innovation, the development and application of new ideas in a non-commercial setting. This is important because much of the provision of healthcare lies in the not-for-profit or public sector, even if the pharmaceutical, medical devices and other companies that supply its inputs are in the private sector.

**Box 2.3 CONCEPTS: Defining innovation**

Department of Trade and Industry, UK, definition of innovation (DTI, 2004):

- The action or process of innovating.
- A new method, idea, product.
- The successful exploitation of new ideas.

Some other definitions:

- 'Anything that creates new resources, processes or values, or improves a company's existing resources, processes or values' (Christensen *et al.*, 2004).
- 'The effort to create purposeful, focused change in an enterprise's economic or social potential' (Drucker, 1985).
- 'Innovation is a slow process of accretion, building small insight upon interesting fact upon tried-and-true process' (Rae-Dupree, 2008).
- 'Innovation is … a new patterning of our experiences of being together, as new meaning emerges from ordinary, everyday work conversations … a challenging, exciting process of participating with others in the evolution of work' (Fonseca, 2002).

Innovation has both a *creative* dimension (often described as 'invention') and a *commercial* or *practical* dimension that involves the exploitation of the invention. Only when both these dimensions are effectively managed does one have an innovation. It is therefore important not to confuse innovation and invention — they are related, but they are not the same. Many ideas fail to make it beyond the invention stage. The pathway to adoption can be long and hard. And even when a decision to adopt has been made, implementation into everyday practice and diffusion across a population can be hard. Perhaps nowhere is this more the case than in healthcare.

Can we be more robust and analytical in how we categorise innovations? This is important because the influence of technology can differ enormously depending on whether it changes *individual components* of a product (or service or business model), or *whole systems* of components, such as the shift from analogue to digital telephones. If we want to better understand the evolutionary process associated with innovation — how



**Box 2.4 SUMMARY: Defining innovation — the key points**

- *New ideas* — a new (or improved) product, process or service, or a whole new business or business model.
- *Exploitation* — the idea must be implementable and potentially value generating (i.e. innovation = invention + exploitation).
- *Successful* — the innovation is adopted by the target audience.
- '*New*' is a relative term — it can mean 'new to the world', 'new to the market' or 'new to the firm'.

A strict definition of the term 'innovation' might restrict its use to first-of-a-kind breakthroughs (e.g. the jet engine), but it also commonly used in connection with more modest incremental improvements to existing innovations.

*Source*: University of Cambridge Institute for Manufacturing.

innovation might change a product or service in the future — we need to make judgments about the degree of technological change embodied in that product or service.

Innovations (rather than the innovation process itself) have been categorised in various ways. One distinction is according to where the demand for the innovation is originating — is it *pushed* by the developers of a new technology or service, where there was previously no demand, such as the e-book. Or it is *pulled* by some kind of expressed demand, perhaps the need to reduce production costs or address a safety or quality issue. In practice, innovation is rarely a simple matter of 'push' or 'pull'. It tends to result from an interaction between the two, in which innovators simultaneously create ('push') new possibilities and at the same time identify evolving consumer or other needs ('pull') (Tidd and Bessant, 2014). For innovators, it is important to maintain a balance between keeping an eye on the market to ensure that their good ideas are actually potential innovations that people might want, and ensuring they are not so close to the market and its short term demands that they are blinkered in their search for truly radical ideas.

Another distinction that is often made is between '*incremental*' and '*radical*' innovation. For much of the time innovation is about exploiting and elaborating ideas, creating variations on a theme within an established technical or market trajectory (Tidd and Bessant, 2014). Occasionally, however, breakthroughs occur, creating a new technology trajectory, at which point the cycle repeats itself.

For our purposes, it is sufficient to classify innovations in three ways, according to:

- their *scope*, i.e. their degree of novelty (how new they are),
- their *form* or *application* (whether they are product, process, service) and
- their *innovativeness* (how much change there is in their components, compared to the current norm).

## *Scope: how new is new?*

How we conceptualise the relationship between innovation and newness is essentially a question of judgement. Whether something is new or not depends on someone's perception of 'newness'. The perspective in innovation research is often that of the adopter. Novelty is seen in relation to the perception of adopters, whether they are individuals, companies or other kinds of organisation. An innovative product or process may already be in existence elsewhere. But its novelty may be in relation to a particular industry sector or a technology ecosystem such as a national healthcare service. Thus a new drug could be an innovation in one health system but not in another, where it is already widely used.

The definition of 'newness' can be subtle. One meaning of newness used in the innovation literature is 'differentness', the extent of departure from the *status quo*. Often this refers to some form of embodied knowledge, such as a prevailing technological norm or an external standard such as commonly accepted 'best practice' (Rye and Kimberly, 2007) (see Box 2.5). Thus medical innovation has been defined as a significant departure from previous techniques in a field, as determined by the collective judgments of experts (Meyer and Goes, 1988). Another definition of newness relates to 'recency', either the actual or perceived time that something has been in the world (Rye and Kimberly, 2007).

A well-known model is that of Cooper (2001), who classified innovations according to the degree to which they are *new to a market* or *new to*



**Box 2.5 CONCEPTS: The ambiguity of 'newness' and 'differentness'**

In their systematic review of the literature on healthcare innovation adoption, Rye and Kimberly (2007) argue that researchers are often rather casual in their use of alternative definitions of 'newness'. This is a problem because how we view newness influences both the definition of an external standard and the perceptions of potential adopters. They describe various options in a simple table:

| | | **External standard** | |
|---|---|---|---|
| | | **Innovation** | **Not an innovation** |
| **Adopter perceptions:** | **Innovation** | 1. Innovation | 2. *Ambiguity* |
| | **Not an innovation** | 3. *Ambiguity* | 4. Not an innovation |

In cell 1, there is clearly 'innovation' both in terms of adopter perceptions and external standards, but it is unclear whether this is because the innovation is novel in relation to an external standard, novel in relation to the adopter's perception, or a mix of these. Conversely, in cell 4, we can say that something is not an innovation but we cannot say precisely why. And there is more ambiguity when, for example, something is not an innovation from the perspective of an adopter but it is innovative in relation to an external standard (or vice versa). Rye and Kimberly argue that:

'The distinctions between definitions of innovation extend well beyond the level of semantics … (They) reveal often deep-seated differences in the fundamental assumptions and viewpoints of researchers, differences that influence the character of research questions and analyses.'

We therefore need to be cautious when comparing the results of innovation adoption studies, because they may be talking about quite different things. It is important to identify clear boundaries between different types of study, because they may be built on quite different conceptualisations of innovation.

*a company* operating in the market. A new product line may be new to a particular company, requiring it to engage internally in innovative development, but for other companies that product may already be well established. Or a company may develop an old product to reposition it, creating

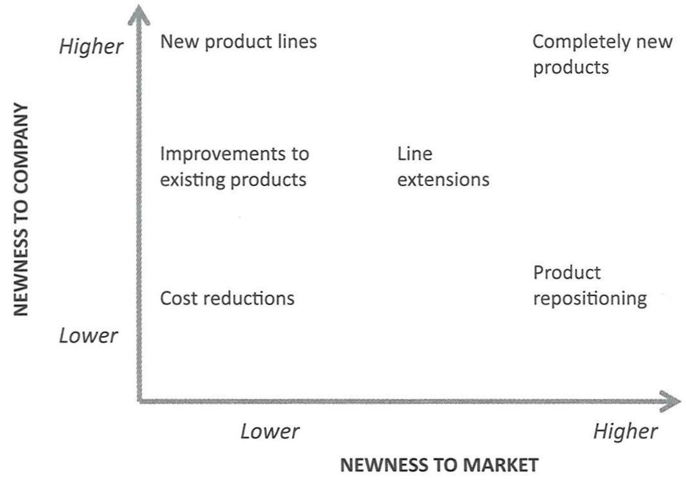


*Figure 2.1.* *Innovation 'newness'.*

*Source*: Cooper (2001).

something new to the market, for example the repositioning of the drink Lucozade from something for people convalescing from illness to an energy drink for the growing fitness market. Really innovative products (or services) are new both to companies and markets. According to Cooper (2013), since the 1990s improvements and modifications to existing products — 'incremental innovations' — have grown substantially at the expense of innovations those are new to the world and new to the market (see Figure 2.1).

Freel and de Jong (2009) categorise innovations according to the *novelty of innovation outcomes* and the extent to which innovation activities mean an organisation or company has to *acquire new capabilities* — expertise, equipment or knowledge. An innovation that is new to a firm but not to the market may simply require enhancement in its capabilities and competence; radical innovations are not only new to the market but also require a firm to develop completely new capabilities (Figure 2.2).



