What's Different about Intangible Investment?

THE FOUR S'S OF INTANGIBLES

This chapter looks at the unusual economic characteristics of intangibles—the reasons why an intangible-rich economy exhibits different characteristics from a tangible-rich one. Those characteristics are summed up in four S's, namely that intangible assets, relative to tangible assets, are more likely to be scalable, *their costs are more likely to be* sunk, *and they are inclined to have* spillovers *and to exhibit* synergies *with each other.*

Investment changes all the time; from warehouses and wharves to mineshafts and mills; from machine tools and dynamos to cooling towers and cash registers, servers, and solar arrays. So why should we care about the move from tangible to intangible assets that we described in chapters 2 and 3?

As we will show, intangible assets are different from tangible assets in a number of important ways. This means that a business that is reliant on intangibles will behave differently from a business with mainly tangible assets. Managers and workers will face different incentives and rewards. And an economy made up of many such businesses will perform in distinctive ways. In this chapter we will look at the unusual characteristics of intangible investments from an economic perspective, and why they matter. We summarize these features under four S's: *scalability*, *sunkenness*, *spillovers*, and *synergies*.

A good way to think about these characteristics is with a story of intangible investments at work.

How EMI Got a Little Help from Their Friends

In the mid-1960s the Beatles were not just a cultural force, they were an economic one. At their peak, their records and ticket sales were generating $650 a second in today's money. The dollar receipts from their overseas tours are even credited with temporarily saving the British government from a currency crisis.

One of the beneficiaries of the rise of the Beatles to stardom was their record company, Parlophone, which since the 1930s had been owned by Electric & Musical Industries Limited, better known as EMI (and later to be the subject of a song themselves by the Sex Pistols). By 1967, 30 percent of EMI's profits were coming just from Beatles sales.

As their expanded name suggests, EMI wasn't only a record label. In the 1960s the company was as interesting for its electrical activities as for its musical ones. In 1959 it had launched a commercial computer called the EMIDEC 1100; it also made color TV cameras, recording equipment, guided missiles, and kettles.

The piles of cash brought in by Beatlemania helped create a culture of investment at EMI. One of the things they invested in was medical equipment research. Godfrey Hounsfield, the researcher behind the EMIDEC, began work on the first commercially viable medical scanner. As the project developed, he was significantly supported by the UK government, which provided over £600,000 of support or £7 million at 2016 prices (Maizlin and Vos 2012). Over four years, he and his team invented and built the first computed tomography scanner (CT or "CAT scanner"—the A stands for "axial").

This was a remarkable feat of science and engineering. For the first time, it allowed doctors to make accurate, 3D representations of patients' soft tissues. This was a real medical breakthrough, transforming everything from brain surgery to cancer treatment. Hounsfield was piled with honors: he received a Nobel prize and a knighthood and was made a Fellow of the Royal Society. But from a commercial point of view, it was something of a failure for EMI.

EMI took out patents on the underlying technologies and invested to build the business, creating partnerships with hospitals

to work out how CT could help doctors and building a sales force to sell the scanners to American hospitals. But as the 1970s rolled on, it became clear that other companies were going to dominate the CT market. General Electric (GE) and then Siemens licensed some of the technologies from EMI and quickly built large CT scanning businesses. By 1976 EMI decided to get out of the CT scanning business entirely.

It may not be obvious to someone listening to a Beatles song or having a CT scan, but this story is all about intangible investments. And it neatly illustrates some of the things that make intangible investments of various sorts different from physical, tangible investments.

First of all, consider the Beatles catalogue, the vast profitability of which helped EMI back the CT scanner. Music rights are a type of intangible asset. Once you own them, you can press as many singles as you like at a pretty low cost (nowadays, in the age of digital music, that cost has fallen close to zero).

This isn't true of a physical asset like a factory or a shop or a telephone line: once these assets reach their capacity, you need to invest in new ones. But intangibles do not have to obey the same set of physical laws: they can generally be used again and again. Let's call this characteristic of intangibles *scalability*.

Next, consider what happened when EMI decided to get out of the CT scanner business. They'd made a lot of intangible investments: most obviously the R&D to design the scanner itself, but also the time they put into working with clinicians on how to use the scanners (in the framework we described in chapter 3, we would call this design, specifically service design); on building a business unit (organizational development); and establishing a market presence in the United States (branding and marketing).

On some of this EMI got a return—they received license fees from their patents from GE and Siemens. But a lot of it looks like it was written off. It's hard to recoup the money spent on setting up a sales force or on building an unsuccessful business unit or brand. Physical assets are often much easier to sell, even if they are quite specialized. Let's call this characteristic of intangibles *sunkenness*.

The role of GE and Siemens in developing the CT scanner illustrates another distinctive feature of intangibles: rather unfairly, the person or business making the investment in them doesn't always reap the rewards. The dazzling R&D that Godfrey Hounsfield carried out, the design work with hospitals, and the hard slog of making early sales yielded a small return to EMI, but a big new market for its competitors. This simply isn't the case with most tangible investments. GE obviously couldn't break into EMI's factories to produce their own CT scanners—there are locks and alarms and laws to stop that sort of thing. But they did manage to make use of EMI's intangible investments, at a relatively low cost. In the language of economics, you could say that it is sometimes hard for the original investor to appropriate the benefits of intangible investment, or, to put it another way, that intangibles often have *spillovers* beyond the company making the investment.

Finally, investments in intangibles become dramatically more valuable when you combine them. EMI's central R&D lab was a melting pot of research on computing, imaging, and electrical engineering; bringing these different types of knowledge together with the clinical expertise of the doctors at Atkinson Morley Hospital, where the first scanners were trialed, helped create a genuine breakthrough.

But it is not just ideas derived from R&D that can lead to these unexpected benefits when you combine them. The eventual success of GE's CT scanner relied on bringing together the technological investment in the device itself with GE's brand and customer relationships. And, of course, the success of the Beatles themselves relied on the bringing together of new musical ideas (from Elvis to Ravi Shankar) and Parlophone's own intangibles: their ability to promote and market the band. All of these are examples of the *synergies* between intangibles—synergies that are often large in size and hard to predict.[1]

The Four S's of Intangible Investment

It should come as no surprise that things that one can't touch, like ideas, commercial relationships, and know-how, are fundamentally different from physical things like machines and buildings.

This fact has not been lost on economists. Over the last century researchers in different subfields of economics have looked into various unusual properties of intangible assets.

