What is Innovation?

Approaches to Distinguishing New Products and Processes from Existing Products and Processes

Bruce S. Tether

ESRC Centre for Research on Innovation and Competition (CRIC)

University of Manchester and UMIST

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Abstract

Innovation is widely perceived to be central to the competitiveness of firms and countries. But is innovation? This paper argues that the notion of innovation is frequently confused, between innovation as achievements, innovation as the impact or consequences of achievements, and innovation as an approach to business and life. The paper is intended to provide some clarity in understanding innovation, and different conceptualisations of it. The paper also discusses the identification of innovations. In particular, it reviews some conceptual and practical approaches to distinguishing new products and processes from existing products and processes.

1. Introduction[1]

Innovation is widely perceived to be central to competitiveness, both at the level of the firm and at the level of countries as a whole. Lord Sainsbury, the UK government minister with responsibility for science and innovation, has stated:

> It is impossible to overstate the importance of innovation. It is one of the key drivers of productivity. It can help businesses improve the way products and services are made and delivered or introduce entirely new ones. It can reduce costs by increasing efficiency. Evidence shows that innovating companies sustain a higher performance and grow faster than non-innovators. Innovation is a source of real competitive advantage for individual businesses. For the economy as a whole, it is central to our prospects for sustained prosperity. … Innovation is about anything that enables a business to improve the products and services it can offer. Exploiting new technology may be one way of doing so. But it is equally likely to come from adopting a new business process, using new management techniques or increasing the skills of your workforce.[2]

Elsewhere, innovation has been defined as the successful exploitation of ideas, or turning ideas into profitable products, processes, services or business practices. But central also to the concept of innovation is doing something exceptional, and therefore dealing with uncertainty and risk taking. Innovation takes many forms, but the two forms that have received the greatest attention are new products and new processes. The central purpose of this paper is to provide some clarity of what innovation is, and in particular to assist with an understanding of how to distinguish new products and processes from existing products and processes.

In order to understand what innovation is, and more particularly to draw a distinction between new and existing products and processes, it is important to provide a context for that understanding. This paper takes the following structure.

Section 2 provides the context by outlining three concepts of innovation and innovativeness. This distinguishes between innovation as achievements 9such as the introduction of new products or processes) from two other things: firstly the consequences or impact of those achievements and secondly from the ability to innovate.

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[1] This paper is based on a research report undertaken for the Innovation Operations department of Competitive Business within Scottish Enterprise. That report, entitled 'How to Define a New Product and a New Process: A Review of Existing Approaches', was intended to assist Scottish Enterprise with the development of a common understanding across the Scottish Enterprise Network about what distinguishes a new product or a new process from an existing product or process. We are grateful to Scottish Enterprise, and in particular Iain Hutchinson, for funding this research, and for agreeing to make the results publicly available. The views expressed are those of the author; they do not necessarily reflect the views of Scottish Enterprise.

[2] Speaking at the London Innovation Conference, 17th March, 2003. Available at: http://www.dti.gov.uk/ministers/speeches/sainsbury170303.html

Section 3 provides a conceptual review about what is and what is not a new product or a new process.

Section 4 is concerned with methodologies used to practically identify new products and new processes.

Section 5 provides a summary and set of recommendations.

2. Three Concepts of Innovation

We have seen that policy makers claim innovation is vital to the economy and the success of individual businesses, but what is innovation? In this section, we argue that the concept of innovation is often confused. In thinking about innovation, people frequently have in mind – and confuse – three different conceptualisations. The first is *innovation as achievement*. The second is the *consequences* or impacts that arise from achievements. The third is the *capacity to change*. We discuss each of these in turn.

2.1 Innovation as (Technological) Achievement

When we think about our lives and the technologies that enhance them we think about innovations as achievements. It is hard if not impossible to rank the 'greatest innovations'.[3] Some would say the contraceptive pill, others the telephone, television, semiconductors, the electricity grid, the car, central heating, the national health service, etc. Thirty years ago one author undertook as study of ten (significant) innovations.[4] These included: variable geometry aircraft; vehicle engines; electronically controlled knitting machinery; the float glass process developed by Pilkingtons; semiconductors; colour television; nuclear power; oscilloscopes; olefin plants for ethylene production; and numerical control systems for machine tools. Some of these have stood the test of time – we would still consider them highly significant today – others have declined in significance. With a little imagination it is not difficult to think of innovations that are, or might be, desirable – a cure for cancer, for aids, or malaria, a simple and effective way of purifying water, a tele-transporter (or teleport) which would allow us to move in physical space

[3] Although the Encyclopædia Britannica provides a web site listing a large number of "Great Inventions". http://corporate.britannica.com/press/inventions.html. In fact, most if not all of these are innovations, not just inventions. An important distinction between invention and innovation is that an innovation has been commercialised where as an invention has not. See also http://inventors.about.com/library/bl/bl12a_e.htm and http://www.greatachievements.org/ amongst the many other web-sites (14,400) that come up when the term "great inventions" is entered in the google search engine (google.com).

[4] Layton, Christopher (with Christopher Harlow and Charles de Hoghton) (1972) *Ten Innovations*, George Allen and Unwin Ltd, London.

cheaply and instantaneously. Of course, what is and what is not desirable can be hugely controversial.

When we think about 'great inventions' or 'great innovations' we tend to think primarily about the impact of the innovation, but that impact was rarely if ever fully anticipated at the time the innovation was first introduced. There are many examples of inventors failing to recognise the potential of their ideas. Alexander Graham Bell, for example, is reported to have thought that the telephone might be used to call ahead to the next town to tell them a telegram was coming. This seems absurd, but largely because we think of technology as unchanging – Bell's telephone should not be compared with the telephone systems of today. Most 'great inventions' are part of technological systems, which were not invented in a flash of genius, but have instead evolved over time. As Gilfillan observed in 1935, "what is called an invention is the perpetual accretion of little details".[5] One reason why some notable technological advances are not adopted to any great extent is because 'mainstream technologies' are often cumulative and 'path dependent' - they build upon one another. Some radical technologies are overlooked because they imply too much disruption to the existing system. We will return to this idea of inventions, or innovations, as systems later in this paper.

It can be difficult to know how easy it will be to develop a new technology, and the extent to which people will want to use it when it is available. For economists, these represent two types of uncertainties in the development of new technologies – technological uncertainties (will it work?) and market uncertainties (will it sell, how quickly, and will competitors quickly introduce their own versions of the product if it proves successful?). In 2000, the UK auctioned radio-spectrum necessary for the provision of third generation (or 3G) mobile phones – five firms paid £22.5bn to the government for the licences to use this spectrum. At that time they presumably believed that the new phones, which allow much greater data-exchange thus permitting new services, such as photo and video-messaging, would be both technically feasible and desired by customers. In fact, the technical difficulties meant the new phones took longer than expected to reach the market, whilst other technical developments meant that the existing infrastructure – developed into what is called 2.5G - was able to provide some of these new services, thus undermining demand for the next generation of phones. Furthermore, the uptake by consumers has been slower than the firms anticipated, as most consumers seems reluctant to

[5] Gilfillan, S. C. (1935) *The Sociology of Invention*, MIT Press, Cambridge, Mass, page 5. Note that Gilfillan uses the term 'invention'. Today we would use the term innovation. Technically, an invention becomes an innovation when it is introduced commercially, usually as a new product (good or services) sold to other businesses or consumers, or used as a new process in the firm's own activities.

use their phones other than as simple communication devices. With the benefit of hindsight, it would appear that the firms paid too much for these licences. Christopher Bland, Chairman of British Telecom, is on record as regretting that BT spent £4bn on its 3G licence.

When we think about innovations as achievements,[6] we should try to think about them in their technological and temporal context – not in terms of their commercial or social impact. There are probably two main types of technological achievement:

1. **Achieving a significant leap forward in the technological frontier**. This often involves overcoming some widely recognised technological bottleneck. This gives rise to new technologies.

2. **Re-conceptualising existing problems** and thereby restructuring technological systems. This is primarily associated with the creative use of existing technologies.