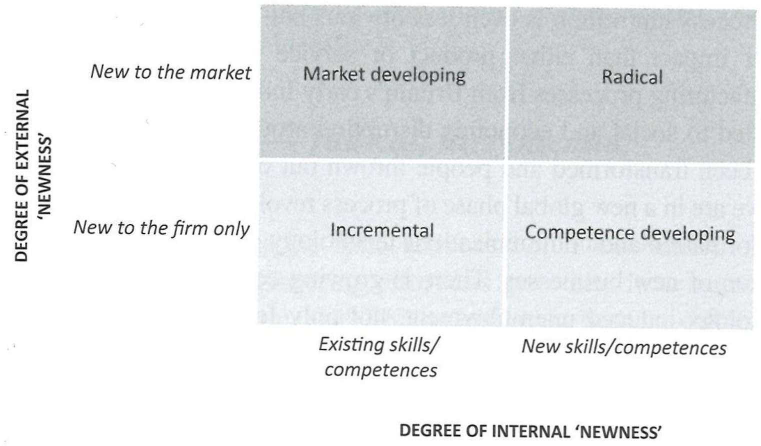


*Figure 2.2.* *'Newness' in relation to company-level capabilities.*

*Source*: Freel and de Jong (2009).

## *Form: product, process or service?*

We can also look at the *form* of an innovation. The three principal forms of innovation are:

- Products — tangible physical objects (e.g. mobile phone) that are acquired and then used by consumers.
- Services — intangible things (e.g. banking, education, and healthcare), where the consumer benefits from the service, but does not actually acquire an object.
- Processes — the equipment, methods, systems used by producers of products or services.

Service innovations are often overlooked because they may be less eye-catching. The public imagination tends to identify with inventions and tangible products, but service innovations also have a huge impact on our lives — think FaceBook, ebay, Google. Service innovation can be subtle, emerging incrementally through the development of individual skills or collaborative relationships between organisations (Tether, 2005).

Process innovation is even less obvious but in the long run may have a bigger impact than either product or service innovation. Innovations in manufacturing processes from Britain's early Industrial Revolution onwards have led to social and economic disruption around the world, as industries have been transformed and people thrown out of work. Some have argued that we are in a new global phase of process revolution because of the impact of information and communications technology on business models and the creation of new businesses. There is growing concern over the prospect of technology-induced unemployment, not only for lower-skilled jobs in the manufacturing and services sectors but increasingly amongst parts of the professional workforce such as accountancy or law.

It has been argued that products or industries typically display lifecycles where the emphasis of innovation shifts between products or processes at different stages. William Abernathy and James Utterback (1975) developed a model in which the early stages are marked by an emphasis on product innovation and uncertainty. After some time, a 'dominant design' becomes established, which matches the market's needs and aspirations but may not be the best design in technical terms (in other words, creating a particular technology trajectory — see above). The emphasis then shifts from the product or product variety towards process innovation, improving manufacturing processes to deliver volume and consistent quality at the right price. Finally, a mature phase emerges, characterised by incremental innovation in both product and process, and extensive competition with other firms. Further breakthroughs eventually return the cycle to its fluid stage again and then moves forwards. From the perspective of companies seeking competitive advantage, this model means that the emphasis of their effort should be on searching for radical product innovation ideas in the early fluid phase and incremental improvements in the mature stage. However, disruption can occur in this stage as incumbent companies' products are displaced by cheaper versions by competitors.

➔*Chapter 6 discusses how disruptive innovation is impacting on the healthcare workforce and on incumbent companies*

The idea that innovations involve technology 'push' and 'pull' stimuli is also associated with this perspective. The focus of mature industries tends to be on pull as they respond to different market needs and try to differentiate themselves by incremental innovation. New industries, on the



other hand, are often dominated by push stimuli, sometimes described as 'solutions looking for a problem'.

## *Types of innovation — radical, incremental and others*

We also need to think about the 'innovativeness' of an innovation — how much R&D, design or engineering effort has gone into its creation and how does this affect performance? This is important because differences in the rate of performance change are partly related to the way innovation takes place, with implications for the kind of capabilities companies and organisations need to acquire as cycles of innovation unfold.

Rebecca Henderson and Kim Clark (1990) draw on the concepts of dominant design and the idea that different kinds of innovations can

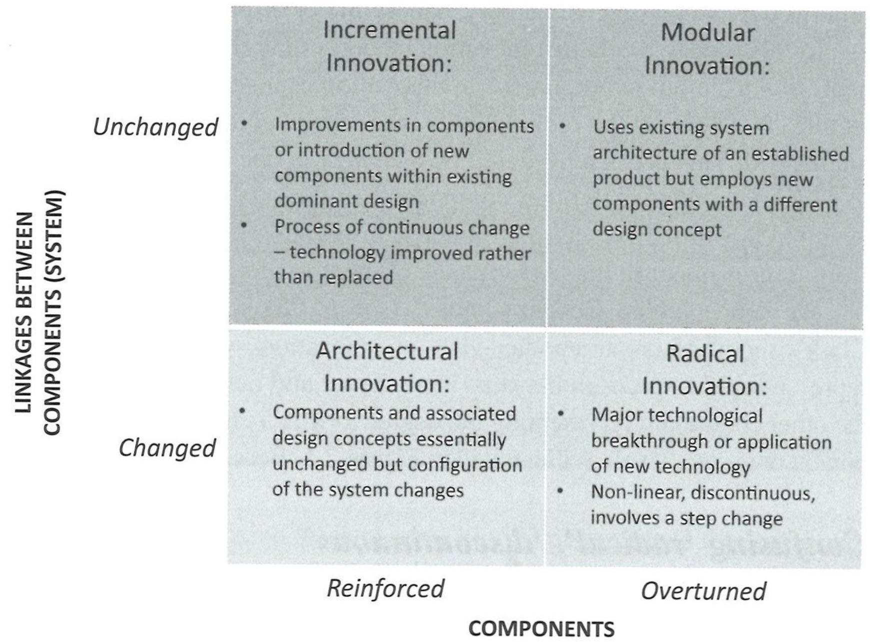


*Figure 2.3. Types of innovation.*
*Source*: Henderson and Clark (1990).

be characterised in terms of their impact on the established capabilities of the firm. They outline a model with two dimensions. One captures the impact of innovation on the knowledge underlying the components of a product (or a service or process); the other captures its impact on the linkages between these components, i.e. the 'architectural' knowledge about the way components are linked together to make the product work. Four types of innovation are therefore possible, shown in Figure 2.3, with *radical* and *incremental* innovation representing extreme points in the innovation space. According to Henderson and Clark radical innovation establishes a new dominant design and, hence, a new set of core design concepts embodied in the components that are linked together in a new architecture. The shift from a portable cassette player such as the Sony Walkman to an MP3 player or an iPod is one example. Incremental innovation, on the other hand, refines and extends an established design. Improvement occurs in individual components, but the underlying core concepts, and the links between them, remain the same. So, once introduced, the MP3 player or IPod is subsequently improved by increasing its memory, battery life or display quality.

In this model, *modular* innovation changes only the core design concepts of a technology. *Architectural* innovation changes a product's architecture but leaves the components and their core design concepts unchanged. This is often triggered by a change in one component leading to new interactions with other components in the established product, for example the shift from ceiling mounted to portable fans, which resulted from improvement in the performance of electric motors and blades.

We can combine Cooper's model (see p. 28) with Henderson and Clark's model to create another view of innovation, with one continuum representing the spectrum between incremental and radical innovation and the other continuum representing the degree to which changes are at a component or system level, as illustrated in Figure 2.4 (Bessant and Tidd, 2007).

## *Confusing 'radical', 'discontinuous' and 'disruptive' innovation*

There is often confusion about the terms that are used to describe more radical types of innovation. The terms 'discontinuous', 'radical' and 'disruptive' innovation are often used interchangeably. While *continuous* innovation improves but preserves the current way of doing things,



| | | | |
|---|---|---|---|
| **SYSTEM LEVEL** | New versions of an existing product | New generations of a product, e.g. shift from cassette player to MP3 player | A new paradigm, e.g. steam power, biotechnology |
| **COMPONENT LEVEL** | Improvements to components | New components for existing systems | Advanced materials to improve components of a product |
| | **INCREMENTAL ('DOING WHAT WE DO BETTER')** | **'NEW TO THE ENTERPRISE'** | **RADICAL ('NEW TO THE WORLD')** |

*Figure 2.4. Another classification of innovations.*

*Source*: Bessant and Tidd (2007).

**Box 2.6 CONCEPTS: Definition of discontinuous innovation**

Discontinuous innovations cause a paradigm shift in science or technology and/or the market structure of an industry. As they are entirely new-to-the world products, made to perform a function for which no product has previously existed, discontinuous innovation requires a good deal of learning for the incumbent organisation and its value network, including the user. Discontinuous innovations disrupt established routine and may even require a very different set of capabilities and new behaviour patterns. The notion of novelty is relative so a discontinuous innovation for one organisation might be an incremental one for another. Radical innovation and discontinuous innovation are used synonymously. Disruptive innovation used to be a synonym until 1997. Since then the term has been strongly associated with Christensen's model. Incremental innovation is the opposite of radical innovation.

*Source*: http://lexicon.ft.com/Term?term=discontinuous-innovation

*discontinuous* innovation leads to some kind of disruption to the *status quo* (Tushman and Anderson, 1986). Radical and discontinuous innovations are essentially synonymous and describe a significant degree of change over the existing technology. But the term 'disruptive' innovation is also sometimes used interchangeably with radical innovation. The *Financial Times* has produced a simple primer, in Box 2.6. We discuss the notion of 'disruptive innovation' in detail in Chapter 6.