David Warsh's fascinating book *Knowledge and the Wealth of Nations* tells the story of how the economist Paul Romer developed an improved theory of economic growth that included knowledge, in particular R&D, rather than treating it as an unpredictable exogenous variable. The work of Romer, Chad Jones, Philippe Aghion, and other pioneers of endogenous growth theory, as it's called, pointed out that knowledge is an unusual type of good because putting an idea into practice doesn't use it up. They used the term "non-rivalry" to contrast a "knowledge good," like an idea, that can be used by many, with a "rival good," like a sandwich, which can only be used by one person. This non-rivalry we express as scalability.

A parallel tradition looks at the way ideas spill over from one firm to another. Alfred Marshall first talked about these spillovers between different firms in the same industry in the late nineteenth century; Nobel laureate Ken Arrow expressed this mathematically in the 1960s, and twenty years later Paul Romer extended the theory (Arrow 1962; Romer 1990). The economist Edward Glaeser coined the term "Marshall-Arrow-Romer spillovers" to refer to these kinds of spillovers and in the same paper demonstrated the importance of spillovers across industries, work following that of Zvi Griliches (Glaeser 2011; Griliches 1992).

Similarly, researchers studying the financing of innovative firms, such as Bronwyn Hall and Josh Lerner, observed that investments in assets like R&D and product development are harder to finance with debt than physical investments (Hall and Lerner 2010). Scholars of the processes and nature of innovation, such as Brian Arthur (2009), have highlighted the importance of blending together different types of knowledge. And scholars of intangibles, like Baruch Lev, have remarked upon their spillovers (Lev 2001).

Let's now look in more detail at the ways in which intangible investment differs from tangible investment. In the section that follows, we'll look at each of the four characteristics of intangible assets—scalability, sunkenness, spillovers, and synergies—and discuss (a) why intangibles behave this way (especially in comparison with tangible investments) and (b) why each characteristic matters

to the wider economy. Before we get there, since there are a lot of closely related concepts that are used variously in the literature, such as "ideas," "knowledge," "data," box 4.1 tries to clarify them. And after we discuss each of the four S's in detail, we shall look at how some emergent properties of intangibles, such as uncertainty and the creation of option values, arise from these S's. To be clear, we don't claim to have discovered these features ourselves. Rather, we think we can conveniently summarize the discoveries of others under these headings.

Box 4.1. Knowledge, Data, Information, and Ideas: Some Definitions

The words "data," "information," and "knowledge" seem interchangeable. As Goodridge and Haskel (2016) point out, the UK *Data* Protection Act "controls how your personal *information* is used," that the UK *Information* Commissioner "promotes data privacy for individuals," and the Freedom of *Information* Act allows citizens to request publicly held *data*sets (all our italics).* Romer (1991), when talking about intangibles, uses terms like "ideas," "blueprints," and "instructions." The OECD talks about the "knowledge economy," while economists typically refer to "knowledge" that is embodied or disembodied. Meanwhile, in his masterful work on the Industrial Revolution, the economic historian Joel Mokyr divides "knowledge" into propositional and prescriptive (Mokyr 2002). How does all this fit together?

Let's start with *data*. Define two kinds of data: raw records and transformed data. Raw records are raw data not yet cleaned up, formatted, or transformed—not ready for analysis. They can include, for instance, data scraped from the web, data generated by transactions between agents, data generated by sensors embedded in machines or equipment (the "Internet of Things"), or data generated as a by-product of some other business operation or process. Transformed data has been cleaned up, formatted, combined, and/or structured such that it is suitable for some form of data analytics.

Turning to *information*, we can think of information as synonymous with transformed data: for example, analyzable data on, say, sales of hurricane lamps and weather, constitutes information. Shapiro and Varian (1998) take information to mean anything that can be digitized, thereby implicitly defining information as digitized data.

We define *knowledge* as connections made between pieces of information, supported by evidence, to form a coherent understanding. Knowledge cannot exist without information, and knowledge is required to fully understand and interpret information. Knowledge can, therefore, include theories, hypotheses, correlations, or causal relationships observed from information constituted by analyzable data.

Joel Mokyr (2002) introduces a distinction between different types of knowledge, "propositional" and "prescriptive." Propositional knowledge includes science and discoveries: knowledge of nature and its properties. Prescriptive knowledge prescribes actions for the purposes of production, such as "recipes," "blueprints," or "techniques." So, for example, the invention by Appert in 1806 of the Appert jar, a method of preserving food by cooking it and sealing it in a jar, was simply a recipe that the inventors got to work, even though they knew nothing of Pasteur's work on food spoilage via microorganisms, which was to come in another fifty years. It was thus innovation founded on prescriptive not propositional knowledge. Mokyr's argument is that preindustrial, stop-and-start growth was founded on chance discoveries. Postindustrial steady growth was only possible due to discoveries being founded on propositional knowledge.

Tangible assets, like airliners, consist of metal but also lots of knowledge, for example, from the production process. Why then isn't a tangible asset simply a collection of intangible assets? It's helpful to think of "embodied" and "disembodied" knowledge. To produce an airliner requires tangible inputs (like metal) and intangible inputs (like software or design). The resulting airliner is a tangible asset since the inputs and knowledge are "embodied" in it. The software and design, insofar as they exist independent of the plane, for example, as code or as a blueprint, are intangible assets since they are "disembodied" from the airliner (and can likely be used again and again in other airliners)

Other classifications of knowledge are "tacit" as opposed to "codified," meaning whether the knowledge is experience-based or formally recorded, for example, in a blueprint; "applied" or "basic," meaning whether the knowledge is directed primarily toward a specific, practical objective or whether it is theoretical, with no particular application in mind (OECD *Frascati Manual* 2015). Finally, "commercialized" knowledge is knowledge applied to a particular business end.

* Quotes in this section are all taken from official UK government websites (.gov.uk): for Data Protection, see https://www.gov.uk/data-protection/the-data-protection-act; Information Commissioner: https://www.gov.uk/government/organisations/information-commissioner-s-office; on Freedom of Information, see https://ico.org.uk/media/for-organisations/documents/1151/datasets-foi-guidance.pdf.

Scalability

Why Are Intangibles Scalable?

Physical assets can only be in one place at one time. Intangible assets, by contrast, can usually be used over and over, in multiple places at the same time.