2.2 Innovation as the Consequences of Achievements

As we have just argued, 'great inventions' or 'great innovations' are primarily thought great because of the consequences of technologies, and not necessarily because of the novelty of the achievement itself, which in any case has usually transformed substantially from the original achievement through the accretion of little details. Conceptually, we should try to separate the two things – one is the achievement itself, the second is the extent to which it is valued or comes to have an impact on our society. Consider, for example, two aircraft: Concorde and the Boeing 747 ("Jumbo"). Both were developed around the same time, and both were very significant technological achievements. Both were developments along technological trajectories: Concorde was the next logical step in terms of speed; the Boeing 747 was, on the other hand, not any faster than existing aircraft, but was a leap forward in terms of size, and as such was the next logical step in terms of efficiency. Arguably, Concorde was the more impressive technological feat, but it was never profitable and is now being withdrawn from service. Meanwhile, the Boeing 747 has become the symbol of the success of global aviation.

The development of another aircraft also holds some lessons for understanding innovation and its consequences. Airbus is currently developing the A380 "super-jumbo", the initial versions of which will carry about 550 passengers, compared with around 400 in a Boeing

[6] Of course, not all achievements are innovations. The 'conquest' of Everest was an achievement but not itself an innovation, although the development of new technologies probably facilitated the ascent. We should be careful of 'technological determinism' here. The existence or development of the new technologies did not make the conquest of Everest inevitable. Furthermore, what we regard as great achievements – either in existence or that we desire – reflect our culture and society – technologies are not independent of their context.

747. The development of the Airbus A380 certainly represents a technological challenge, and more so for Airbus than it would for Boeing, as Airbus does not currently have direct experience with the production of aircraft approaching this size, whereas Boeing does. In this sense, innovation is relative. But the A380 is more than a technological challenge, it also reflects an understanding of how the market for air travel is expected to develop, an understanding that is not necessarily shared by all. At least publicly, Boeing claim "We have a completely different view of the future (from Airbus)".[7] Fundamentally, Boeing believe that passengers will increasingly want more direct – 'point-to-point' – services, which will mean less demand in the near future for very large aircraft such as the A380 than Airbus expects. Airbus's market forecast is based on the further growth of hub-and-spoke operations out of already congested airports like London Heathrow and Tokyo Narita. Only time will tell who will be right, but whoever is wrong will look foolish, while whoever is right will be hailed a sage.

But apart from highlighting the importance of market uncertainty, the development of the A380 also has another profound consequence – it introduces competition in the very large aircraft market, a market in which Boeing has held a monopoly for 30 years since the introduction of the Boeing 747. When firms face competitors in a market they are likely to behave differently – in terms of pricing, product development and customer relations - from when they hold a monopoly. What is important here is that innovation has unintended consequences that benefit everyone. Economists call these unintended consequences **spillovers**, or **positive externalities**.

However, although innovations tend to have positive externalities, not all positive externalities are caused by innovation.[8] Suppose, in order to reduce the cost of transporting their goods to the markets on the mainland, a group of manufactures on an island gather together to build a bridge between their island and the mainland. The technology used to build the bridge is not new – the same technology has been applied many times before, but as a consequence of building the bridge the tourist industry on the island receives a significant boost. Should we describe this boost to the tourist industry as innovation? The answer is no. The benefits to the

[7] Randy Baseler, vice president of marketing for Boeing Commercial Airplanes, quoted at the Paris Airshow, 2003. See: http://seattlepi.nwsource.com/business/126952_airshow17.html
[8] Innovations can also be associated with negative externalities, such as pollution.

island's tourism industry are a 'spillover benefit', an unintended consequence that arose following the construction of the bridge.[9]

Now suppose that the bridge had instead been paid for by the tourist industry on the island. For simplicity, consider that the island is owned by one firm and is operated as a resort. By building the bridge, the resort owner intended to increase the accessibility of the resort and thereby increase the number of tourists wanting to visit the island. Again, the bridge is made of conventional rather than new technologies. Is this an innovation? This is more difficult to judge. Although not a technological achievement, the bridge might be considered an innovation because the resort owner has taken a (calculated) risk that its construction will enhance his product sufficiently to transform the (level and/or quality of the) demand for it. Whether or not the bridge is considered an innovation depends on the extent to which the resort owner has taken a risk and backed that risk with investments that are substantial and largely irretrievable. Economists term these irretrievable investments sunk costs. If the risk (and sunk cost) is small, such as building a slide for the swimming pool, this is not an innovation, even if the consequences are massive. Moreover, arguably innovation is relative not absolute. The same bridge constructed by an international resort operator such as P&O constitutes a lower risk than if it is built by a small independent operation. It is 'product differentiation' or 'product enhancement'. Clearly, it can be difficult to draw a line between innovation and product differentiation or product enhancement.

Fundamentally, though, it is important to distinguish between the nature of the achievement (such as whether it involves technological and/or market uncertainty and therefore risk) and the (intended and unintended) **consequences of that achievement**. The notion of risk or uncertainty is fundamental to innovation, but there is also a fundamental difference between calculated risk taking and reckless gambling.

2.3 Innovation as 'Dynamic Capabilities'

According to Richard Branson:

> An innovative business is one which lives and breathes "outside the box". It is not just good ideas, it is a combination of good ideas, motivated staff and an instinctive understanding of what your customer wants.[10]

[9] Note that even if the bridge was the result of new technologies, and was constructed in a novel way, the benefits to the tourist industry would remain a 'spillover benefit' of constructing the bridge, although in this case the bridge itself would be considered a technological innovation.

Richard Branson is much admired as a businessman and entrepreneur, but is less widely associated with innovation, and certainly technological innovation.[11] This conceptualisation of innovation – as a process – is becoming more widespread. Here, innovation is less associated with particular acts or achievements (and their consequences), and is more associated with an attitude of mind, and a whole ensemble of behaviours and practices associated with that attitude. This relates to the final observation in the last section – that there is a distinction between calculated risk taking and reckless gambling, just as there is a distinction between innovation and luck.

We have all heard of the idea that, given an infinite amount of time, an infinite number of monkeys would manage to type to complete works of Shakespeare. Underlying this is the idea of chance, or serendipity. Great works, or inventions, can happen by accident! In reality, advances in technology or other areas of human endeavour rarely happen by chance, and even if they do, 'Chance favours the prepared mind', as Louis Pasteur said. The story of Alexander Fleming and the discovery of Penicillin is pertinent here. On returning from holiday in 1928 Fleming was cleaning up petri dishes he had left out before going on holiday. A curiosity caught his attention – a clear halo had emerged around a yellow-green mold. This indicated something to Fleming. He soon discovered that the mold was releasing a substance that was killing the bacteria in the halo around it – this substance was penicillin. Without his prepared mind, Fleming would have discarded the evidence that led to one of the great scientific discoveries of the 20th Century.

The point here is that research, development and innovation are systematic and managed processes. They are processes focused on the ability to learn and adapt. A truly innovative firm is not one that introduces a new product 'once in a blue moon', but is instead one that is continuously engaged in practices intended to enhance the probability that it will 'discover' new or better products or processes of making them. Innovative firms are therefore alive to new ideas. They are likely to develop several new product concepts, or ideas of how to change their existing processes – even though many of these will not be implemented. Central to this concept of innovation is being alive to change. Being flexible – being able to adapt what is done in different circumstances, such as to particular customers needs – is usually insufficient to constitute being truly innovative.

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[10] On publicity material for the London Innovation Conference, 17th March 2003 - http://www.event-org.com/html/lda.pdf

[11] Branson is associated to some extent with the adoption and use of new technologies, rather than with the production of new technologies.