## *The origins of innovation — lead users and open innovation*

The role played by the users of a technology (the 'end users') in its innovation processes has been widely explored. There are a number of different models by which users and companies engage with each other in the development and commercialisation of new products. Just as we can characterise an innovation according to its various functional attributes or degree of newness, we can also characterise it according to the processes by which it came about.

One way of doing this is to think about role end-users play in the innovation development process and the level of *openness* there is in sharing knowledge about the innovation as it is being developed, i.e. how freely the innovators reveal their intellectual property (IP). Figure 2.5 categorises different models on this basis, showing how there are different forms of innovation ranging from traditional supplier-centred, technology push models where the knowledge underpinning an innovation is either generated internally or acquired externally, through more user-centred

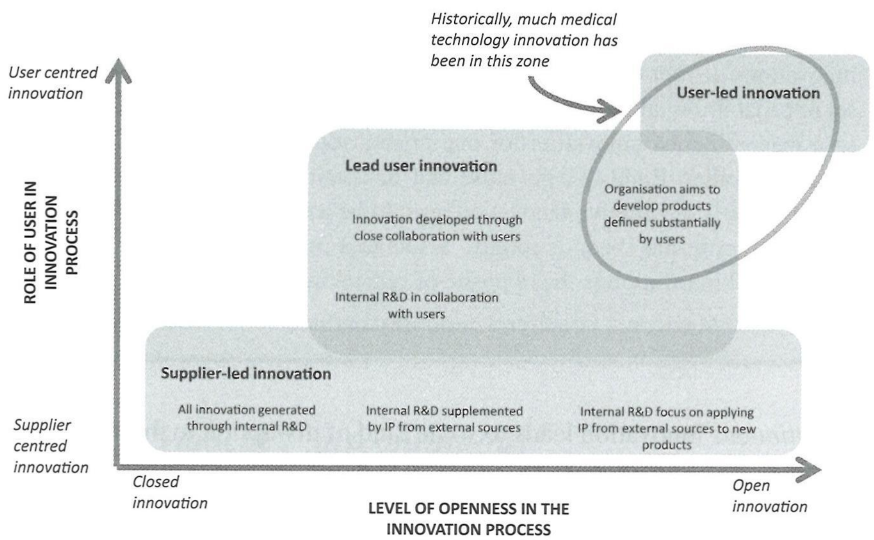


*Figure 2.5. Differentiating supplier-led, lead-user and user-led innovation.*
*Source*: Based on Savory (2009a).



models where 'lead-users' are important contributors to the innovation process, to 'open innovation' models in which users take on the prominent role in creating and developing an innovation.

Lead users are defined by Von Hippel (2005) as members of a user population who experience needs — ahead of mainstream users — that will eventually become the norm and who anticipate significant benefits from obtaining a solution to their needs. Lead users are potentially important to companies because they can provide input into the development of innovations. The difference between lead user innovation and more open or user-led models lies in who controls the development and sales process, which remains with the innovating company in the lead user case.

Another type of user needs pull is the idea of 'extreme environments' as sources of innovation. Roy Rothwell and Paul Gardiner described how 'tough customers mean good designs' (Gardiner and Rothwell, 1985), meaning that the needs of extreme environments or problems drive innovators to come up with cutting-edge ideas and radical innovations. Originally this was applied to advanced technological solutions to problems such as the need to create a radar-invisible military aircraft. More recently, the concept has overlapped with the notion of 'disruptive' and 'frugal innovation' to provide cheaper, simpler solutions to segments of a market previously not catered for, perhaps through novel business models for the 'bottom of the pyramid' population.

➔*Go to Chapter 6 to find out more about frugal innovation in healthcare*

Different aspects of this area of research on innovation processes were brought together in the late 1980s by Henry Chesbrough into a model of open innovation (Chesbrough, 2003). The concept rejects the assumption that innovation only stems from an organisation's internal R&D capacity. Rather, some companies seek innovative ideas from outside, taking them on to develop and bring to the market, or sometimes selling on for another party to exploit them (Lichtenthaler, 2010). The emphasis in open innovation is on combining these internal and external ideas in order to advance the development of new technologies. This requires the power of actual and potential users to be harnessed to an organisation's own resources.

Essentially open innovation breaks the traditional technology-push paradigm of innovation development. While technology-push may still be the dominant model in many sectors, including much of healthcare, user-driven models have always been significant and open innovation is seen as an increasingly important way of generating new ideas. Some have described the shift towards open innovation as a 'democratisation' of innovation (Von Hippel, 2005) — the end-users of a product are active in its innovation process, often collaborating in communities (now assisted by social networking tools) and prepared to freely reveal their innovations.

➔ *Chapter 4 discusses open and other user-led innovation models in healthcare*

Open innovation has been criticised for being a rather vague and prescriptive concept, and there is a lack of robust academic research on its benefits (Tidd and Bessant, 2014). While it emphasises that firms should acquire knowledge or other innovation resources from external parties, and share their own internal resources with them, when and how a firm should do this is less clear. User-innovators can be reluctant to relinquish control of their innovation projects when additional skills need to be brought in. However, if it is left too late development may have gone too far down the wrong track; too early and the innovator risks giving away their IP. Various benefits and challenges for companies embarking on an open innovation strategy are described in Table 2.1.

### Box 2.7 CONCEPTS: Chesbrough's principles of open innovation

- Not all the smart people work for you.
- External ideas can help create value, but it takes internal R&D to claim a portion of that value for you.
- It is better to build a better business model than to get to market first.
- If you make the best use of internal and external ideas, you will win.
- Not only should you profit from others' use of your IP, you should also buy others' IP whenever it advances your own business model.
- You should expand the role of R&D to include both knowledge generation, and knowledge brokering.



*Table 2.1. Potential benefits and challenges of applying open innovation.*

| Six principles of open innovation | Potential benefits | Application challenges |
|---|---|---|
| Tap into external knowledge. | Increase the pool of knowledge. Reduce reliance on limited internal knowledge. | How to search for and identify relevant knowledge sources. How to share or transfer such knowledge, especially tacit and systematic. |
| External R&D has significant value. | Can reduce the cost and uncertainty associated with internal R&D and increase depth and breadth of R&D. | Less likely to lead to distinctive capabilities and more difficult to differentiate. External R&D also available to competitors. |
| Do not have to originate research in order to profit from it. | Reduce costs of internal R&D, more resources on external strategies and relationships. | Need sufficient R&D capacity in order to identify, evaluate and adapt external R&D. |
| Building a better business model is superior to being first in the market. | Greater emphasis on capturing rather than creating value. | First mover advantages depend on technology and market context. Developing a business model demands time consuming negotiation with other actors. |
| Best use of internal and external ideas not generation of ideas. | Better balance of resources to search and identify ideas rather than generate them. | Generating ideas is only a small part of the innovation process. Most ideas unproven or no value so cost of evaluation and development high. |
| Profit from others' IP (inbound open innovation) and others user our IP (outbound open innovation). | Value of IP very sensitive to complementary capabilities such as brand, sales network, production, logistics and complimentary products and services. | Conflicts of commercial interest or strategic direction. Negotiation of acceptable forms or terms of IP licenses. |

*Source:* Tidd and Bessant (2014).

## Technology, innovation and performance improvement

Usually the performance of a product improves and unit costs fall over time. We have all experienced this with consumer goods such as laptops, tablets or mobile phones. But forecasting the future impact of innovation is often hard. We may only have limited knowledge about the rate of change in an innovation, which parameters or components are changing, or whether the effects are specific to the product or system-wide. More broadly, it is hard to accurately appraise the future because the external environment of a particular industry may be highly complex and fast changing, driven by technical, economic, social and political change.

Using 'Delphi' panels and scenario building are two approaches to exploring technological futures. We can also use historical data to tell us how a particular trend evolved in the past and extrapolate it to help guide us on its possible future evolution, or we can use heuristics — simple mental models of a phenomenon. One well-known example in innovation research is the *performance 'S curve'* (not to be confused with the *adoption and diffusion S curve*, discussed below, p. 56). Richard Foster (1986) argues that the performance of a product typically grows slowly in its early stages then speeds up before finally tailing off (Figure 2.6). This is the result of increasing, then declining, R&D productivity within a given innovation architecture. The shape of the curve implies that significant effort is needed during the early stages, but once this learning has been achieved, performance can improve with marginal effort. For some industries or products there may then be a breakthrough to a new curve, as radical innovation completely changes the innovation architecture. In other words, there is a discontinuity between the old and new

> "*Those who have knowledge, don't predict. Those who predict, don't have knowledge.*"
> (Lao Tzu, 6th century BC philosopher and poet from ancient China.)

> "*There are two classes of people who tell us what is going to happen in the future – those who don't know, and those who don't know they don't know.*"
> (John Kenneth Galbraith, economist, Wall Street Journal, 22 January 1993.)