Once you've written the Starbucks operating manual in Chinese—an investment in organizational development—you can use it in each of the country's 1,200-plus stores. The costs of developing the app Angry Birds—and investment in software—can be spread over an arbitrarily large number of downloads (currently well over two billion). And an aircraft engine manufacturer only needs to design a particular type of jet engine—an investment in R&D and design—once, before it can then make an arbitrarily large number of engines.

This scalability applies to many sorts of intangible assets. Once a business has created or acquired an intangible asset, it can usually make use of it again and again at relatively little cost, compared to most physical assets.

The scalability of knowledge in general is something economists have known for decades. Paul Romer, one of the pioneers of how economists think about economic growth, used to give the example of oral rehydration therapy (ORT), a simple treatment that has saved countless lives in the developing world by stopping children's deaths from diarrhea. The insight of ORT is that just drinking water isn't a good solution to dehydration; you also need sodium, and sugar to help the body absorb the sodium.

Most of the physical things an aid organization might invest in to tackle death from dehydration don't scale. If you build a water pump, dig a well, or buy a water tanker, you can only meet the needs of so many people before you need to repeat the investment. But the idea of ORT can be used again and again, once you have discovered it.

The idea that knowledge is scalable sits at the heart of "New Growth Theory," the new approach to economic growth that Romer pioneered. Rather than treating technology as an exogenous force that manifests itself from time to time and makes the economy more productive, Romer and fellow theorists, such as Robert Lucas, treated it as an investment that yielded an economic return across the economy as a whole.

From an economic point of view, scalability derives from a key feature of ideas: what economists call "non-rivalry." If I drink a glass of water, you cannot drink the same glass: it is a "rival" good. But if I use an idea, you too can use the same idea: the idea is non-rival. While rivalry might then be the economic primitive behind scalability, we shall use scalability for mnemonic convenience.[2]

Scalability becomes supercharged with "network effects." A network effect exists when assets become more valuable the more of them exist. Network effects can be found among both tangible and intangible assets. So, for example, telephones or fax machines are much more valuable when almost everyone has them. Indeed, the current digital tech revolution has drawn people's attention to the potential network effects of physical assets, mobile phones and networked computers being prime examples. But if we look closer, it's really the intangible investments of the current wave of digital technologies where the big network effects are.

The network of Uber drivers and AirBnB hosts and Instagram users (all organizational development investments) or the power of HTML and the innumerable standards the Web is based on (variously, investments in software, design, and organizational development) are intangibles, not tangibles.

It's worth noting that real life intangibles are not usually infinitely scalable. The salt-sugar mixture for ORT, in fact, has to be tweaked for different levels of dehydration. The McDonald's menu and its recipes vary, sometimes quite significantly, by country. Software requires patches and updates. Most R&D-intensive companies are continually tweaking their designs. The scalability of training is limited by the number of hours the employee you have trained can work in a day.

But, nevertheless, we would expect intangible assets to be, on average, significantly more scalable than tangible ones.

Why Does Scalability Matter?

We might expect to see three unusual things happening in an economy where more investments are highly scalable.

First, there will be some very intangible-intensive businesses that have gotten very large. Starbucks has been able to leverage an effective brand, operating processes, and supply chains to allow it to spread across the world. Google, Microsoft, and Facebook need relatively few tangible assets compared to the manufacturing giants of yesteryear. They can scale their intangible-asset bundle or software and reputation and so get very big. This type of scalability is, of course, enhanced by network effects.[3]

Second, with the prospects of such large markets, more and more firms will be encouraged to try their luck in these markets. They face a hard choice, for although the prospective market might be large, encouraging them to have a go, competition might be very tough, thereby discouraging them. The net result of this was described by the economist John Sutton in the early 1990s: in markets where scalable investments (like R&D or branding) are important, you'd expect to see "industry concentration"—a relatively small number of dominant large companies.

Third, businesses looking to compete with the owners of scalable assets are in a tough position. On the one hand, the rewards are high. After all, Google started off as a competitor to a whole host of search engines that were once household names. But in markets with highly scalable assets, the rewards for runners-up are often meager. If Google's search algorithm is the best and is almost infinitely scalable, why use Yahoo's? Winner-takes-all scenarios are likely to be the norm.

Sunkenness

Why Are Intangibles Sunk Costs?

If a business makes an intangible investment and later on decides it wants to back out, it's often hard to reverse the decision and try to get back the investment's cost by selling the created asset—and, in general, it's harder than in the case of a tangible asset. Economists describe these kinds of irrecoverable costs as "sunk."

Consider a world in which some commercial disaster hits a hypothetical chain of coffee shops—let's call it Tarbucks—and the company goes bust. What assets could the liquidators sell to pay off its outstanding debts?

First to go would be the shops that the company owns or leases; there's an active and liquid market in commercial property, so finding a buyer at a reasonable price should be possible. Its coffee machines and shop fixtures and delivery vehicles and cash registers will also be salvageable: there are secondary markets where these sorts of things are bought and sold. (Indeed, as we saw in chapter 1, there are markets for all sorts of exotic plant and machinery, from oil tankers to tunnel-boring machines.)

But its intangible assets are harder to sell. Its brand may be valuable, but perhaps not—and even if it is, getting money for it may rely on a trade sale that has to be negotiated specifically for the purpose. Tarbucks's codified operating procedures and the processes it uses to serve customers quickly may have been very valuable to the company when it was in business, but they will prove difficult to sell to someone else, especially if they are specific to Tarbucks's layout or product offering. If Tarbucks has some valuable intellectual property, say, a patented roasting technique, the liquidators may be able to sell this. But if the knowledge isn't governed by formal intellectual property rights (say, the know-how involved in buying coffee beans effectively) or if it's distributed among the company's employees (for example, through training), it becomes, to all intents and purposes, impossible to sell.

Now, of course some tangible assets are also hard to sell if a company or a project fails. Very specialized machinery may be worthless to anyone but its original owner, implying a certain proportion of its cost is sunk. An isolated coal mine dug in a spot that can only sell to a local power station is worthless if the local power station does not want to buy its coal. The Channel Tunnel or Narita Airport can't be packaged up and moved should they no longer be required in their present location. But on the whole, the problem is worse when it comes to intangible assets.

In particular, there are two characteristics of tangible assets that make them easier to sell and less likely to be sunk investments.