In the jargon, we say that firms that are innovative tend to have 'dynamic capabilities'. 'A dynamic capability is a learned and stable pattern of collective activity through which the organisation systematically generates and modifies its operating routines in pursuit of improved effectiveness. ... Dynamic capability is exemplified by an organisation that adapts its operating processes through a relatively stable activity dedicated to process improvements'.[12] The ability to learn and adapt is central to this conceptualisation of an innovative business. Moreover, innovation can and does arise in strange places – even in the way in which airports use their runways, for instance.[13]

According to the European Commission's Green Paper on Innovation, "The innovative firm thus has a number of characteristic features which can be grouped into two major categories of skills:

- **strategic skills:** long-term view; ability to identify and even anticipate market trends; willingness and ability to collect, process, and assimilate technological and economic information;

- **organizational skills:** taste for and mastery of risk; internal co-operation between the various operational departments, and external co-operation with public research, consultancies, customers and supplier; involvement of the whole of the firm in the process of change, and investment in human resources."

In the context of the current paper, it is worth noting that innovation in the sense outlined above does not necessarily coincide with innovation in the form of introducing new products and new processes.

[12] Zollo, M. and Winter, S. (2002) 'Deliberate learning and the evolution of dynamic capabilities, *Organization Science*, 13.3, pp. 339 – 351.
[13] Tether, B. S. and Metcalfe, J. S. (2003) 'Horndal at Heathrow? Capacity Creation through Co-operation and System Evolution', *Industrial and Corporate Change*, 12.3, pp. 437-476.

3. Conceptual Approaches to Defining New Products and New Processes

Having discussed innovation in broad terms, we now turn to the definition of new products and new processes. Although there are other dimensions to innovation, the introduction of new products and new processes are the most directly measurable outputs of innovative activity.[14] This does not mean the identification and measurement of new products and new processes is unproblematic, especially in activities other than manufacturing.

3.1 Conceptualising Products, and New Products

A product is essentially a static concept. It is generally 'an end' - something that is provided by a producer to a user, which is valued by the user as fulfilling some purpose – it is simultaneously an output of a producer and an input to a user. Users frequently combine products from one or more producers to produce their own products. With tangible goods, there is generally a transfer of property rights involved, but this is more complex in the case of intangible products and (relational) services.

Product Characteristics of a Car

Technical Characteristics	**Service Characteristics**
Engine - number of cylinders, etc.	Acceleration and speed
Transmission – automatic, manual, etc.	Comfort
Brakes – drum, disc, anti-lock, etc.	Carrying Capacity: Seats & luggage space
Suspension – coil sprung, leaf sprung, etc.	Kudos
Etc.	*Etc.*

In conceptualising products, we follow Saviotti and Metcalfe, who distinguished two aspects of a product – what it is (i.e., its technical characteristics) and what it does (i.e., its service characteristics).[15] As consumers, we are mainly concerned with what a product does (or is perceived to do),[16] not how it does it. We are mainly interested in the service characteristics of a product and the price at which it is available. The table above outlines some of the product characteristics of a car. Some of the technical characteristics are shown on the right, whilst some of the service characteristics on the left. The 'pattern of mapping' between the technical

[14] Employment or expenditures on R&D are also used as measures of innovation activity, but R&D is essentially an input rather than an output measure of innovative activity.

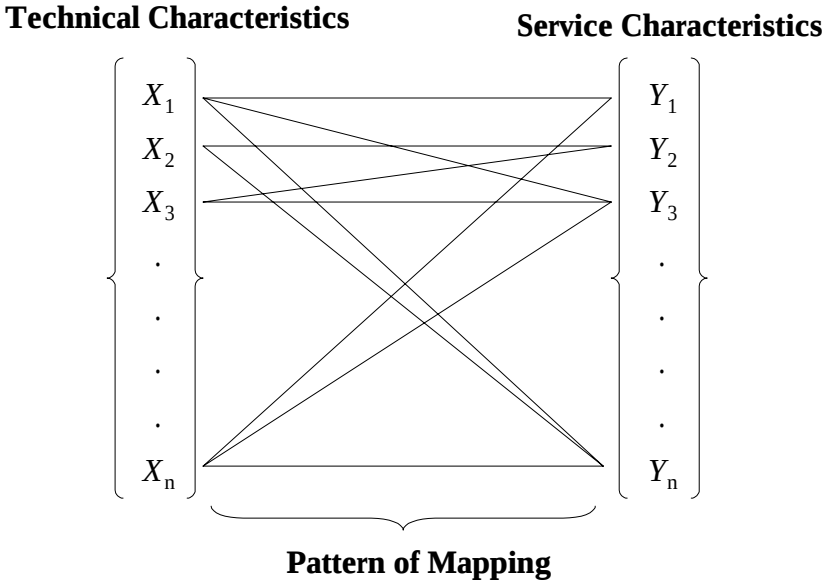
[15] Saviotti, P. P. and Metcalfe, J. S. (1984) '*A Theoretical Approach to the Construction of Technological Output Indicators*', Research Policy, 13, pp. 141-151.

[16] This includes both its objective function and its subjective function – a branded good may be perceived to enhance the status of the user. Admittedly, users may not be fully conscious or aware of why they chose to adopt one product rather than another. Certainly, we should not assume there is one universal rationality in the adoption of goods and services.

characteristics and the service characteristics is generally complex, rather than a simple one-to-one mapping.

Conceptualising a Product

Following Saviotti and Metcalfe, 1984



The figure above represents Saviotti and Metcalfe's (1984) conceptualisation of a product, which is composed of three elements: the (vector of) technical characteristics – each technical characteristic has a value, or weight; the (vector of) service characteristics – each service characteristic has a value, or weight; and the 'pattern of mapping' between the technical and service characteristics. Before proceeding, we should note some caveats. Firstly, whilst the technical characteristics are likely to be definable and measurable, this is less clearly the case with all of the service characteristics. Comfort and kudos are difficult to measure except through proxies. Kudos in particular may not relate directly to the particular product, but to a sort of metaproduct, an important part of which is reputation, which has been built over time, through advertising and brand development and the experience of users. For example, Skoda and Audi are part of the same company group, and most of their products are based on the same technical platforms, but an Audi is more expensive and is generally thought to have greater kudos than a Skoda, not because of their current products but because of their past products. Secondly, and following from the understanding that the service characteristics are not always precisely definable and measurable, the 'pattern of mapping' between the technical characteristics and the service characteristics will not be precisely understood.

Within Saviotti and Metcalfe's framework, five types of change are possible:

1. A change in the absolute values of one or more of the technical characteristics (X_i). This includes the disappearance of certain characteristics (if the value of X_i falls to zero), and the appearance of new features (if the value of X_i, which was zero and thus a latent characteristic, increases above zero).

2. A change in the mixture or balance of the technical characteristics (X_i). This will often be a consequence of the change (1. above) of the absolute values of one or more of the technical characteristics

3. A change in the pattern of mapping between the technical characteristics and the service characteristics.

4. A change in the mixture or balance of the service characteristics.

5. A change in the absolute values of one or more of the service characteristics.

It is clear that, whilst conceptually separate, most of these changes are interdependent. Nevertheless, we can imagine a case of *pure substitution* where exactly the same set of service characteristics are fulfilled by an alternative technology – or set of technical characteristics. Imagine perhaps a new type of computer able to run Microsoft Office no faster nor slower and no more reliably than the current computers so we would not know the difference. Another case would be digital television replacing analogue television, but with no more channels, no change in the quality of reception, and no additional interactive features. Essentially the same product is being provided (in terms of its service characteristics), but by different technical means. Such pure technical substitution is only likely to occur if the new technologies are cheaper to produce and/or use resources (such as the radio spectrum) more efficiently than the pre-existing technologies.

On the other hand, if an entirely new set of service characteristics are provided, through a new combination of existing (and perhaps new) technical characteristics, this would clearly constitute *a new product*. Generally, there will be intermediate cases. Digital television enables more channels to be made available to the consumer, and new interactive features are also possible – even though many viewers will still use their televisions in the same way as they did before with the pervious analogue technology. Similarly with digital mobile telephones and the additional features these provide over analogue mobile phones.

Saviotti and Metcalfe's conceptualisation of a product is a useful conceptual device for deconstructing products and thinking about the nature and extent of change to them, but it has significant practical limitations – quite simply, it is difficult to gather the data required even for the technical characteristics which are the most clearly defined and objectively measured. Deciding what is and what is not an innovation still seems to be a matter of judgement. Another conceptual device which is useful for thinking about innovation, and new products in particular, is the hierarchical decomposability of technological systems, which is implicit in Saviotti and Metcalfe's conceptualisation.