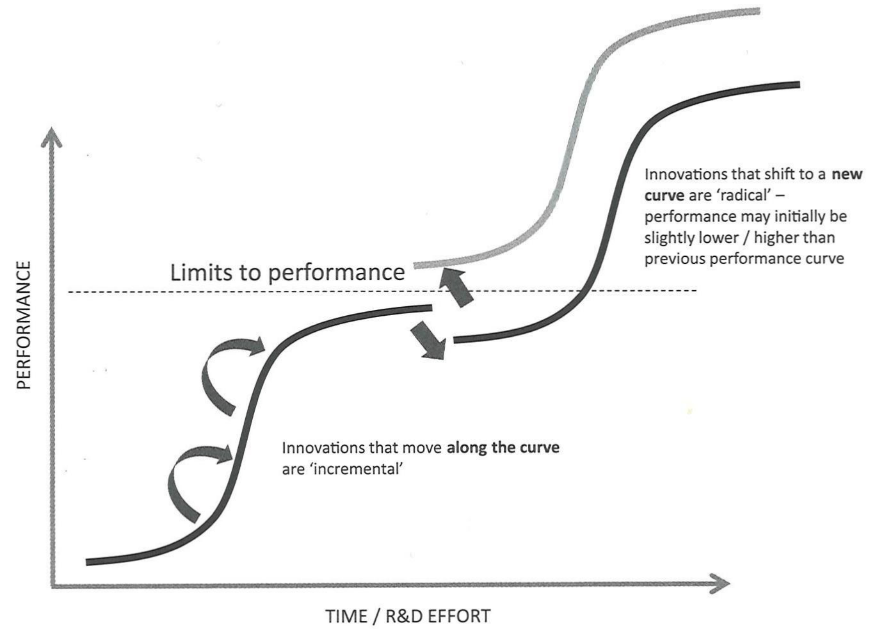


*Figure 2.6. Foster's performance S curve.*

curves. Understanding the nature of S curves gives us an insight into the competitive dynamics in a particular industry or technology sector. For example, in his book *The Innovator's Dilemma*, Clayton Christensen discusses how each successive computer hard drive industry was wiped out by the introduction of new technology platforms (Christensen, 1997).

This S curve model therefore helps us to assess where a technology is in its likely lifecycle and provides an indication of industry maturity. It is, however, simply a generalisation of an observed pattern of changing performance — in reality the shape of the curve can vary considerably and we cannot infer how great the future gains are likely to be or when and how a discontinuity (i.e. radical shift) may take place. Nevertheless, performance S curves have been observed in many industries and for many technologies (e.g. Asthana, 1995).

➔ *We return to this when we look at the pharmaceutical industry in Chapter 4.*

## Innovation as a process: invention, commercialisation, diffusion

The process of innovation has commonly been divided into three stages, known as 'the Schumpeterian trilogy' after the economist Joseph Schumpeter:

- The *invention phase*, where ideas are turned into workable inventions, is typically characterised by experimentation to prove the concept. Incremental innovations may involve little or no experimentation but nevertheless require a considerable amount of technical development. Much effort has gone into improving the life of mobile phone or laptop batteries as these devices have grown ever-more power hungry.
- The technological potential of an invention has to be transformed into economic value. *Commercialisation* is where the latent value of a technology is unlocked in order to generate real value. There may be many possible ways to commercialise an idea, but only a few are likely to succeed. Today the term 'commercialisation' is often used synonymously with the concept of 'business models', which are essentially enabling devices to allow inventors to profit from their ideas (Chesbrough, 2006).
- *Adoption and diffusion* is the process by which innovations are taken-up and spread through a population. This rarely takes place at a steady, linear rate. If the adoption of an innovative product is plotted over time, it frequently exhibits an S shaped curve, not to be confused with Foster's performance S curve. We come back to the adoption and diffusion curve below, p. 56.

"*... inventiveness should not be equated with the development of novel artefacts, or indeed with novelty and innovation in general. Rather, inventiveness can be viewed as an index of the degree to which an object or practice is associated with opening up possibilities ... What is inventive is not the novelty of artefacts and devices in themselves, but the novelty of the arrangements with other objects and activities within which artefacts and instruments are situated, and might be situated in the future.*"
(Barry, 2001)



The distinction between these phases emphasises the point that successful innovation requires the entire process from invention to diffusion to be carried out. An invention is merely a nascent innovation and it may be many years before it makes it to innovation status. Equally, a nascent innovation may never make it — it may simply remain as a patented technology that is never commercialised. Failure may occur even after adoption as the implications of the innovation are more fully understood. Drugs where previously unforeseen side effects only emerge after widespread use are an example. These 'failed innovations' are rarely studied (Hadjimanolis, 2003).

"*When innovation work begins, the process does not unfold in a simple linear sequence of stages and sub-stages, Instead, it proliferates into complex bundles of innovation ideas and divergent pathways of activities by different organisational units...the process diverges into multiple, parallel, and interdependent paths of activities.*"
(Van de Ven, 1999)

There are weaknesses in this way of characterising the innovation process. In particular, the Schumpeterian trilogy has been criticised because it is seen as too linear. However, linear models are widely used by policy-makers, the business community and academics as a basic blueprint for technological innovation activities because of their simplicity (Godin, 2006). And clearly defined innovation strategies in companies — such as those relating to new product development (Cooper, 2000; Cooper *et al.*, 2000) or the development of new drugs (Northrup *et al.*, 2012) — generally make use of at least some aspects of linear innovation models.

➔*We see how important this is in healthcare especially in Chapters 5 and 7.*

Nevertheless, linear models hide the true complexity of the innovation process and because of this, they are seen by many as normative and deterministic. Researchers now emphasise feedback between different innovation stages and interactions between actors. Innovation — as a process — is therefore better characterised as a non-linear, dynamic system. Inventions and new ideas can occur at any point in the system, they may need to be adapted to local contextual circumstances, and their form may evolve through the process of adoption. In healthcare services especially, the innovation process tends to be iterative, problem-oriented and collaborative, starting with an issue to resolve and defining the innovations that potentially provide a solution. Either explicitly or implicitly, this process may be informed by 'design thinking' (Brown, 2008).

The innovation process is also complex because in certain industrial sectors, innovations may emerge as an output of processes within national and regional systems of innovation, sustained by an infrastructure of supporting institutions (Chapter 4) (Edquist, 2001). Other innovation systems may be sectoral, focused around a specific industrial sector and based on networks of relationships (Malerba, 2004), or technological fields (Carlsson *et al.*, 2002), or they may draw on expertise from different industrial sectors or technical disciplines defined, for example, by patent classes (Coombs *et al.*, 2003).

Technological innovation therefore needs to be seen as the result of interactions within ecosystems that bring together companies and other institutions within a particular technology or industrial sector, rather than as an output of a series of discrete processes. Different industries are characterised by different forms of innovation process, ranging from highly structured and formalised new product development processes to ones that are more evolutionary and adaptive.

## New product development

From the perspective of companies producing innovative products, the ideal process is one where uncertainty is gradually reduced by tackling R&D in a series of stages in which emerging problems are systematically addressed. In this way, the product moves along a logical pathway, starting with initial scanning of potential user needs, progressing through technology development and prototyping, refining the product and finally launching it on the market. This requires firms to integrate their market- and technology-related activities along the way (Tidd and Bessant, 2014).

> "*Managing new product or service development is a fine balancing act between the costs of continuing with projects which may not eventually succeed (and which represent opportunity costs in terms of other possibilities) — and the danger of closing down too soon and eliminating potentially fruitful options.*"
> (Tidd and Bessant, 2014)



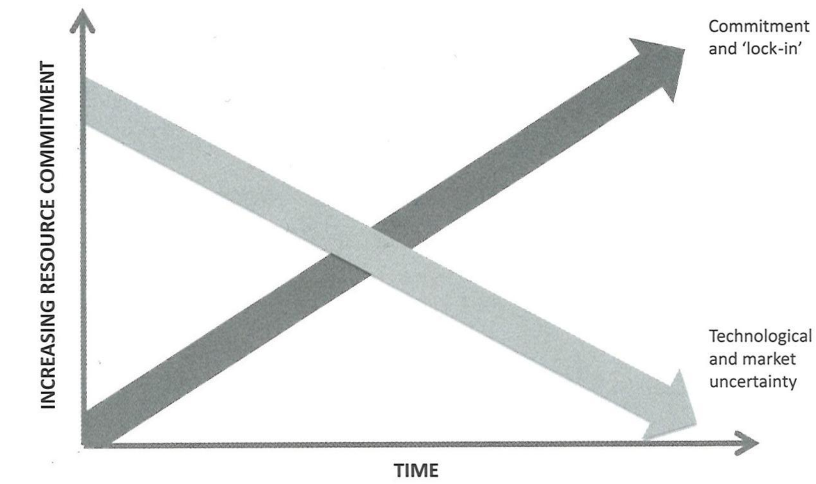


*Figure 2.7. Uncertainty and resource commitment in innovation projects.*
*Source*: Tidd and Bessant (2014).