The first are the phenomena of mass production and standardization. One of the wonders of mass production is that many tangible assets are copies of other tangible assets. The world's businesses own lots of Ford transit vans, lots of Windows servers, lots of ISO-668 shipping containers. This makes them easier to sell. (It also makes it easier to estimate their price, since there are often published market values for secondhand tangibles, a point we will return to.) Standards also help make tangible assets fungible between businesses. Common power sockets and voltages make it easier to move machine tools from one factory to another. Mid-sized vans are to some extent interchangeable. But there are far fewer standards among intangible assets, nor are most intangibles mass-produced.

The second reason tangible investments are easier to sell is that they are less likely to be uniquely linked to the firm that owns them and its business. Plenty of tangible assets, from buildings to land, are useful to many types of business. A patent, a clever set of operating procedures, or a brand are more likely to be mainly useful to the company that developed them in the first place. Even where markets for intangibles exists—such as for patents—many

of the assets are much more useful to their original owner than to anyone else.

Why Does Sunkenness Matter?

Investments with high irrecoverable costs can be difficult to finance, especially with debt. One of the reasons banks love mortgage lending is that their loans are secured on a valuable, immobile asset that can, if the borrower defaults, be seized and sold.

Companies with lots of intangible assets are, on the other hand, a total pain in the neck for banks if it all goes wrong. First, can such assets be seized? In some cases they can simply walk out the door—such as knowledge and know-how in employees' heads. (This is a consequence of lack of property rights, which gives rise to spillovers that we discuss below.)

Second, can they be sold? A consequence of sunkenness is: likely not. Because the assets are often context-specific, it is hard for markets to emerge to trade them, unlike a house. With no market, you have to find another way to value the asset, which is hard to do. Do you value a patent at the cost it took to develop it (if so, you have to apportion the costs correctly), at a professional valuator's estimate (for which you have to pay, and they, in any case, might be wrong), or at a figure based on its future earnings potential (can you trust the borrower to tell you this)?

No wonder many small business loans, especially in the UK and the United States, demand a lien on directors' homes as security—it changes complex, messy intangible lending into something a lot more like a simple mortgage.

Sunkenness also contributes to the uncertainty around intangible assets. Part of the reason for sunkenness is that intangible assets are often very context-specific. It might be a supply chain relationship that is unique to the particular industry or suppliers. It might be a reputation for product quality in a very particular area. All this makes it harder and harder to value the worth of such an asset, for sunkenness stops the creation of markets for such assets. The lack of markets means that value is very hard to assign.

The sunkenness of intangible investment may also have an effect on the way businesses behave. Psychologists have long known

that people have a tendency to become overattached to sunk costs and unwilling to write them off (Kahneman, Lovallo, and Sibony 2011). For example, as McKinsey[4] points out, promoters of the Vancouver Expo 86 kept refusing to cancel the project even as the costs ballooned by twenty times, from the original Can$78 million in 1978. This "sunk-cost fallacy" can be particularly fatal to good decision making when linked with other cognitive biases, such as confirmation bias, in this case massively overinflated forecasts of visitor numbers.

We might expect managers of businesses who have sunk lots of money into intangible investments like R&D or setting up new business units to overestimate their value and to be more reluctant to let them go. Indeed, a world in which this behavior was common would see an unsettling psychological shift. Because of the sunk-cost fallacy, we might expect to see more businesses sticking with bad investments that they were better off drawing a line under. What's more, the lack of markets for most intangible assets would make it harder for managers to obtain an external read-out on what their assets were really worth. In the short term, this could lead to overoptimistic overinvestment—and more frequent bubbles.

As well as helping inflate bubbles, the sunken nature of intangible investment could make it more painful when the bubbles finally burst. We're used to the idea that when a market crashes, businesses often have to sell their assets very cheaply, since almost everyone else also wants to sell. This is bad enough when the assets are somewhat fungible, like property or fiber-optic cable: the price plummets, but there is usually at least some residual value. But when a bubble based on sunk, firm-specific intangible assets bursts, there's the risk that the assets will be worth more or less nothing.

In light of this, you might well ask why firms ever make this kind of investment decision at all. First, some of the returns might be very high, high enough to reward all these risks. Second, although the cost might be harder to recover than in the market for secondhand tangible investments, there are other extra-market benefits. An investment in knowledge, even if it fails to create a marketable asset directly, might still be very valuable if it creates

information that resolves uncertainty for the firm. Many firms perform simultaneous research projects: a failure of project A might not directly create a marketable asset (a patent, say), but may very well contribute to the success of project B by revealing what not to do. Thus intangible investment might give a very high payoff via giving very valuable information to the firm about the opportunities that it faces, what is called an "option value" (Dixit and Pindyck 1995). We treat this value as an emergent property arising from the irreversibility/sunkenness of an asset. See the section on emerging characteristics below.[5]

Spillovers

Why Do Intangibles Generate Spillovers?

Some intangible investments have unusually high spillovers: that is to say, it is relatively easy for other businesses to take advantage of intangible investments they don't themselves make.

The classic example is R&D: copying other people's ideas is relatively easy, unless the law prevents it by means of patents or copyrights. In the language of economists, the ideas created by R&D are non-rival—my using a piece of knowledge doesn't prevent you from also using it. In Thomas Jefferson's words, "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me."[6]

Ideas are also to some extent "nonexcludable": that is, it is relatively hard to prevent you from using an idea that I came up with, unless I keep it secret, or unless I can use legal means, like a patent, to stop you. The benefits of non-rival, nonexcludable investments are likely to spill over beyond the companies that make them, and ideas, such as those from R&D, are a prime example. Oral Rehydration Therapy is a perfect example.

But spillovers don't just arise from R&D. After Apple released the iPhone, almost all smartphones started looking just like it. Apple's investments in software, design, and supply chains (for example, creating the software supply chain we call the App Store) were adopted or imitated by its competitors as they sought to create phones like Apple's. By creating what marketing experts would call the smartphone "category" (or more precisely, growing it significantly), Apple benefited not just themselves but other smartphone manufacturers.

The iPhone also provides an example of marketing spillovers. Part of the iPhone's success was a result of Apple's willingness to throw its brand behind the new product. Earlier smartphones had been rather clunky, but Apple had a reputation for making stylish, user-friendly devices. By creating the category, as marketers would say, Apple not only made a lot of profits for themselves (the iPhone is now around 66 percent of Apple's total revenues [Miglani 2016]), but they also helped Samsung, HTC, Google, and other competitors create profitable smartphone businesses.

Perhaps less obviously, we can also see examples of spillovers in organizational design, training, and branding and marketing. In the 1950s and 1960s the consulting firm McKinsey & Company pioneered a new way of providing business advice that was in essence an organizational innovation.