3.2 Radical Innovation and the Hierarchical Decomposability of Technologies

The literature on innovation is replete with references to radical and incremental innovations, yet there is considerable confusion about what distinguishes an incremental from a radical innovation. Partly this confusion is due to different conceptualisations of innovation itself – is it the achievement or its consequences that is being considered? Freeman's definition,[17] for instance, of radical innovations as those that 'transcend the technical limitations (of the existing technologies)', focuses essentially on the achievement. This is also the case with Saviotti and colleagues,[18] who state that: 'Incremental innovation can be defined as a series of quantitative changes in known parameters or in the introduction into a given product of technical characteristics already used in some similar product. A radical innovation would be, instead, the appearance of a new technical characteristic. Although sometimes the distinction between incremental and radical innovation is ambiguous, in many instances it is relatively simple to distinguish the two types of innovation.' By contrast, other scholars have tended to define radical innovation by their impact, for example on the structure of the industry, where a radical innovation is one that leads to a significant re-structuring of the industry.[19]

Constant observes that

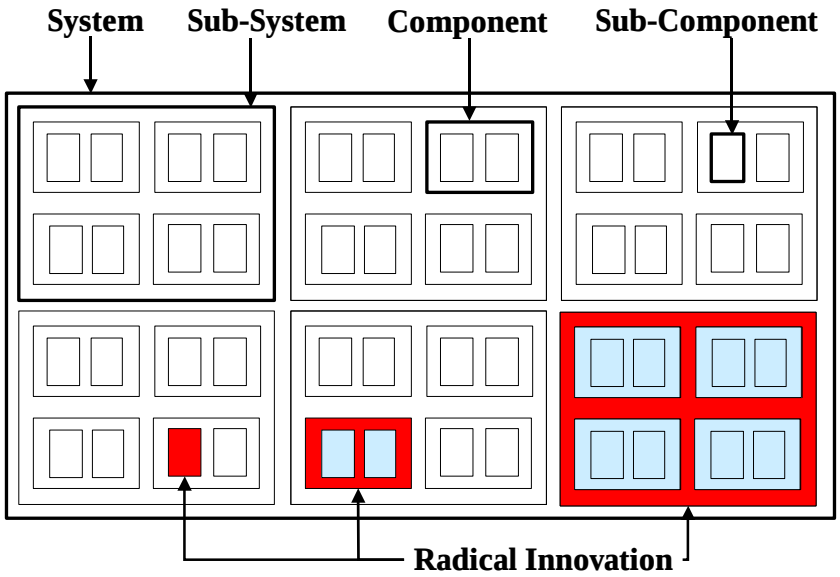
> [P]robably no issue has caused so much disharmony amongst students of science and technology as the problem of revolutionary versus incremental change. … [T]he dispute is not really about the nature of change but stems from the failure

[17] Freeman, C. (1982) *The Economics of Industrial Innovation*, 2nd Edition, Francis Pinter, London.
[18] Saviotti, P. P., Stubs, P., Coombs, R. and Gibbons, M. (1982) 'An Approach to the Construction of Indexes of Technological Change and Technological Sophistication: The Case of Agricultural Tractors', *Technological Forecasting and Social Change*, 21, pp. 133-147.
[19] Along similar lines, Tushman and Anderson (1986) distinguish between competence enhancing and competence destroying innovations. "Competence-destroying discontinuities are so fundamentally different from previous dominant technologies that the skills and knowledge base required to operate the core technology shift. … Competence-enhancing discontinuities are order of magnitude improvements in price/performance that build on existing know-how within a product class. Such innovations substitute for older technologies, yet do not render obsolete skills required to master the old technologies (Tushman and Anderson, 1986, p. 442).

> to confront the hierarchical structure of all complex technological systems and therefore of all technological practice. … Ontologically, systems are composed of sub-systems which are composed of an immense variety of components. … [T]his hierarchical decomposability suggests the absolute relativity of all change: Whether a given change is perceived as radical or incremental depends solely on the hierarchical level chosen. A new valve, a new turbine material or fabrication technique may represent a revolutionary solution to a specific sub-problem at that level; yet the same change, viewed from the level of the total aircraft system may appear only as a typical incremental innovation.[20]

Conceptualising a Technological System

Following Constant, 1987

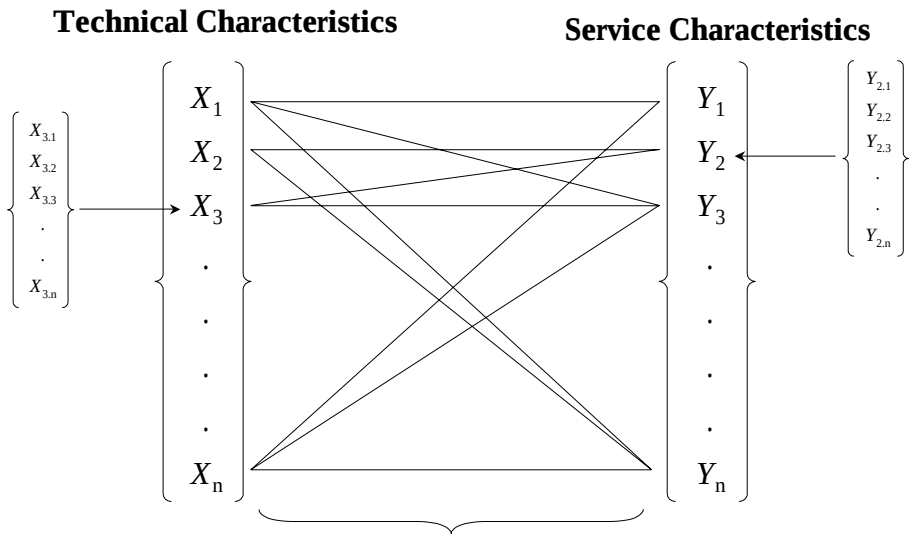


The figure above shows this schematically. The system shown is composed of four levels: the system decomposes into sub-systems, which themselves decompose into components which themselves decompose into sub-components. Although this decomposition will not always be as clear cut as is depicted in the figure – and the extent to which the various parts are loosely or tightly coupled will vary – the figure also shows how 'radical innovation' can occur at different levels – at the sub-component level, at the component level, the sub-system level, as well as at the system level (although this is not shown). Such radical innovations are likely to give rise to significant improvements or improvements in the performance of the technology at the levels above that of the innovation. Clearly, we would expect that the lower the level of the radical innovation the less disruption it will have on the system as a whole.

[20] Constant, Ed. (1987) 'The Social Locus of Technological Practice: Community, System or Organisation', in Bijker, W., Hughes, T. and Pinch, T. (eds.) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, MIT Press, Cambridge, Mass, page 227.

Returning to the conceptualisation provided by Saviotti and Metcalfe, the extent of innovation depends on the product level considered. A new approach to braking technology, for example might be a radically new technology at the component level, but is likely to be only an incremental level at the level of the car as a system – at the level of the car as a systems, it provides only improved service characteristics rather than radically new service characteristics. This hierarchical decomposability of technologies is incorporated into Saviotti and Metcalfe's framework in the figure below, in which the composition of X_3 and Y_2 are shown to be decomposed into separate vectors..