The model emphasises a series of planned phases of development that reduce risk and control costs to ensure final delivery of a saleable and usable product to customers. Over the life of a project, the growing commitment of resources and locked-in, sunk costs incurred by the company make it increasingly difficult to change direction (see Figure 2.7). Central to this aspect of technology and innovation management is the acquisition of knowledge obtained through market research, competitor analysis, and technological R&D. This allows uncertainty to be converted into measurable risk, an ability to take a calculated decision about whether or not to proceed with an innovation project. This process has often been described in terms of a 'development funnel', where many ideas or prototypes are progressively whittled down as uncertainty is reduced and external and internal resource constraints come into play (Cooper, 2001) (see Figure 2.8).

Actively managing the progress of technology projects from inception to development and commercialisation requires some form of structured decision-making process. This should involve clear stages and rules on which to base decisions to proceed or abandon a project. There are many variations, but the approach has been influential across a wide range of technology sectors. A well-known version is Robert Cooper's 'stage-gate' model

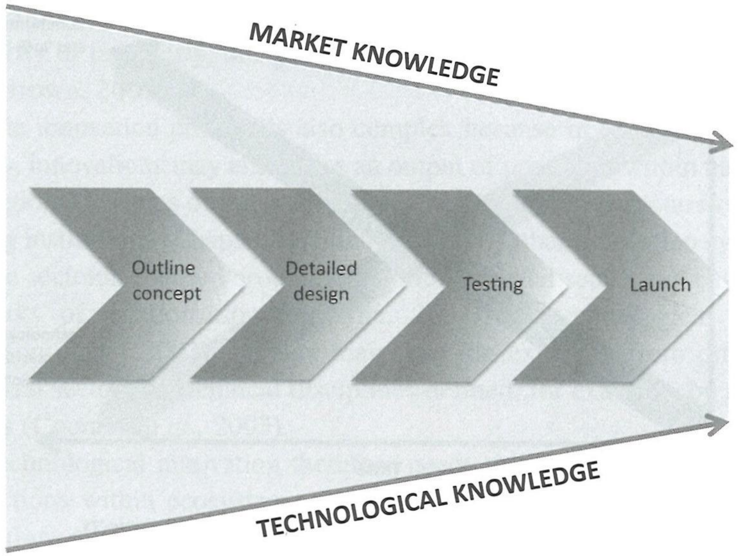


*Figure 2.8. Development funnel for new product development.*

*Source*: Tidd and Bessant (2014).

(Cooper, 2001). Here, innovation projects have to meet specific decision criteria, 'gates', as they move through a series of discrete stages. Decisions are made according to technical, financial or marketing criteria that are appropriate to the stage (see Figure 2.9). Partly in response to criticism that the approach is too inflexible and unable to cope with more serendipitous ideas, different variations on this idea exist, such as the notion of 'fuzzy' — less rigid — gates, and the number of gates varies, but the basic stages are:

- Concept generation — identifying the opportunities for new products and services.
- Project assessment and selection — screening and choosing options which satisfy certain criteria.
- Development — translating concepts and options into a product and testing the winning ideas.
- Commercialisation — launching and marketing the new product.

In practice, new product development is not usually the simple, linear, and unidirectional process implied by these models. The reality is often



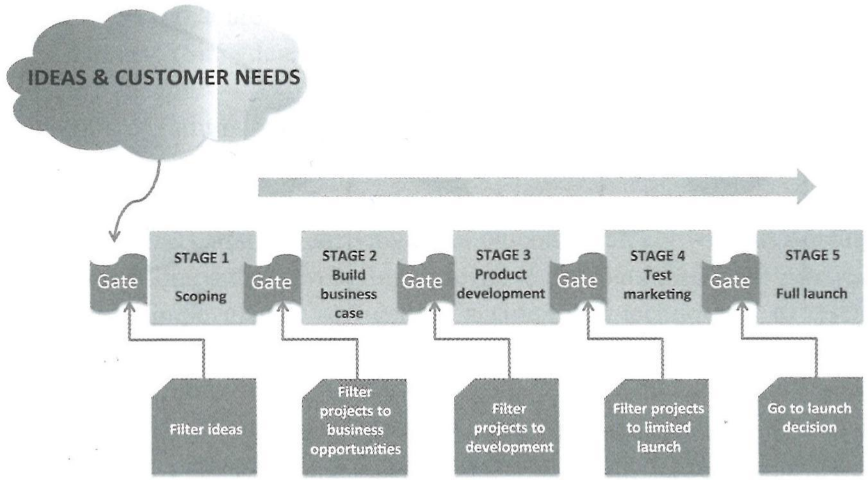


*Figure 2.9. A stage-gate process.*

*Source*: Tidd and Bessant (2014) and others.

far messier and iterative, depending on the particular characteristics of the industry — its competitive or regulatory environment, or its sophistication in using approaches like concurrent engineering to optimise the product development process.

> ➔*Chapter 4 discusses how there are distinctive approaches to new product development within the healthcare industries, depending on the specific sector, notably the drug-development pipeline and development of medical devices.*

David Nichols (2007) has criticised of the notions of funnels and stage-gates as too rigid and constraining, because the whole emphasis is on whittling down a large number of ideas to a smaller number by culling weaker ones and picking the winners. He argues that a more constructive approach is needed to speed up the innovation process. Nichols proposes an 'innovation rocket' in which the end goal is clearly established through a full understanding of the problem, multiple ideas are generated in a process of 'combustion', potentially fruitful mixes are then subject to more detailed R&D and attention from possible funders and partners, and the best ideas are 'accelerated' through the development process (Figure 2.10).

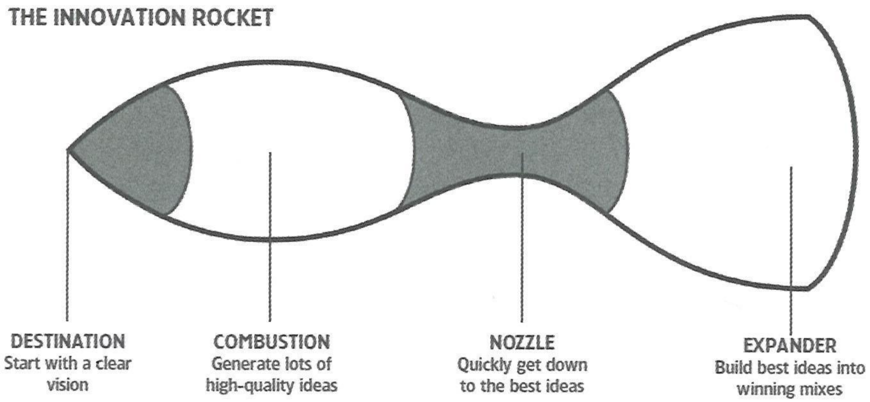


*Figure 2.10. Innovation rocket.*

*Source*: Nichols (2007).

## Experimentation, 'fast fail', 'safe fail'

Some companies tackle the challenge of creating new product ideas through a process of experimentation, adaptation, and evolution, using trial and error to produce a range of workable solutions in increasingly real-world situations. Experimentation might involve trying out multiple approaches or variants of an innovation, gradually focusing attention as more is understood about the innovation and its implications. This is an evolutionary approach, combining variation — pursuing a number of different options such as small-scale interventions or prototypes — and selection, where variants that work are replicated. It is essentially a *breadth* rather than *depth* first approach (Ellerman, 2004; Barder, 2010; Beinhocker, 2006).

Barder (2010) describes how a new nozzle for foam was developed by testing a set of (random) variations on the initial prototype, choosing the most effective one, testing a new set of random variations on that nozzle and so on. This approach proved far more successful than having experts try to design the optimum nozzle. One lesson is that the emphasis should not be on the need to always strive for success or ensure that failure is always avoided. Rather, ideas that are not useful should be tried and allowed to fail, but to do so in contained and tolerable ways, paving the



way for those that are beneficial to be adopted — the concept of 'safe-fail experiments' (Snowden, 2010). This is all about learning quickly and learning cheaply — both in terms of costs of the innovation process itself and costs of failure — and allowing the emergent possibilities to become more visible.

For companies, therefore, safe-fail experiments are a way of tackling the critical risks first and arriving at an outcome quickly without wasting resources. Companies developing innovative products might use proxies, perhaps a single market segment or a simplified technology, to test a hypothesis and find out whether it has value, instead of pursuing an expensive idea that may lead nowhere. The goal is to try out more ideas at a lower cost, and in doing so perhaps discover unexpected new sources of value and identify possible routes to adoption.

➔*The concept of 'safe-fail experiments' contains lessons from theories about complexity and complex systems, such as 'adaptation' and 'emergence', which we discuss in Chapter 7.*

Related to this is the notion of 'fast fail' and 'pivoting', the ability to manoeuvre very quickly during the development phase when companies realise that their product is

**Box 2.8 BACKGROUND: Fast fail is just an excuse for poor management**

The concept of fast fail has been criticised as fashionable and misplaced hype. As Rob Asghar (2014) says,

'Forget the cute mantras. No one should ever set out to fail. The key, really, shouldn't be to embrace failure, but to *embrace resilience* and the ability to bounce back. And the goal shouldn't be to glorify mistakes and errors and catastrophes, but to cultivate the ability to adapt and learn from them.'