Rather than hiring industry veterans to tell businesses how to improve, which was what most early management consulting consisted of, McKinsey hired graduates from elite business schools and put them to work together in small, focused consulting teams. These teams disaggregated problems into parts using a set of replicable methodologies, allowing bright and hardworking, but relatively inexpert, consultants to work collectively to solve relatively complex business problems. An aggressive culture of performance management and promotion attracted suitably high-flying youngsters and kept them hungry and mean enough to ensure a high work rate.

This set of organizational innovations is now the norm in the management consulting industry. It got that way by being copied; indeed, McKinsey copied aspects of it from the legal profession (McKinsey's managing partner at the time was a former lawyer).

Finally, training spillovers occur every time a trained employee leaves a company and goes to work for another firm where their training is useful.

Now, it must be said that tangible assets might have spillovers: if you own a port and I build a freight railway leading to it, my invest-

ment probably benefits you, to the extent that a well-connected port is more useful and profitable than a poorly connected one. If a popular department store opens a branch in a mall, it may benefit other shops by attracting more passing trade.

But the physical nature of tangible assets makes solving the excludability problem much easier: if I run a bus company that owns a fleet of buses, my competitors can't simply sneak into my depot and use them—the buses have ignition keys and locks, my depot has an alarm, and I have hundreds of years of property law to enforce my rights.

You might just take the view that spillovers would disappear if property rights can be sensibly established. But it seems very hard in practice to do this, despite centuries of trying.

To explain the contested nature of intangibles, let's return to the bus company. We used the bus company as an example of how relatively straightforward it is for a firm to appropriate the benefits of tangible assets. But we slyly failed to specify the country the bus company was based in. While bus companies in developed countries can be fairly sure their buses can't simply be borrowed by others, in some parts of the world this isn't the case.

In 2014 news emerged of a horrific incident in which dozens of students were abducted and, it seems, murdered by some combination of police and organized criminals in the Mexican state of Guerrero. One of the incidental details of the crime was that the students were, at the time they were kidnapped, riding in one of a number of buses they had commandeered to take them to a protest in Mexico City. It turns out that commandeering buses was "routine" and generally tolerated, so much so that the bus companies and their drivers had established protocols for what to do when it happened.

In developed countries, we are not used to people being able to take valuable things like buses and to use them against their owners' wishes. Social norms and law enforcement conspire to make it transgressive and rare. The background to the Guerrero kidnapping is a reminder of how dependent this is on our social context.

But when it comes to intangible assets, the rules around ownership and control are much more contested, even in developed countries. Patents and copyrights are, on the whole, less secure and

more subject to challenge than the title deeds to farmland or the ownership of a shipping container or a computer.

One important reason for this is history. About four thousand years ago, a scribe in the south of what is now Iraq wrote a list on a clay tablet. People in ancient Mesopotamia had been using clay tablets for centuries to write down everything from lists to legends.

But this clay tablet was something different: it was a list of laws, the laws of the King of Ur, Sumer, and Akkad, who was called Ur-Nammu. It is the earliest code of laws that survives today. What's interesting about it for our purposes is that alongside the standard fare of ancient legal codes—dealing with murder, mutilation, fornication—it contains plenty of mentions of property. The code describes people owning land, silver, grain, unspecified other goods, and slaves.

To put it another way, people have been making rules about the ownership of tangible things for as long as they have been making rules at all. The four thousand years that have passed since Ur-Nammu has given human societies a lot of time to think about what ownership of physical things means and how to resolve difficult issues.

This process is not just difficult from an intellectual point of view. It is political and gets resolved not just by brain work but by social and societal conflict, which takes time. The better part of a million people died when the United States fought a civil war over the question of whether it was right to own other human beings. The world reached the brink of nuclear annihilation in a cold war between countries who disagreed on the question of whether owning property was in fact theft. But over time, people's understanding of what it meant to own things grew and became clearer, especially in developed countries with stable legal systems.

Now consider intangible assets. It's a matter of debate when the first law on the ownership of intangible assets was made. People tend to mention late medieval Venetian laws on glass-making techniques and French and English grants of monopolies for protoindustrial techniques in the sixteenth century. But in any case, it was millennia after the Code of Ur-Nammu.

Intangible property laws then went through a process of slow evolution, as the economic historian Zorina Khan has pointed

out (2008). Some early modern English monopolies enjoyed the right to operate what we would call new technologies, but others covered the right to trade (to sell salt or whatever). Gradually, monopolies become restricted to new ideas, and legislators started thinking more programmatically about what a good patent or copyright law should look like.

By the eighteenth century, English patents were becoming more detailed. Rather than a patent to run steam-powered machinery, government granted patents for specific processes that had to be described and published. At the same time, the 1709 Statute of Anne represented the beginning of English copyright law.

The newly formed United States took intellectual property very seriously. Indeed, America's Constitution includes a clause on patents and copyright.[7] The US system was from the start simpler, more rational, and radically cheaper than that of contemporary Britain or France.

This development process continued. Countries started to tweak their patent and copyright systems to encourage more invention. Trademarks acquired legal recognition in various countries in the nineteenth century, creating a legal basis for the idea of branding and marketing assets.

In the 1920s Edgar Rice Burroughs acquired a trademark for Tarzan, one of his fictional creations, in addition to his copyright. This fusion of creative and commercial intangible property is what we have to thank for the media franchises of today, from Star Wars lunchboxes to Princess Elsa costumes. And, of course, today issues of intangible property continue to be contested. Global trade negotiations founder on disputes between the United States and China over piracy and fair use. Patent trolls pursue their controversial calling in the courts of the Eastern District of Texas or of Moscow. Controversies arise when companies try to push the limits of the intellectual property rights in new ways, such as when, in 2015, tractor maker John Deere argued that, under the US Digital Millennium Copyright Act, customers who had bought its tractors did not have the right to repair them themselves.

In the long process of agreeing on norms and rules, tangible property has a three-and-a-half-millennium head start on intangible property. If the same holds true for intangibles, this means 3,500 more years for the technicalities and ethics of ownership to be worked through, debated, and fought over, and more uncertainty.

So the tendency of intangible investments to spill over to other firms works on two levels. On the one hand, it is an inherent characteristic of assets that consist of knowledge, because knowledge is non-rival. At the same time, the difference between the spillovers of tangible and intangible investment are exacerbated by history. The fact that developed countries have better institutions for deciding who owns tangible assets than intangible ones is partly the result of history and the way institutions have evolved.