Conceptualising a Product with Hierarchical Decomposability



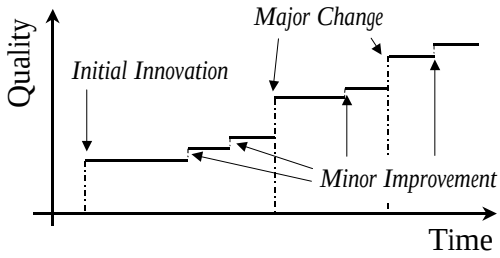
One final point is worth noting, which is how the extent of innovation relates to the organisations of industries. Consider that we have two parallel economies, identical in all aspects other than in the organisation of their industries. In economy 1, all the sub-component and component producers are independent firms, whilst in economy 2 all the sub-component and component producers are divisions of firms that produce sub-systems and systems. Even though they are identical, economy 1 is likely to record much more product innovation – because at the level of the final output of the firms (sub-components through systems) the greater presence of component and sub-component producers in economy 1 means innovation at this level is more likely to be identified. One way in which an economy can apparently raise its

innovative performance in terms of the number of new products introduced is to encourage the decomposition of integrated firms.[21]

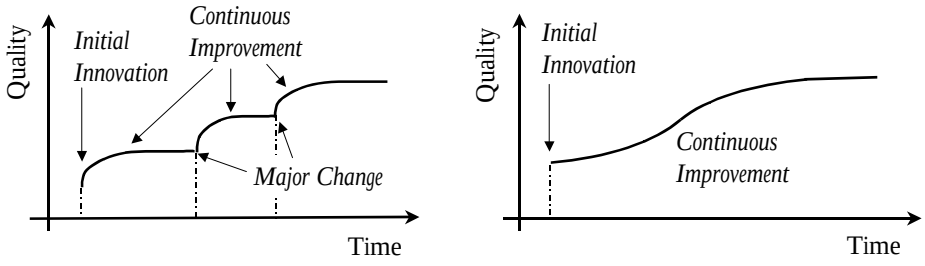
3.3 Conceptualising Processes

So far, we have introduced some ideas to aid the conceptualisation of products, but what of processes? What are processes? Processes are 'means'. By definition they are active, and economic processes tend to be associated with transformations, which involve adding value. Especially within a manufacturing context, processes are normally undertaken within a firm (rather than between firms) – the result of the firm's processes is the firm's product. We can apply the same type of distinction between the purpose of the process (what it does – the product of the process) and how it does it (the activities involved) as we did with products, where we distinguished between their technical and service characteristics. However, with a product we think primarily about what it does (the service characteristics); with a process we think primarily about how it does it.

'The Innovation Staircase' – Common with Standardised Products



Alternative Innovation Trajectories
Common for Customised Goods, Services and Processes



The pattern of innovation in processes is likely to differ from that of products, and particularly from standardised 'mass produced' products. With standardised products, a new product is typically introduced (following processes of experimentation and prototype development) after which it will remain unchanged for some time. A few minor upgrades will be

[21] Note that whilst in the disintegrated economy the number of innovations is likely to be higher, the number of innovations per firm may well be lower.

introduced over time, after which a bigger, generational change will be undertaken. The product will again remain unchanged, perhaps with the exception of some minor upgrades, that are introduced over time. The cycle is then repeated with the third and fourth generations of the product. Over time, the scale of improvement between the generations is likely to decline. This pattern of innovation is shown in the figure above – it is a step change pattern, hence we call it 'the innovation staircase'. Innovation is fairly easily measured, at least in principle, by the scale of the jumps, or steps between the products available.

By contrast, innovation in processes – and indeed in services as well as customised products - can follow a different path. Sometimes there is rapid learning immediately after the introduction of the process – this is the learning curve, initially the process is slow and inefficient, but gradually and on a continuous basis, minor improvements are introduced. The same pattern is repeated if a substantially new process is later introduced. This pattern is shown in the bottom left of the diagram. Alternatively, after the initial innovation, there may be a slow process of continuous improvement, but after a while the scope for improvement diminishes – this is shown by the S-curve path in the bottom right of the diagram. The point here is that improvements, and innovations, may be much harder to identify in processes (as well as in customised products and services) than with the archetypal mass-produced standardised products because improvements are less likely to occur in definite steps. In particular, it can be difficult to distinguish between variations and innovations.

4. Practical Approaches to Identifying Product and Process Innovation

We now turn to the practical approaches used to identify new products and new processes. Broadly, two approaches have been undertaken: the 'object based approach' which focuses on innovations themselves; and the 'subject based approach' which focuses on firms and asks them about their innovative activities. We will discuss each of these in turn.

4.1 The "Object Based" Approach to Identifying and Measuring Innovation

The object base approach identifies innovations directly. The earliest studies using this type of methodology include a study by Gellman Research Associates in 1976 which identified 500 major innovations for the National Science Foundation in the United States. Around the same time, the Science Policy Research Unit (SPRU) at the University of Sussex undertook a study which sought to identify all the major technological innovations introduced in the UK since the end of the second world war. This exercise, which involved asking experts in various technical fields to identify significant innovations, ended in 1983 with the identification of over 4,378 innovations. Because of its nature, the database had a strong bias to artefact (as opposed to service) innovations, and to product as opposed to process innovations. Essentially, both of these early studies used ad hoc methodologies. If the experts used by SPRU defined significant advances in different ways, then innovations could be included or excluded on idiosyncratic basis.

A later and more systematic attempt to identify innovations directly was based on trade journals and was undertaken by researchers who were not themselves experts in the technologies being assessed. In the early 1990s, these researchers - led by Alfred Kleinknecht - developed a schema to determine the nature of innovations.[22] Their purpose was to classify innovations by their novelty and complexity.[23]

By **novelty**, Kleinknecht et al distinguished between:

1. A **totally new or radically changed product [or service]** (e.g., a mountain bike, electronic banking).

2. A **modestly improved product [or service]** (e.g., a more user-friendly laser printer; a more secure credit card).

[22] Kleinknecht, A., Reijnen, J., and Smits, W. (1993) 'Collecting Literature-Based Innovation Output Indicators: The Experience in the Netherlands', in Kleinknecht, A. and Bain, D. (eds.) *New Concepts in Innovation Output Measurement*, St Martins Press, London.

[23] And then to determine the source (e.g., industry, small or large firms, etc) and destination (e.g., consumer or industrial product, industry of use, etc.).

3. A **new or improved accessory** of an existing product [or service] (e.g., a safer child seat on a bicycle; a hospital benefit linked to a life insurance).

4. **Product [or service] differentiation** (e.g., marmalade with a different taste; a different after sales service).

5. **Process innovation** (examples of which were expected to be found only rarely, as the methodology involved examining trade journals, which would focus on firm's products or services, rather than their processes.

Elsewhere, and for the UK, Coombs and colleagues[24] introduced a distinction within the first category of products / services, between:

1a. A new or decisively changed product, with a **completely new function** or functions.

1b. A new or decisively changed product with a **different technology**, but with the product having the **same functionality** as before.

Although they do not use the example, the bagless vacuum cleaner introduced by James Dyson reflects this difference. Although Dyson used a different approach to the problem and was able to dispense with the problematic 'bag', Dyson's novel vacuum cleaner still has the same function as a conventional vacuum cleaner - it should therefore be graded 1b rather than 1a.

We make three comments about the categorisation developed by Kleinknecht, Coombs and colleagues. The first concerns the role of technology. It is notable, particularly from the examples used by Kleinknecht and colleagues, that the role of technology is downplayed. The mountain bike was essentially a re-conceptualisation of the bicycle, which made it more suitable for 'off road' activities. It became very popular, and rejuvenated the bicycle industry, but fundamentally the 'mountain bike' did not depend on new technologies, but adaptation and application of existing technologies. By contrast, the 'more secure credit card', which is given as an example of a 'modestly improved service', may well have involved significant new technologies, but the researchers have not given this service product the highest grading simply because of this. Although they did not employ the conceptual separation between the technical and service characteristics developed by Saviotti and Metcalfe, it is clear that for Kleinknecht and

[24] Coombs, R.., Narandren, P. and Richards, A. (1996) 'A Literature Based Innovation Output Indicator', *Research Policy*, 25, pp. 403-413

colleagues innovation is primarily about change in the service characteristics (what is it does), rather than change in the technical characteristics (how it is does it).

However, although Kleinknecht and colleagues have not privileged technological novelty, it does seem that they have been influenced in their assessment and subsequent grading of these products and services by what they know of their impacts or environments. Had mountain bikes not been so successful it seems probable that the researchers would have graded them lower, as a 'modestly improved product' or even conceivably 'product differentiation'. Meanwhile, if credit card insecurity was such a major problem that most consumers refused to adopt them, and an improvement to their security proved sufficient to encourage consumers to use them then it is likely that a 'more secure credit card' would have been graded a 'radically altered service' (although one, in Coombs' terms, that fulfils an existing rather than new function). Given that credit cards were already widely used despite security being widely known to be a problem, the improved security did not transform the product or its uptake – hence the lower grading. It follows from this that to grade innovations accurately, rather than on the basis of their own opinions or prejudiced, researchers need to know a great deal about the products and particularly their service characteristics, as these are perceived amongst the relevant consumer groups. This itself is a difficult task.