Others go further and argue that 'failing fast' and 'pivoting' are simply excuses for explaining repeated failures, revealing that a company doesn't really know what its innovation has to do in order to address customer needs (Villon de Benveniste, 2014). What is more important than failing fast is how fast you learn from failures and successes, and quickly recognising how to modify an innovation to take advantage of the lessons.

not going the right way. Blank (2013) argues that this favours experimentation rather than elaborate planning, customer feedback over intuition, and iterative design over traditional 'big design up front' approaches. The concept of 'fast fail' has been criticised (see Box 2.8), but the principle of embracing notions of 'adaptation' and 'emergence' from complexity theory has nonetheless become an accepted part of the innovation process in many areas, including healthcare. For the drug companies, technological innovation and alliances with technology platform companies has helped them engage in large-scale experimentation in a faster, systematic process of trial and error (see Chapter 4).

## Innovation adoption and diffusion

### *Language matters — some definitions*

As with many discussions about 'innovation', there is a certain wooliness about the terms used when describing how innovations are taken up into mainstream use. Words are often used interchangeably to mean the same or very similar concepts (Box 2.9).

The *adoption* and *diffusion* of an innovation initially seem fairly clear as descriptive terms. Adoption refers to the process of making a decision to do or acquire something — the factors that are influential, the weights

**Box 2.9 CONCEPTS: What is in a word?**

All these are routinely used to describe the process of adopting and diffusing innovation:

- Adoption
- Implementation
- Normalisation
- Routinisation
- Mainstreaming
- Scaling-up
- Diffusion
- Spread
- Translation
- Transfer



we attach to them, the trade-offs that are made between them, the circumstances under which certain factors outweigh others, and so on. Diffusion is usually defined in relation to the 'spread' of an innovation through a population or perhaps geographically through a region or country — how rapidly it is taken up and factors that influence this.

But other terms are also common currency in this area of innovation research and practice — 'implementation', 'normalisation', 'routinisation', 'mainstreaming', 'scale-up', 'spread', 'translation' (or 'transfer'). The first four are frequently used more or less interchangeably, but there are subtle differences between them. These words imply a sense of action and often relate to the processes by which an innovation is taken-up by an organisation and introduced into everyday practice.

There is little consensus on the operational meaning of the other terms — 'scaling-up' or 'spread' and 'translation' or 'transfer'. These are found especially within discussions about the adoption of innovations in healthcare. We discuss this in detail in Chapter 5. Briefly, scale-up and spread capture the idea that diffusing successful trials or innovations on a wider basis can be challenging, especially in healthcare, something that researchers, practitioners and policy-makers have long wrestled with. Definitions of scaling-up include widening the geographical coverage of interventions, institutionalising practices, increasing capacity, mobilising and empowering populations, and transforming demonstrably successful pilot projects into large or mainstream programmes by going to scale (Bloom and Ainsworth, 2010).

➔*Go to Chapter 5 for a discussion about adoption and diffusion of innovations in healthcare and the differences between these concepts*

Technology 'translation' or 'transfer' is related to the movement of novel ideas from a research laboratory setting into the market and everyday use. It implies putting knowledge to use in some way. We will see in Chapter 4, how this is important in healthcare in relation to the commercialisation of new technologies. In contrast to diffusion, which essentially involves the spread of a product or idea through a given social system, technology transfer is a more discrete, point-to-point phenomenon (Tidd and Bessant, 2014).

Many researchers have noted that adoption is not a one-off, all-or-nothing event; it is more of a process, a sequence of decisions and actions. After initial acceptance, an innovation may need to be adapted to its local context and institutionalised within organisations and their practices (Meyer and Goes 1988; Zhu *et al.*, 2006). A distinction is therefore often made between different phases in the process of adopting an innovation within an organisation — 'evaluation', 'initiation', 'implementation' and 'routinisation' (Damanpour and Schneider, 2006). Trisha Greenhalgh, Glenn Robert, and colleagues argue that in healthcare narrow definitions of 'adoption', which fail to look beyond the initial decision to acquire an innovation, are unhelpful because in reality much of the hard work is about ensuring that innovations, once 'adopted', are assimilated into daily practice (Greenhalgh *et al.*, 2004; Robert *et al.*, 2009). Also focusing on healthcare, Carl May and his colleagues (May *et al.*, 2007; May and Finch, 2009) have developed a theory of 'normalisation' to explain the work involved in implementing, embedding and sustaining new practices in situations where the innovation and its context are marked by complexity and emergent behaviour.

## Factors influencing adoption and diffusion

Adoption can be defined in terms of the processes which influence a decision to take-up an innovation, while diffusion relates to the spread of an innovation through a population. The factors which influence adoption have been much studied by a range of disciplines.

Economists often see the innovation process as the cumulative aggregation of individual, rational calculations, influenced by an assessment of the costs and benefits, under conditions of limited information and uncertainty (Tidd and Bessant, 2014). This makes the transfer of *information* about an innovation important in the adoption and diffusion process (see Box 2.10). However, this perspective has been criticised because it ignores the effects of social characteristics of adopters, of learning and feedback between them as innovations are adopted, and the impact of externalities such as the benefits of a growing population of users taking



### Box 2.10 CONCEPTS: The role of information in adoption and diffusion

The importance of information flows between adopters features in various models of adoption and diffusion (Geroski, 2000):

- Probit adoption — where potential users or customers *weigh costs and benefits*. The heterogeneity of preferences means that different users or customers adopt an innovation at different paces.
- Epidemic adoption — where adoption is influenced by the *availability of information*. As potential users and customers become aware of what an innovation does and how to use it, they will adopt it.
- Information cascades and path dependence — once an innovation becomes established and its (improved) features are well known, it is legitimised and network effects take over.

'Bandwagon' effects sometimes occur. These result from pressure caused by the sheer number of people who have already adopted an innovation, rather than by individuals assessing its benefits. This can allow technically inefficient innovations to be widely adopted and sustained, such as the QWERTY keyboard (see p. 24).

To cope with the fact that adopters often have limited information on which to make decisions, Bayesian models of diffusion have been developed. These allow potential adopters to hold different beliefs about the value of an innovation, which they may revise according to the results of trials. If such trials are conducted privately, other potential adopters cannot learn from them and imitation cannot take place. This means that there is no automatic link between how well informed potential adopters are and how quickly they adopt an innovation.

up an innovation. The initial benefits of adoption may be small, but with improvement, reinvention and the effect of externalities, the benefits can increase and the costs decrease over time, as in the early days after the introduction of mobile phones as more and more people became owners.

A very influential book is Everett Rogers' *The Diffusion of Innovations*, first published in 1962. Rogers distinguishes between three types of decision-making process relevant to adoption:

- Individual: the individual is the main decision-maker. Decisions may be influenced by social characteristics and norms, and interpersonal relationships, but the individual ultimately makes the choice, independent of others. This would be typical of a consumer deciding to purchase a new product.
- Collective: choices about adoption are made jointly with others in a social system, and there is peer pressure or formal requirement to conform. An example would be the introduction of new policies to promote the recycling of domestic waste.
- Authoritative: a few individuals within a social system who have professional status or expertise have the power to make the decision to adopt. Doctors may be in this position for some types of medical technology.

Everett Rogers identified five product-based factors that govern the rate of adoption and diffusion:

- **Trialability** — the degree to which a product may be *experimented* with prior to launch.
- **Compatibility** — the degree to which a product is *consistent* with the user's context, their values and experiences.
- **Observability** — the degree to which product *usage and impact* are visible to others.
- **Relative advantage** — the degree to which a *product is better* than the product that it replaces.
- **Complexity** — the degree to which a product is *difficult* to understand and use.

However, Rogers also emphasised that simply focusing on the relative advantage of an innovation will only give us part of the story. Values and beliefs will vary with the social, economic, and cultural context. This in turn means that adopters may hold different views on the costs and benefits of an innovation, or its compatibility with their organisation, or way



*Table 2.2. Key demand- and supply-side influences on innovation adoption.*

| Demand-side factors | Supply-side factors |
|---|---|
| • Degree of direct contact with or imitation of earlier adopters<br>• Different perceptions of benefits and risk held by adopters | • Relative advantage of an innovation<br>• Availability of information<br>• Technical or economic barriers to adoption<br>• Feedback between developers and users |

*Source*: Tidd and Bessant (2014).

of life or needs. Drawing on studies from rural sociology on agricultural innovations, Rogers characterised adoption and diffusion as an essentially social process. Actors create and share information through communication, perhaps influenced by opinion leaders, and make decisions on the basis of this. It is therefore unrealistic to assume that all potential adopters are similar and have the same needs. Nor can we assume that every potential adopter has perfect information about the innovation and its qualities. In practice, a range of demand- and supply-side factors influence adoption patterns (Table 2.2).

Opinion leaders and innovation 'champions' can be critical for adoption and diffusion, especially when an innovation requires stakeholders or consumers to change their behaviour or attitudes. Research has shown how opinion leaders and early adopters can have an important influence on the spread of certain consumer goods. In healthcare, they can be especially important in public health programmes or sex education, both in developed and developing countries' health systems. There has been much research on different forms of opinion leader and champion, and on the way they help to bridge boundaries between groups. We return to this in Chapter 5, where we look at their role in the processes of implementing healthcare innovations.