Why Do Spillovers Matter?

Spillovers matter for three reasons: first of all, in a world where companies can't be sure they will obtain the benefits of their investments, we would expect them to invest less. Second, there is a premium on the ability to manage spillovers: companies that can make the most of their own investments in intangibles, or that are especially good at exploiting the spillovers from others' investments, will do particularly well. Third, spillovers affect the geography of modern economies.

The classic answer to the problem of spillovers is government funding. If businesses can't make the most of their intangible investments, especially in R&D, the government should step in and either fund the research directly (for example, in university or government labs) or support businesses to do it. And indeed, this happens a lot. The US government funds 30 percent of R&D that goes on in the country (Appelt et al. 2016). Public R&D is especially important in areas of basic research and in new fields (like the US military's development of the semiconductor sector in the 1950s.)

Spillovers also affect the behavior of individual companies, as businesses strive to maximize the value of the intangibles they do make. Indeed, a significant part of the strategy of intangible-rich companies is combining and managing their intangibles in such a way as to minimize the spillovers and maximize the benefits they get from them.

Someone who is unusually honest about the lengths businesses go to in order to stop others benefiting from their lovingly created intangibles is venture capitalist and entrepreneur Peter Thiel, the so-called don of Silicon Valley's PayPal Mafia. Thiel's refreshingly candid book on entrepreneurship *Zero to One* makes it clear that the way to create very valuable start-ups is to create businesses that, as far as possible, have monopoly positions in big markets.

In Thiel's management philosophy, you create these defensible opportunities by investing in the right sorts of software, marketing, and networks of customers and suppliers (three classic intangibles) and by bringing them together in ways that competitors find hard to copy.

What's more, the ability to attract the spillovers of other firms' intangible investment is perhaps just as important as the ability to maximize the gain from one's own. Being well networked, knowing about important developments in one's field, and having the standing to bring together collaborations, ask for favors, and coordinate partnerships becomes more important in a business where investments have greater spillovers. After all, exploiting the spillovers from another firm's investment is in some ways a free lunch.

The crudest way companies can keep their knowledge to themselves is through the law. James Watt and the Wright brothers riled their contemporaries with their willingness to enforce patents to stop other people's research on steam and flight, respectively. Patent trolling can be thought of as a pure-play form of this strategy. The patent troll buys up patents, often from defunct companies, and goes around seeking to enforce legal rights against anyone who might otherwise benefit from the spillovers of the original investment. There are good reasons to deplore patent trolling—but it is a pretty straightforward consequence of the spillover characteristic of intangible assets.

If the law isn't strong enough, companies can lobby to have it changed. Copyright lawyers sometimes talk about the Mickey Mouse Curve—the steadily increasing length of copyright in US law that grows just fast enough to stop Disney's iconic mouse from entering the public domain. When Disney first created Mickey, his copyright was due to expire in 1984. Extensions in 1976 and 1998 mean that this won't happen until 2023. And who knows what new laws might be made between now and then.

Patent trolls and copyright lawsuits catch our attention because they are newsworthy, but other ways of capturing the spillovers of intangible investment are more common—in fact, they're part of the invisible fabric of everyday business life. They often involve reciprocity rather than compulsion or legal threats. Software developers use online repositories like GitHub to share code; being an active contributor and an effective user of GitHub is a badge of honor for some developers. Firms sometimes pool their patents; then they realize that the spillovers from each company's technologies are valuable, and that enforcing everyone's individual legal rights is not worth it. (Indeed, the US government helped end the patent war between the Wright brothers and Curtiss Aeroplane and Motor Company that was holding back the US aircraft industry in the 1910s by getting everyone to set up a patent pool, the Manufacturers Aircraft Association.)

Finally, to reap the benefits of spillovers people can organize themselves in various ways. One of the most obvious of these is into cities. As Edward Glaeser, one of the leading economists working on cities, has put it, one of the puzzles of urbanization is the increased willingness of people to pay very high rents to live next door to other people paying very high rents (Glaeser 2011). This seems a particular puzzle in our connected world, where the importance of proximity would surely have declined. One answer is that the spillover benefits of living in cities have increased. Indeed, given the undoubted increase in the *disbenefits*—congestion, prices, and air pollution—there must be some offsetting benefits, and those might very well be around the chances of more interactions and collaborations.

All this means that in an intangible-intensive economy, the ability to make good the problem of spillovers becomes very important. This calls for a particular range of skills: technical skills to understand the intangibles themselves, such as scientific or engineering knowledge; in some cases, legal expertise or a talent for deal-making; in others, softer skills like leadership and networking. And it calls for more living together in cities. We will explore the implications of these skills for inequality in chapter 6.

Synergies

Why Do Intangibles Exhibit Synergies?

Ideas and other ideas go well together. This is especially true in the field of technology.

Take the microwave oven. Toward the end of the Second World War, the US defense contractor Raytheon was busy mass-producing cavity magnetrons, a sort of vacuum tube that was an important part of the radar defenses the British had pioneered earlier in the war. Percy Spenser, an engineer working for Raytheon, realized that microwaves from the magnetrons could heat food by creating electromagnetic fields in a metal box.

Within a few years, the technology was sufficiently advanced that you could buy a "Speedy Weeny" microwaved hot dog at a novelty stand in New York's Grand Central Station. A few companies tried to sell domestic microwave ovens, but none were very successful. Then, in the 1960s, Raytheon bought Amana, a white goods manufacturer, and combined their microwave expertise with Amana's kitchen appliance knowledge to build a more successful product. At the same time, Litton, another defense contractor, invented the modern microwave oven shape and tweaked the magnetron to make it safer.

In 1970 forty thousand microwaves were sold. By 1975 it was a million. What made this possible was the gradual accumulation of ideas and innovations. The magnetron on its own wasn't very useful to a customer, but combined with other incremental bits of R&D and the design and marketing ideas of Litton and Amana, it became a defining innovation of the late twentieth century.

The story of microwave ovens is entirely typical of how new technologies evolve. Brian Arthur of the Santa Fe Institute wrote a memorable book, *The Nature of Technology* (2009), which made the point that technological innovation was "combinatorial." That is to say, any given technology depends on the bringing together of already-existing ideas. In Arthur's words: "Every novel technology is created from existing ones, and therefore . . . every technology stands upon a pyramid of others that made it possible in a succession that goes back to the earliest phenomena that humans captured."