The third point concerns the third level of innovation, which is as accessories to another product or service. This points to the hierarchical decomposability of products or services that we discussed above: what may be radically new or different at the component level may not be radically new or different at the level of the system. In the wider transport system a mountain bike is just a bicycle, and in the financial system electronic banking is still banking, even though both are changed to a degree. The level of observation is important to the grading of innovations. Kleinknecht and his colleagues dealt with this through their second classification of **complexity** (although they argue novelty and complexity are independent). Here they introduced three categories:[25]

1. **High Complexity**: The innovation is a system, consisting of a large range of parts or components, coming from different disciplines. Examples include an aircraft, an automobile, or a weather satellite.

[25] Kleinknecht and colleagues claim that this classification by complexity is independent of the classification by novelty, but the existence to the accessory category in the novelty classification suggests the independence is not complete. As products increase in complexity they are less and less likely to be considered totally new or radically changed.

2. **Medium Complexity**: The innovation is a unit, considering of a certain number of parts of components. Typical cases are various types of machines.

3. **Low Complexity**: the innovation is a simple unit, such as, for example, a bicycle pump.

This categorisation hints at the degree of technological uncertainty. An innovation involving high complexity is likely to involve much more technological uncertainty than an innovation of medium or low complexity.

Overall, it is clear that whist systematic, Kleinknecht's categorisation involves considerable discretion and judgement on the part of the researchers. One methodology is to ask several researchers to make independent classifications of the innovations and to discuss those where disagreement arose. Finally, this methodology tends to identify many tangible product innovations, but fewer services (as these are often harder to describe) and few processes, as information about these tends not to be made public.

4.2 The "Subject Based" Approach to Identifying and Measuring Innovation

The second approach to identifying innovations introduced by firms is to ask firms directly whether they have or have not introduced new products or new processes. This is the approach followed by the OECD in its 'guidelines for collecting and interpreting innovation data' – the so-called 'Oslo Manual'.[26] It – and indeed the Oslo Manual – is also the approach followed by the European Community Innovation Surveys (CIS). The first of these surveys was undertaken in 1992, the second in 1998, and the third in 2001.

The Oslo Manual and CIS are framed around asking firms about their innovation activities. Innovation is therefore at the level of the firm. The Oslo Manual and CIS focus on technological innovation, and in particular technological product and process innovation (or TPP). The Manual declares: 'TPP (technological product and process) activities are all those scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of technologically new or improved products or processes' (para 31). It states:

> **Technological product and process (TPP) innovations** comprise implemented technologically new products and processes and significant

[26] The current version of the Oslo Manual is the second edition, released in 1996. The first edition was published in 1992. The Manual is now in the process of further revision, but we understand the basic definitions of new products and new process will not to be significantly changed. The current, second edition of the Oslo Manual is available here: http://www.belspo.be/belspo/stat/meth/acrobat/Oslo_e.pdf

> technological improvements in products and processes. A TPP innovation has been **implemented** if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organisational, financial and commercial **activities**. **The TPP innovating firm** is one that has implemented technologically new or significantly technologically improved products or processes during the period under review. (para 130)

The Manual then provides definitions of technologically new products and technologically new processes:

> **A technologically new product** is a product whose technological characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge. (para 136)
>
> The first microprocessors and video cassette recorders were examples of technologically new products of the first kind, using radically new technologies. The first portable cassette player, which combined existing tape and mini-headphone techniques, was a technologically new product of the second type, combining existing technologies in a new use. In each case the overall product had not existed before. (para 137)
>
> **A technologically improved product** is an existing product whose performance has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher-performance components or materials, or a complex product which consists of a number of integrated technical sub-systems may be improved by partial changes to one of the sub-systems. (para 138)
>
> Technologically improved products may have both major and minor effects on the firm. The substitution of plastics for metals in kitchen equipment or furniture is an example of the use of higher-performance components. The introduction of ABS braking or other sub-system improvements in cars is an example of partial changes to one of a number of integrated technical sub-systems. (para 139)
>
> The distinction between a technologically new product and a technologically improved product may pose difficulties for some industries, notably in services. (para 140)
>
> Innovation is also distinguished from product differentiation, were:
>
> Product differentiation is the introduction of minor technical (or aesthetic) modifications in order to reach a new segment of the market, to increase apparent product range or to reposition a product in relation to a competing one.

> It can only be considered technologically improved product innovation if changes significantly affect the performance or properties of the product concerned or the use of materials or components therein. … For example, the renaming and repackaging of an existing soft drink popular with older people, to establish a link with a football team in order to reach the youth market, is not TPP innovation (para 171). New models of complex products, such as cars or television sets, are product differentiation if the changes are minor compared with the previous models, for example offering a radio in a car.[27] If the changes are significant, based on new designs or technical modifications to sub-systems for example, the improved products could be considered technologically improved product innovations (para 172).

There are several interesting aspects of these definitions. The first is the distinction between new products that are based on new technologies, and those that are based on re-combinations of existing technologies. The second is the implicit recognition that the complexity of technologies varies, and that the incorporation of new components (such as ABS braking) – which would be a new product to the component manufacturer – is likely to provide a significant improvement at the level of the system (i.e., the car) – and would therefore constitute a 'technologically improved product' from the producer of the complex product. Thirdly, the effects on the firm are mentioned, although only with respect to technologically improved products. It is noted that the effects may be minor and major; essentially what is being judged is the achievement, not the impact of the achievement.

Elsewhere, the Oslo Manual notes:

> If [a retailer or wholesaler] begins to deal with a completely new line of goods, that may be considered a product innovation. For example, a new software package is a technological product innovation for the computer service firm. For the wholesaler or retail outlet distributing it, it is a new product in the catalogue but not a technological product innovation unless the company had never previously distributed any software products. (para 148).
>
> Innovations may be implemented for both the principal and secondary production activities of a firm (para. 151). For example, a computer hardware company may issue a major upgrade of a program which it sells as a separate secondary product, or a restaurant may introduce gaming machines as a new secondary service product. (para. 152).

Where to draw the line between innovation and non-innovation is admittedly problematic. Although innovation can occur in the primary and secondary activities of the firm,

[27] Offering a radio in a car is unlikely to constitute a technological innovation today, but when radios were first introduced into cars then this could well have been a technological innovation. This also raises the issues of new to who? – new to the world, new to the industry or market, or new to the firm?

it is questionable whether the introduction of gaming machines in a restaurant constitutes technological innovation. By contrast, the introduction of sophisticated in-flight entertainment systems by airlines probably would constitute technological innovation. The difference lies in the level of technological and market uncertainty involved, and the commitment of sunk costs. A restaurant owner can experiment with putting gaming machines in the restaurant, but if this does not work out she can have them removed by selling them or cancelling the rental agreement – the risk is likely to be low. By contrast, the incorporation of sophisticated in-flight entertainment systems in aircraft (especially when these were still novel!) was innovative, because it involved significant technological challenges and market uncertainty – how much would the availability of these systems influence consumer choice? Moreover, during the installation the aircraft have to be taken out of service, thereby loosing revenue. Similarly with the retailer or wholesaler selling a completely new line of goods. Although there is market uncertainty involved, it is questionable whether this should be regarded as technological product innovation. If this were the case, then the likes of "Delboy" from the television series 'Only Fools and Horses', who makes a living buying and selling anything, would be highly innovative. We can argue that he is not, because 'buying and selling anything' is routine to "Delboy" – it is what he does – innovation involves change in routine.