What are the implications of these ways of understanding the factors that shape the spread of an innovation through a population? How might they be translated into patterns of adoption and diffusion?

Rogers proposed a five-way classification of adopters, based on the normal distribution (bell-curve):

- Innovators (2.5% of the population of adopters)
- Early adopters (13.5%)

- Early majority (34%)
- Late majority (34%)
- Laggards (16%)

The first groups of adopters — 'technology enthusiasts' and 'visionaries' — have rather different characteristics from the other potential adopters, who simply want reliable, fool proof and finished products or services. Innovators selling to these groups therefore need different communication and sales strategies. A well-known book that elaborates on this idea is by Geoffrey Moore (1991). This focuses on the characteristics of potential adopters such as their personality, values, attitudes, interests or lifestyles. Moore argues that initial adopters may provide promising sales and enthusiastic feedback for innovating companies, but reaching the *early* and *late majority* is ultimately more important for commercial success. These groups have different perceptions of a product and its potential benefits (i.e. they want something reliable and finished), so significant changes to the product or service offer may be required. The 'chasm', for Moore, is the potential gap between the early adopters and late majority.

Cumulatively, the take-up of innovations by a population over time displays an S shaped curve. This characteristic is seen in many product innovations. The model assumes that the population of potential adopters is homogeneous. An innovation spreads because information about it is transmitted through the population by personal contact, observation and proximity to existing and potential adopters.

> ➔*Be careful not to confuse the two types of S curve in innovation — one relates to performance improvement over time (Foster) and the other to the adoption and spread of an innovation (Rogers)*

Many innovations will, however, deviate from this neat path because of the effects of a diverse range of interactions and circumstances that are contingent on the local context for adoption — these include the policy, regulatory or economic factors that shape adoption decisions. Savory and Fortune (2013) note how assumptions about linearity in innovation development processes (see above, p. 43) are also reflected in the innovation diffusion literature. Rogers' six-phase model of diffusion is essentially a



linear model, although he is careful to note how serendipitous events can knock an innovation off course and that his model is a just a general guide.

The time taken for an innovation to pass through each phase in the Rogers diffusion model varies considerably. The may be a long gap between initial adoption by enthusiasts or pioneers and mainstream use. Joe Tidd and John Bessant (2014) argue that a critical, but under-researched, question in diffusion research is what happens *before* the regular S shaped diffusion curve begins to take hold. This is very important for the creators of an innovation. The market introduction of a new product may be followed by an erratic pattern of adoption, a 'pre-diffusion phase'. This may be the case even after an innovator has invested in the infrastructure necessary for the manufacture and distribution of the product. The market in this pre-diffusion phase is unstable. In consumer electronics, for example, the diffusion of new products and services often starts with the launch, withdrawal, adaptation, and reintroduction of product variants before mainstream designs appear and diffusion takes off. The length of the pre-diffusion phase varies, but research on a sample of products and industries suggests that the average length can be more than a decade.

> ➔*We will see in Chapters 4 and 5 how and why the pre-diffusion phase in healthcare innovation can be long.*

A different, but related — perspective on adoption and diffusion, and the S shaped adoption curve, can be seen in the concept of a 'hype cycle'. This was developed by Gartner, the IT industry consultants. The hype cycle views the process of market penetration as a series of stages related to adopters' changing expectations. Initial enthusiasm gives way to disillusionment, realism and eventual acceptance. This model seems to work for many technological innovations. An example of the hype cycle in mid-2014 for a selection of emerging technologies can be found at http://www.gartner.com/newsroom/id/2819918

The factors that influence adoption and diffusion are therefore complicated. Actual or potential users or customers are usually heterogeneous in their characteristics — they have diverse needs, and they place different values on how best to meet those needs. Moreover, their needs change over time. Sometimes this is due to exogenous changes, in other words what customers want is responsive to their own changing circumstances or broad societal shifts. Sometimes they may be due to endogenous changes, where their own beliefs and behaviour change in response to technological innovation opening up new demands.

It is often hard to get people or organisations to adopt novel products or services. According to John Gourville (2006), most potential customers, most of the time, are loath to change their behaviour. They are unfamiliar with novel products, which almost always require them to make trade-offs between cost, functionality, added value and their requirements. Customers tend to be overly sensitive to the *disbenefits* of a novel product and they therefore evaluate a product on its perceived relative value. Businesses, on the other hand, often *overestimate* the potential benefits but *underestimate* switching costs for customers adopting a new product. Gourville therefore views adoption as a world populated by 'eager sellers' and 'stony buyers', with the results shown in Table 2.3.

Richard Nelson and colleagues describe four models of innovation adoption and diffusion based on two dimensions (Nelson *et al.*, 2004) — whether or not increasing returns to the adoption of an innovation exist

*Table 2.3. Adopter behaviour change, innovation payoff and the likelihood of success.*

| | | Payoff | |
|---|---|---|---|
| | | **Low** | **High** |
| **Behaviour change** | ***Not much*** | Easy sells | Smash hits |
| | ***A lot*** | Sure failures | Long hauls |

*Source*: Based on Gourville (2006).

*Table 2.4. Models of innovation diffusion.*

| | **Absence of dynamic increasing returns** | **Presence of dynamic increasing returns** |
|---|---|---|
| **Ability to get sharp persuasive feedback** | Model I: rational choice diffusion | Model II: quasi rational choice with possibility of 'lock in' |
| **Inability to get sharp persuasive feedback** | Model IV: fads | Model III: social construction |

*Source*: Nelson *et al.* (2004).



(i.e. the extent to which the value of adoption is increasingly enhanced as more people adopt it) and secondly the ability to receive clear feedback on the impact of an innovation (i.e. whether or not there is ambiguity in the evidence of its performance). This follows the notion that the way a technology is perceived and understood — hence valued — may be socially constructed, as noted earlier, p. 23. In one of the options, outlined in Table 2.4, there is the possibility of 'lock in' to a sub-optimal, inefficient technology because of the presence of increasing returns as more and more people use the innovation.

➔*Nelson et al. (2004) applied their model to a healthcare innovation, polio vaccine, discussed in Chapter 5.*

## Moving from a view of adoption that is focused on individual users

There is a huge volume of research on innovation processes in an industrial and consumer market context which shows that adoption and diffusion is more likely when innovations are simple, trialable, observable and so on — recall Everett Rogers' list of factors. But there are three limitations to much of this research, both as a body of knowledge on innovation in general and, as we will see later, when it is applied to healthcare. First, it has tended to focus on new *products* rather than *services* or *business models*. Second, the innovations studied have often been *single products with unambiguous characteristics* — a specific product delivering a clear benefit to the user. In the healthcare context, this is rarely the case. Finally, explanations have often stressed the aggregate effect of *independent decision-makers* making *individual* adoption decisions. Innovations involving collective or organisational decision-making have been relatively neglected. In healthcare, we are more likely to be interested in the latter, for example whether or not a hospital as an organisation decides to adopt an innovative scanner or whether it decides to embark on a series of radical changes to operational processes. So how are adoption decisions made at an organisational level?

Organisations can be highly complex entities, possibly none more so than in healthcare. Many academic and other studies have explored the

**Box 2.11 CONCEPTS: Innovation leadership**

Innovation leadership is the work of:

- Creating the right conditions for innovation to occur.
- Putting in place the infrastructure to support innovative thinking — the roles, decision-making structures, networks, physical space, equipment and so on.
- Envisioning a better future.
- Having the courage to challenge the *status quo*.
- Being comfortable with risk taking.
- Having sufficient ego strength.
- Facilitating and empowering others to be as creative as they can.

*Source*: Malloch (2011).

attributes of organisations seen as innovative. An organisation's ability to recognise, absorb and apply knowledge from outside — its 'absorptive capacity' (Cohen and Levinthal, 1990; Zahra and George, 2002) — has been closely linked to attitudes towards innovation and its adoption. This in turn rests on the right kind of organisational culture to provide a foundation for a climate in which innovation can be fostered. The important characteristics of an innovative organisational culture include:

- A climate conducive to experimentation and risk taking, and an expectation that all members challenge assumptions.
- Visionary staff in pivotal positions.
- Clear strategic vision.
- Strong leadership.

The last of these points itself requires certain cultural attributes, such as a high regard for creativity and openness to new ideas. Innovation leadership therefore requires leaders to possess the right characteristics, outlined in Box 2.11.

Being 'ready' for the adoption of innovations generated elsewhere and being 'innovative', in the sense that an organisation generates and uses new ideas internally, are not necessarily the same thing, although there is



a blurring between the two; organisations prepared to scan the world for new ideas and take them on may well be more prone to generate innovations themselves.

The adoption of innovations at an organisational level is likely to be more complex than decision-making by individuals about a single product, and will be influenced by factors such as the range of stakeholders involved in adoption decisions, their goals and how powerful they are, as well the four characteristics outlined above. The *evidence* for the benefits of the innovation may be important — how clear and unambiguous are the facts about what it delivers? And the *nature* of the innovation, how radical or incremental it is, may also make a difference.