Science writer Matt Ridley took the idea a step further, stressing the evolutionary nature of ideas. "Exchange is to cultural evolution as sex is to biological evolution"; Ridley described innovation as what happens "when ideas have sex" (Ridley 2010, 453).

Another way of looking at this is to say that intangible assets—ideas, like the outputs of R&D, new designs, or new ways of structuring a business or marketing a product—have synergies with one another; they are worth more when you combine them. Now, tangible assets have synergies too. A bus and a bus stop; a supply of electricity and a Marshall stack; a PC and a printer. But the scope of different ideas to interact, and the fact that ideas are not expended when they are combined, makes the potential synergies much higher.

The microwave oven story also reflects another aspect of the synergies between different ideas—that they are often unpredictable and jump across domains. In this case, military information technology gave rise to a kitchen appliance. This kind of exaptation seems to happen again and again in the world of ideas, making it relatively hard to predict where synergies between intangibles will arise.

Intangible investments also show synergies with tangible assets, in particular information technologies, especially networked computers and smartphones. A striking example of this is the role of Walmart in saving the US economy in the 1990s. In the 1980s the US economy had been experiencing sluggish real productivity growth. People worried this was becoming a "new normal" and that growth might never recover. But as the 1990s went on, productivity went up. In 2000 the McKinsey Global Institute analyzed the sources of this productivity increase. Counterintuitively, they found that the bulk of it came from the way big chains retailers, in particular Walmart, were using computers and software to reorganize their supply chains, improve efficiency, and lower prices. In a sense, it was a technological revolution. But the gains were realized through organizational and business practice changes in a low-tech sector. Or, to put it another way, there were big synergies between Walmart's investment in computers and its investment in processes and supply chain development to make the most of the computers.

It's a relationship that has been documented in detail by Erik Brynjolfsson, an economist at MIT and a guru of the digital economy. Brynjolfsson's research showed that organizational investment and tech investment were highly complementary; that is to say, the businesses that got the most out of their whizzy software were the ones that invested in organizational change too (Brynjolfsson, Hitt, and Yang 2002). Nicholas Bloom, Raffaella Sadun, and John Van Reenen (2012) compared the productivity of American businesses that invested in IT to European ones and found that European ones didn't get the same level of benefits from computers because they weren't willing or able to change organizational and management practices as much.

The synergies between IT and intangibles work on a couple of levels. First of all, computer hardware has a direct, and in a sense trivial, synergy with one type of intangible: software. That's the point of software. To put it another way, computers are physical devices that become useful and valuable when you fill them with useful, *intangible* information.

Because computers and networks of computers deal in information, they also help make other intangible investment easier or more effective. Consider the network of big sharing-economy companies like Uber or AirBnB. There is nothing about their business models that absolutely requires computers and the Internet. Before everyone had a smartphone, there were networked cab companies, some of which, like London's ComCab or Radio Taxis, used independent drivers. Before AirBnB, there were house-share clubs with brochures and telephone booking systems. Both the house-share clubs and the taxi networks made investments of time and money to develop their networks of suppliers.

But in both cases, the Internet and smartphones made it possible to build very big networks, to do it more cheaply, and to strengthen the value of being a member of the network (through ratings and searchability, for example). Here again, there is a strong synergy between IT—technologies that deal with information and networking—and intangible investment, which to a great extent is investment in information and connections.

So it seems that intangible investments have synergies with one another, whether they relate to ideas (which have a tendency to create new ideas when you bring them together) or new structures (which seem to be complementary to new technologies). What's more, it's often difficult to predict how these combinations will happen or to plan them: serendipity and chance seem to play an important role.

Why Do the Synergies of Intangible Assets Matter?

If the spillovers of intangibles encourage companies to keep their investments to themselves, or at best to share in a self-interested way, then the synergies of intangibles have the opposite effect.

If your ideas are worth more when combined with other ideas, there's a strong incentive to get access to as many ideas as possible. One manifestation of this is the increasing prominence of open innovation.

In its simplest form, open innovation happens when a firm deliberately connects with and benefits from new ideas that arise outside the firm itself. Cooking up ideas in a big corporate R&D lab is not open innovation; getting ideas by buying start-ups, partnering with academic researchers, or undertaking joint ventures with other companies is.

Open innovation became a management buzzword in the 2000s, after it was popularized in a best-selling management book (of the same title) by Henry Chesbrough, though other researchers had been observing it since at least the 1970s, and companies had been doing it long before that.

Consider nineteenth-century blast furnaces, an example famously analyzed, using very detailed contemporary records, by Robert Allen from Oxford (1983). Key determinants of the efficiency of blast furnaces were height and temperature. But the physics of the time were inadequate to allow an engineer to deduce the optimal design for the blast furnace. So how did they design it? There was a host of experimentation with different heights and temperatures by local entrepreneurs. Regional and national societies, like the Institution of Cleveland Engineers, the South Wales Institution of Engineers, the Institution of Mechanical Engineers, and the 1869 Iron and Steel Institute swapped information. What was the outcome? As Allen described, this "open" innovation transformed the industry:

> Between 1850 and 1875 several important changes in blast furnace practice were developed in England's Cleveland district. The most dramatic were the increase in the height of the furnace from fifty feet—the previous norm—to eighty feet or more, and the increase in the temperature of the blast from 600°F to 1400°F. Together, these improvements reduced the fuel requirement for making pig iron enough to justify scrapping the original short, low temperature furnaces and replacing them with the new designs. (Allen 1983, 3)

Much of the rhetoric around open innovation today takes an almost moral tone: it's about sharing knowledge; it is about working together; it is even about humility. This moral aspect of open innovation derives from the synergies of intangible investment—which can make sharing ideas mutually beneficial. (There's also a sense in which open innovation is more self-interestedly about exploiting the spillovers of other firms' investments, but that tends to be less talked about.)

What's particularly interesting is that the existence of synergies between ideas creates a tension with the spillovers we discussed above—a dilemma for intangible-rich businesses. Closing itself off to the world and relying on strong intellectual property law can help keep a firm's intangibles from spilling over, but it's a fatal sort of isolation because it reduces the opportunities for synergies with other people's ideas—and most ideas are other people's ideas. In Bill Joy's words, "no matter who you are, most of the smartest people work for someone else" (Lakhani and Panetta 2007).