With regard to technological process innovation, the Oslo Manual states:

> **Technological process innovation** is the adoption of technologically new or significantly improved production methods, including methods of product delivery. These methods may involve changes in equipment, or production organisation, or a combination of these changes, and may be derived from the use of new knowledge. The methods may be intended to produce or deliver technologically new or improved products, which cannot be produced or delivered using conventional production methods, or essentially to increase the production or delivery efficiency of existing products. (para. 141)[28]

There are some striking features of this definition. Firstly, that technological process innovation is defined as the adoption of new technologies.[29] The adoption of these technologies need not be associated with new knowledge (and hence learning), and need not be associated with the intention to produce new or enhanced products. Arguably, this is too broad a definition

[28] In some service industries, the distinction between process and product may be blurred. For example, a process change in telecommunications to introduce an intelligent network may allow the marketing of a set of new products, such as call waiting or call display (para. 142).

[29] "Innovation in the distributive trades will largely be process innovation, *for example the introduction of just-in-time delivery by a wholesaler, or computer-controlled inventories for a retailer*. It is suggested that where the diffusion of a new or improved product as described above does require some technological activity by the distributing firm, it should be treated as process innovation (para 149) – the notable feature here is 'require some technological activity', which hints at learning and adaptation, rather than simple technological adoption.

of technological process innovation – it is really a definition of technological adoption. The Manual further states that:

> During the process of diffusion, one firm's new or improved product may become another firm's new or improved process. For example, a more powerful model of computer is a technologically improved product for the business machinery industry but might constitute an entirely new technological process for an accountancy firm. Furthermore the accountancy software used with it might be an established product of the computer services industry but a completely new process to the accountancy firm (para 147 – emphasis added).

By the same logic, a household that adopts – perhaps having been given as a gift, a digital television, but continues to view television in exactly the same way as before would qualify as a process innovator. Indeed, the Manual notes that: 'In the case of software, for example, the purchase of a new version of a set of programs for Windows may be considered a technological process improvement, whereas the acquisition of interim updates which do not add significantly to the programs' performance is not.' (para. 163).

Arguably, neither the adoption of a digital television or a new set of Windows programs should, by itself, not constitute process innovation. By itself, this is technological adoption.[30] In the context of the firm, process innovation should be associated with learning and adaptation and with either or both an increased efficiency in the execution of existing tasks or with the production of improved products. Instead, for the Manual, innovation can be passive – firms may introduce new products and processes that have been developed elsewhere, at no risk to themselves, and with no impact on their activities.

4.3 Other Issues – New to Who, and Who Should Judge?

The Oslo Manual makes very clear that technologically new products and new processes should at least be new to the firm. This is in order to embrace the diffusion aspects of innovation. As such, innovations do not need to be wholly novel (or "new to the world"), nor new to the market (defined by geographical or product 'space'), although clearly some types of hierarchy can be conceptualised between 'new to the world', 'new to the country or industry', and 'new to the firm'. Indeed, the Manual defines two of these different levels:

[30] This is particularly the case as the next generation of a technology may be easier to use than its predecessor. For example the replacement with command driven computer programmes with menu driven programmes – this effectively means that less knowledge is needed to operate the programme, and experienced users will be deskilled. This is technological innovation on the part of producer of the programme, and for the new users, but it seems doubtful that it is innovation for the existing skilled users, unless it increases their productivity.

> **Worldwide TPP innovation** occurs the very first time a new or improved product or process is implemented. **Firm-only TPP innovation** occurs when a firm implements a new or improved product or process which is technologically novel for the unit concerned but is already implemented in other firms and industries (para 143).

As such, the Oslo Manual is as concerned with imitation as 'true innovation'. Indeed, arguably, it is more concerned with imitation and technological adoption (processes central to technological diffusion) as it is with genuine innovation. But in this it can also be confused. Take the example cited earlier of the introduction of a radio in a car. This is certainly not 'new to the world', but by the logic of the Oslo Manual it could conceivably still constitute innovation for a car marker that has, for whatever reason, until now failed to provide a radio in its cars.

As innovation is defined as being (at least) new to the firm, it follows that only people working in the firm are likely to be able to judge whether or not an innovation has been introduced.[31] The consistency of this judgement would be improved if personnel trained in identifying innovations could also be involved.[32] The involvement of such trained personnel would also be useful, as the Manual recognises that firms may consider some of their developments innovations which the Manual would not regard as innovations:

> Technological innovation requires an objective improvement in the performance of a product or in the way in which it is delivered. In the case of many goods and services sold directly to consumers or households, the firm may make improvements in its products which make them more attractive to the purchasers without changing their "technological" characteristics. These improvements may have a considerable effect on the firm's sales, and it may well view them as innovations. They are not, however, TPP innovations. (para 173)

[31] The Manual states: 'Many borderline cases will clearly occur … , and the final judgment about the nature of the change rests with respondents and/or persons selecting TPP innovations to include in databases' (para 162).

[32] It is generally thought that if the questionnaire is answered by someone from a marketing background they are much more likely to state that the firm has introduced innovations (particularly product innovations) than if the questionnaire is answered by someone with a engineering or technological background.

Examples given by the Oslo Manual of TPP Innovations in Selected Service Industries

Wholesaling of machinery, equipment and supplies

- Creation of web sites on the Internet, where new services such as product information and various support functions can be offered to clients free of charge.
- Publication of a new customer catalogue on CD (compact disc). The pictures can be digitally scanned and recorded directly on the CD where they can be edited and linked to an administrative system giving product information and prices.
- New data processing systems.

Road transport companies

- Use of cellular phones to reroute drivers throughout the day. Allows clients greater flexibility over delivery destinations.
- A new computer mapping system, used by drivers to work out the fastest delivery route *(i.e.* from one destination to another). This makes it possible to offer clients faster deliveries.
- The introduction of trailers with eight globe-shaped containers instead of the usual four.

Post and telecommunications companies

- Introduction of digital transmission systems.
- Simplification of the telecommunications net. The number of layers in the net has been reduced by using fewer but more highly automated switching centres.

Banks

- The introduction of smart cards and multipurpose plastic cards.
- A new bank office without any personnel where clients conduct "business as usual" through the computer terminals at hand.
- Telephone banking which allows clients to conduct many of their banking transactions over the phone from the comfort of their own homes.
- Switching from image scanning to OCRs (Optical Character Readers) in the handling of forms/documents.
- The "paperless" back-office (all documents are scanned for entry into computers).

Software consultancy and supply companies

- The development of a whole range of different customer packages in which clients are offered varying degrees of assistance/support.
- The introduction of new multimedia software applications that can be used for educational purposes and thus eliminate the need for a real life human instructor.
- Making use of object-oriented programming techniques in automatic data processing systems development.
- The development of new project management methods.
- Developing software applications through computer-aided design (CAD).

Technical consultancy companies

- A new method of purifying water abstracted from lakes for use as household drinking water.
- Offering customers a new "supply control system" which allows clients to check that deliveries from contractors meet specifications.
- The development of a standard for construction work carried out in already densely built-up areas (where care has to be taken not to inflict damage on any of the surrounding buildings).

Advertising and marketing companies

- Delivering lists of potential customers on diskette together with a list filing system (software) that allows the client firms themselves to analyse and draw samples from the list.
- Being able to assist clients in direct marketing campaigns by offering to distribute pre-labelled advertising leaflets, etc., addressed to selected households.
- Initiating a control process to check by phone with random households that they are actually receiving the adverts/leaflets they are supposed to.
- Delivering the software applications needed for clients themselves to be able to analyse data along with statistical databases.

4.4 Implementing the Oslo Manual – The European Community Innovation Surveys

The Oslo Manual has formed the basis of three rounds of the European Community Innovation Survey (CIS), the first of which was undertaken in 1992, the second in 1998, the third in 2001. The first survey was confined to manufacturers (in all countries except the Netherlands), whilst the second and third have embraced (certain) marketed services. In the UK, the survey is voluntary, administered by post, and some notes and a telephone number are supplied for assistance.[33]

In this section, we will discuss the approach to identifying innovations used in the third European Community Innovation Survey, and particularly the UK's version of the survey. Generally the third survey used simpler questions than had been used on the earlier versions. Readers interested in a critical assessment of the second Community Innovation Survey, and in particular the UK response to it, can find this as CRIC discussion paper 48.[34]

The CIS questionnaire begins by stating that:

> An innovation, as defined in this survey, is a new or significantly improved product (good or service) introduced to the market or the introduction within your enterprise of a new or significantly improved process. The innovation is based on the results of new technological developments, new combinations of existing technology or utilisation of other knowledge acquired by your enterprise.