As Tidd and Bessant (2014) point out, decisions about adopting an *incremental* innovation may be fairly straightforward. A well-defined business case can be assembled, costs and benefits can be argued and the innovation's 'fit' with the organisation's current activities can be demonstrated. But the more *radical* an innovation or the greater its complexity, the higher the likely resource commitment and risks of adoption, and the more that emotional or political influences within the organisational will be influential.

Radical innovations may require organisations to reframe their mental models of the world. Organisations will ask themselves what the alternative options are ('what if we don't adopt this innovation?') and whether the strategic decisions involved are consistent with each other. Simply gathering more evidence for the benefits may be insufficient and an organisation — and the individuals within it — may need to change the 'frame' through which it sees and interprets that evidence in order for it to make sense within its specific context.

This can be especially challenging when the core competencies of a firm or organisation are strong and long established. Organisations have comfort zones beyond which they are reluctant or unable to consider innovation projects, whether as innovators or adopters. In Chapter 4, we discuss stage-gate models used by companies developing new products to decide whether to proceed or not. These work where the criteria for decisions are clearly established and perceived as appropriate by all stakeholders, and there are steady-state conditions where the world is not rapidly changing. But the higher levels of uncertainty associated with more radical innovations put pressure on these models. This may result in organisations (or individuals — see Box 2.12) rejecting ideas which do not fit their

## Box 2.12 CONCEPTS: Cognitive barriers to innovation held by individuals

Our ability to accept change is also constrained by cognitive barriers that work at the level of individuals within organisations. Some of these are associated with a lack of awareness or knowledge of an innovation, but others relate to a lack of willingness to try out innovations (Lettl, 2005). In his book *Adapt*, Tim Harford (2011) describes how various psychological attributes prevent us from learning from our failures and moving forwards. One of these is denial (challenging a *status quo* of our own making) due to 'cognitive dissonance', the mind's difficulty in holding two seemingly contradictory thoughts simultaneously. Another is the way we 'chase our losses' in an attempt to make them go away, typical gambling behaviour. Finally, there is 'hedonic editing', where we convince ourselves that previous mistakes or problems don't matter, or we reinterpret past failures as successes.

mental model. There may be nothing irrational about defending an established mental model. Decisions not to proceed with an innovation project (or to adopt an innovation) may make sense in terms of the criteria associated with an organisation's dominant cognitive framework; the reasons for rejection may be clear and consistent with its own decision rules and criteria. But as Tidd and Bessant (2014) explain, organisations can cloak decisions in a shroud of 'rationality' by using empirical evidence or the lack of it as justification. Persuading such an organisation to adopt the innovation is not simply a case of gathering new information — say evidence for the benefits of an innovation — but changing the frame through which it sees and interprets that information.

➔*Chapter 5 discusses the relationship between evidence and trialling or piloting healthcare innovations*

Such a perspective makes it easier for us to understand the 'not invented here' syndrome common in many sectors. This is especially prevalent in healthcare where there is a problem of repeated trialling of innovations by different organisations, even when there is a good evidence base. Table 2.5 shows typical reasons presented by organisations for the non-adoption of innovations.



*Table 2.5. Examples of justifications for non-adoption of innovations.*

| **Argument** | **Underlying perceptions from within the established mental model** |
|---|---|
| 'It's not our business' | Recognition of an interesting new business idea but rejection because it lies far from the core competence of the firm |
| 'It's not a business' | Evaluation suggests the business plan is flawed along some key dimension — often underestimating potential for market development and growth |
| 'It's not big enough for us' | Emergent market size is too small to meet growth targets of large, established firm |
| 'Not invented here' | Recognition of interesting idea with potential but rejection — often by finding flaws or mismatch to current internal trajectories |
| 'Invented here' | Recognition of interesting idea but rejection because internally generated version is perceived to be superior |
| 'We're not cannibals' | Recognition of potential for impact on current markets and reluctance to adopt potential competing idea |
| 'Nice idea but doesn't fit' | Recognition of interesting idea generated from within but whose application lies outside current business areas — often leads to inventions being shelved or put in cupboard |
| 'It ain't broke so why fix it?' | No perceived relative advantage in adopting new idea |
| 'Great minds think alike' | 'Groupthink' at strategic decision-making level — new idea lies outside the collective frame of reference |
| '(Existing) customers would not/do not want it' | New idea offers little to interest or attract current customers — essentially a different value proposition |
| 'We have never done it before' | Perception that risks involved are too high along market and technical dimensions |
| 'We were doing OK as we are' | The success trap — lack of motivation or organisational slack to allow exploitation outside of current lines |
| 'Let's set up a pilot' | Recognition of potential in new idea but limited and insufficient commitment to exploring and developing it — lukewarm support |

*Source*: Tidd and Bessant (2014).

## Applying lessons on technology and innovation management to healthcare

In the rest of the book, we will use these basic building blocks from the research on technology and innovation management to explore what they mean for the healthcare sector. The important question to ask at this point is how the particular features of healthcare might influence its innovation processes. How might the complexity of healthcare make a difference? How would you expect its closely regulated environment to impact on innovation adoption? What about attitudes towards the quality of evidence for the benefits of an innovation?

Two key features of healthcare are that its innovations can be often rather ambiguous in their characteristics — their technology and organisational components. The innovation itself may be multifaceted, perhaps embracing elements of hard technology mixed with a considerable degree of organisational change. It may require adopters to learn new skills (soft technology) in order to use it. An innovation may be targeting several objectives at the same time, such as improvements in quality *and* safety *and* cost. Or the evidence for improved performance may be ambiguous or contested by different types of healthcare worker. The context for their adoption may also be complex — there may be multiple users of the innovation, all of whom can be seen as 'adopters'. These may be situated in different types of organisation such as primary or secondary care providers, or they may come from different professional groups or have differing cultural characteristics. Moreover, multiple stakeholders from across primary, secondary and social care may be affected by the innovation, all with the potential to veto adoption decisions.

So often the adoption and diffusion of healthcare innovations is erratic. Conventional models, applicable widely across industries, need to be adapted. This means that not only does the adoption and use of acknowledged best practice or evidence-based innovation vary between considerably countries, it may be uneven within a country's own health system, with some healthcare providers using the leading technologies and practices but others continuing to use outmoded approaches. This can result in significant geographical differences in access to the best treatment — hence the interest of policy-makers in improving the



effectiveness of healthcare innovation processes and, in particular, the spread of best practices across the system.

## Chapter summary

- Definitions are important — we need to make a distinction between 'technology' (which is the application of knowledge to solve problems and not just a physical artefact) and 'innovation'.
- Innovation does not simply refer to inventions — it is both, a process which embraces different stages from initial idea to adoption and diffusion, and it is also an outcome of this process — we talk about 'an innovation' when referring to something new.
- There are different ways of looking at an innovation — we can see it in terms of its 'newness', its form (whether it is a product, process or service), or its type (is it radical, incremental or some other type, depending on the theory we use?).
- The performance improvement of a specific technology or product can often be seen as an S shaped curve, where performance initially improves slowly, but then speeds up through the application of R&D and new knowledge. Eventually it begins to tail-off as it reaches a limit.
- The adoption and diffusion of innovation is influenced by a range of factors, including the attributes of the innovation itself, the adopting individual's or organisation's context and the compatibility of the innovation with that context, and the degree to which the innovation offers the prospect of benefits.
- The processes involved in the adoption of innovations by organisations tend to be more complex and are influenced by factors like organisational culture and leadership, and the range and power of stakeholders.
- The adoption of an innovation can be plotted (typically) as an S shaped curve, with slow initial take-up followed by faster adoption by the majority of users, before tailing off.
- There are limitations to using the concepts from mainstream innovation research to explain innovation processes and adoption/diffusion in a healthcare context.

## Questions for discussion

1. Why do we make a distinction between 'technology' and 'innovation'? What is the difference between 'hard' and 'soft' technology?
2. Explain the differences between 'invention' and 'innovation'. Which do you consider to be the most important and why?
3. Give examples of product, service and process innovations and describe their main characteristics.
4. Why do we categorise innovations? How might this be useful for innovators and policy-makers?
5. What is meant by 'radical innovation'? Take an example of a radical innovation and explore its impact on society. Do the same for an 'incremental innovation'.
6. Use the theory of the S-shaped technology performance curve to distinguish between radical and incremental types of innovation, using examples.
7. Using an innovation of your choice:

   - Describe the *type* of innovation using one of the models.
   - Describe the various steps in the innovation process.

8. What are the differences between 'open' and 'closed' innovation models?
9. What are the implications of open innovation as far as individual researchers and innovators are concerned?
10. Why does Eric Von Hippel describe innovation as having been 'democratised'?
11. What are the limitations of portraying innovation as a series of phases?
12. Explain what is meant by 'stage-gates' in relation to the innovation process and discuss the advantages and disadvantages.
13. Distinguish between the three main types of decision-making process in the adoption of innovations. Why might we want to focus on organisations rather than individual users when considering how adoption takes place?



## Selected further reading

Chesbrough H (2003) *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Cambridge: Harvard Business School Press.

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Rogers E (2003) *Diffusion of Innovations*. New York: Free Press.