The effect of the synergies of intangibles also matters at the level of national and local economies. If my business's research or process innovations become more valuable if your business and a dozen other businesses are also coming up with great, synergistic ideas, an economy can end up in either a virtuous or a vicious cycle. If everyone else is doing research or developing new processes, and if that makes my investment more valuable, it is in my interests to invest in R&D too. If no one else is, it may not be worthwhile for me either.

This idea of complementary know-how sits at the heart of the idea of the "industrial commons," developed by economists Gary Pisano and Willy Shih (2009). Pisano and Shih argued that America's manufacturing sector was suffering because there was no longer enough expertise and research in basic industrial processes needed to create a shared knowledge base.

The synergies between ideas also create a tension between serendipity and coordination. On the one hand, the vast number of ways that ideas can combine usefully makes it hard to plan centrally. The accidental discovery of new properties of technologies—like how the magnetron became the microwave—seems to be a common phenomenon.

Based on this logic, if we want to increase productive investment in ideas, we should encourage "interdisciplinarity," casual exchanges between people working in different fields and diverse places. Where these exchanges will happen a lot is in large, walkable cities with plenty of public spaces and opportunities for social interaction.

On the other hand, sustained research in a particular area matters too. At least some of the synergies between different ideas work best in a particular field. The microwave oven was a success not just because of the radical leap from military communications to cooking, but also because lots of researchers from Amana, Litton, and their Japanese competitors worked on the design and improved the technology of the magnetron.

Sometimes this coordination happens spontaneously. But we can also think of things that help it along. Prizes, like the eighteenth-century Longitude Prize or the twenty-first-century Ansari-X Prize for private spaceflight, can help crowd investment into a neglected area. No doubt, part of the reason the technology press hypes new technologies, like the Internet of Things or solar energy, is not only because it makes for more exciting stories, but because it also has a functional role of drawing attention to up-and-coming areas and encouraging coordinated investment. Perhaps the hype is misplaced; but the role of encouraging coordination is important nevertheless.

Finally, the synergies between intangibles can be a valuable competitive tactic for individual companies. Consider the epipen—or rather the EpiPen®. EpiPens are the pen-like devices that can give epinephedrine (hence the name) injections, thereby saving the lives of people suffering from anaphylactic shock. EpiPen is by far

the market-leading epinephedrine device. But this isn't because it has patented epinephedrine, which is in the public domain. Nor does it have an uncopiable design: several competitors have come up with alternative designs for injectors, some of them arguably better than the EpiPen. But a combination of intangibles has kept it as the market leader: the name and brand, its design, the widespread understanding among first aiders of how to use the device all act to make it hard for competitors to succeed (we discuss the EpiPen some more in chapter 5).

These synergies not only give companies an advantage over competitors: they also affect the dynamics between companies and their talented employees. Consider an expert designer at Apple, a company famed for, and to some extent reliant on, its good design. What stops that designer, from an economic point of view, demanding more and more money in return for not leaving for the competition or setting up a new, design-led start-up?

One answer to the question is synergies. Apple's design is especially valuable in the context of a whole set of intangible assets Apple owns: its technologies, its customer service, and the power of its brand and marketing channels. All of these things make an Apple designer more valuable to Apple than to an alternative employer, and they reduce the incentives to leave.

So, synergies matter because they create strong incentives for companies and governments to bring together different intangibles, especially new ideas. To this extent they work in the opposite direction of spillovers, encouraging openness and sharing rather than appropriating. They also matter because they create an alternative way for firms to protect their intangible investments against competition: by building synergistic clusters of intangible investments, rather than by protecting individual assets.

Some Emergent Characteristics of Intangibles Due to the Four S's

So we have seen that intangible investments differ from tangible investments in a number of ways: they are more likely to be scalable, to have costs that are sunk, to generate spillovers, and to exhibit synergies with one another.

Let's conclude this chapter by noting that these properties combine to produce two other, more general characteristics of intangibles: *uncertainty* and *contestedness*.

Any investment, tangible or intangible, is a step into the unknown. No business can know for sure what the return will be. But it seems that because of the four S's we have discussed, intangible investment has a tendency to be more uncertain. First of all, owing to its *sunkenness*, intangible investments tend to be worth less if they go wrong. It's harder to recover their value by simply selling them. Second, the upside of an intangible investment is potentially much higher, since it is more likely to benefit from *scale* (so a modest investment can reap a big return) or *synergies* (increasing its value directly). So when things go wrong, intangibles tend to be worth less, and when they go well, they tend to be worth much more.

But this is not just a case of replacing a narrow distribution of possible outcomes with a wider one. The tendency of intangible investments to generate *spillovers* makes it radically harder to estimate the future returns to the company making the investments. And the absence of markets for many intangibles (which contributes to their *sunkenness*) makes it harder to form a realistic estimate of their value.

All other things being equal, then, we would expect firms in an intangible-rich economy to exhibit more uncertainty. And part of this uncertainty shows up in giving intangible firms *option values* to their investment. Consider an intangible investment that is sunk and proceeds in stages. At each stage, the firm might learn something, say, about the feasibility of the investment. That information is valuable to it, especially if the spending is sunk. So intangible investment tends to have an option value associated with it (see the discussion above).

Intangibles also tend to be *contested*. People and businesses will often vie to see who can control them, own them, or benefit from them. This is partly a function of *spillovers*. As we have seen, businesses often seek to get the benefit of intangible investments made by other firms. Sometimes this happens by mutual consent (for example, when businesses undertake open innovation); sometimes not (for example, Google's development of the Android operating system, which enraged Apple's Steve Jobs).

Synergies between intangibles also increase their contestedness. When particular combinations of intangibles are unusually valuable, the power of people who are sufficiently networked or knowledgeable to broker these connections increases, a theme we will return to in chapter 6.

Contestedness is exacerbated by the ambiguity of rules over who owns intangible investments: firms dispute patents so often because the ownership of intangible property is less well established and less clear-cut than the ownership of tangible property.

Conclusion: The Four S's of Intangibles

Intangibles have four unusual economic properties. These properties can exist with tangible investments, but on the whole intangible assets exhibit them to a greater degree. These characteristics are:

- Scalability
- Sunkenness
- Spillovers
- Synergies

Three further characteristics emerge from these four, namely, uncertainty, option value, and contestedness. The rest of the book discusses the consequences of an increasingly intangible-rich economy that emerge from these characteristics.

PART II

The Consequences of the Rise of the Intangible Economy