The survey then asks about **product innovation**, which is:

> Product innovation is a good or service which is either new or significantly improved with respect to its fundamental characteristics, technical specifications, incorporated software or other immaterial components, intended uses, or user friendliness. The innovation should be new to your enterprise; it has not necessarily to be new to the market. It does not matter whether the innovation was developed by your enterprise or by another enterprise. Changes of a solely aesthetically nature, and purely selling of innovations wholly produced and developed by other enterprises, shall not be included. (emphasis in original)

The UK version of the survey used a simpler definition of product innovation:

> For this survey product innovation covers both goods and services introduced to the market which are either new or significantly improved with respect to fundamental characteristics. The innovation should be based on the results of new technological developments, new combinations of existing technology or

[33] The UK's version of the 3rd CIS questionnaire can be found at: http://www.dti.gov.uk/iese/cis_quest.pdf
[34] This is available here: http://les1.man.ac.uk/usercgi/cric/cricpaperdl.asp?paper=dp48

> utilisation of other knowledge by your firm. For examples of product innovations see inside front cover. We are interested in products **new to your enterprise** - even if already on the market - as well as those that are new to your market (emphasis in original)

Some examples of new products and new services identified by firms in the previous round of the innovation survey were also given. The questionnaire then asked the firms: **During the period 1998-2000, did your enterprise introduce onto the market any new or significantly improved products (goods or services) for your enterprise ?**[35]

Examples of Product Innovation given on the UK version of the CIS-3	
Goods	**Services**
Fibre optic based display lighting range	IT based Credit Risk assessment service
Automation of electronic testing equipment	On line estate agency
Lighter weight vehicle bodies	Geographical Information System software
Multi-function printer / scanner	A new computer mapping system, used by drivers to work out a faster delivery route
Carbon fibre sports equipment	

Examples of Process Innovation given on the UK version of the CIS-3
Linking of Computer Aided Design station to parts suppliers
Introduction of Electronic Point of Sale equipment in Garden Centre
Digitising of pre-press in printing house
Robotised Welding

Those that answered yes to this question were then asked the source of these innovations, that is: '**Who developed these products?** Please tick the most appropriate alternative: Mainly your enterprise or enterprise group; Your enterprise in co-operation with other enterprises or institutions; or Mainly other enterprises or institutions.' These firms were also asked whether they had also introduced product innovations that were not only new to their firm, but also to their market: **During the period 1998-2000, did your enterprise introduce new or significantly improved products (goods or services) not only new for your enterprise, but also new for your enterprise's market?** The survey also asked for a description of the firm's most significant product innovation, as well as for the share of turnover due to innovative products in the year 2000.

The survey then asked about **process innovation**, which is.

[35] The UK version asked: During the three year period 1998-2000, did your enterprise introduce any technologically new or significantly improved products (goods or services) which were new to your firm?

> Process innovation includes new and significantly improved production technology, new and significantly improved methods of supplying services and of delivering products. The outcome should be significant with respect to the level of output, quality of products (goods/services) or costs of production and distribution. The innovation should be new to your enterprise; your enterprise has not necessarily to be the first to introduce this process. It does not matter whether the innovation was developed by your enterprise or by another enterprise. Purely organisational or managerial changes shall not be included. (Emphasis in original)

The UK version of the survey used as shorter definition, omitting the sentence about the outcome of the innovation:

> For this survey process innovation is the use of new or significantly improved technology for production or the supply of goods and services. Purely organisational or managerial changes should not be included. … We are interested in processes **new to your enterprise** - even if already in use in your industry - as well as those that are new to your industry.

Some examples of process innovations cited by firms in the previous round of the survey were provided. The survey then asked: **During the period 1998-2000, has your enterprise introduced any new or significantly improved production processes including methods of supplying services and ways of delivering products?**[36] The survey then asked who developed these processes (as it had asked who developed the product innovations), for a short description of the most significant process innovation, and the UK version asked whether any new to the industry processes had been introduced.[37]

These questions about product and process innovation form the core of the survey's definition of innovation.[38] As such, the survey follows closely the Oslo Manual's definition of innovation. The table below summarises what matters and what does not matter for the classification of innovations according to the CIS. Arguably, the European Community Innovation Surveys (CIS) set a very low threshold for innovation behaviour - one that conflates technological adoption with innovation.

[36] The UK version asked: 'During the three year period 1998-2000, did your enterprise introduce any new or significantly improved processes for producing or supplying products (goods or services) which were new to your firm?'

[37] During the three year period 1998-2000, did your enterprise introduce any new or significantly improved processes for producing or supplying products (goods or services) which were new to your industry?

[38] After these questions, the survey then asked about incomplete and abandoned innovation activities, the firm's expenditures on innovation, its participation in R&D and collaborative arrangements for innovation, the information sources it used for innovation, and which factors hampered its innovation efforts.

Innovation from the Point of View of the Community Innovation Survey

What Matters …	**What Does not Matter …**
That the new product or process is commercialised. That is that the product innovation is put on the market and made available to consumers (including other firms). A process innovation has to be implemented in the firm's own activities. A new product or process that is not commercialised, but remains a concept or prototype is an invention, not an innovation.	**That the new product or process is a commercial success**. It may never make a profit, and it might be withdrawn shortly after its introduction. What matters is whether or not it achieved commercial introduction, not whether or not it was a success. Concorde is a classic case of an innovation that was not a commercial success.
That what is commercialised includes technologically novelty. Technological novelty is not easy to define. It is easier to identify its absence. The Innovation Survey considers that the repositioning of goods in a market through renaming or repackaging is not technological innovation, nor is a new model of a complex product (such as a cars or TV set) if the change is minor, such as offering a radio in a car.	**That the business developed the technologies itself**. It may have adopted technologies developed by others (especially in the case of process innovation), and it may effectively be marketing (although not simply selling) an invention made by another organisation (in the case of product innovation).
That the innovation (product or process) is new to the business that introduced it. It may also be a 'significant improvement' over the business's previous products or processes	Two things here. Firstly, **the innovation did not have to be developed by the business that introduced it** (see the point above). Secondly, **the innovation may be an imitation of products already available or in use elsewhere in the world**. It may even have already have been introduced by other businesses within the same company group.

5. Summary and Recommendations

The purpose of this paper has been to review existing approaches to the definition of new products and processes in both conceptual and practical ways. The ultimate aim is to assist firms, policy makers and students of innovation with the development of a practical tool for the identification of new products and new processes. We have seen that there is no simple and straightforward definition of new products and new processes. The use of conceptual tools is helpful in providing a basis on which distinctions can be made. We have also reviewed the main practical approaches to the definition of new products and new processes.

The OECD's Oslo Manual represents the internationally adopted approach to the definition and identification of new products and new processes. The approach adopted by a firm or other organisation will necessarily depend on the uses to which the information will be put. It is the view of the author of this paper that the OECD's Oslo Manual has some significant shortcomings in its approach to the definition of new products and new processes. The purpose of this section is to try to develop an approach to identifying innovation which does not conflate this with technological adoption, as is the case in the Oslo Manual.

Before we begin, **we should understand that innovation is a relative not an absolute concept – innovation can only be understood in its context** – that is the time and space (geographical and technological) in which it occurs. This is why giving examples is always problematic – as times change, so things that were innovations look like obvious developments or obvious failures.

5.1 A Suggested Approach to Identifying Product Innovations

We consider that product innovation involves offering something new for exchange[39] to intermediate and final consumers (i.e., other firms and individuals). This may be an enhancement of an existing product, or it may be a totally new product. The distinction between true innovation and product differentiation should be based on three factors: the conceptual novelty of the product, and the degree of technological uncertainty faced in its development; and the degree of market uncertainty faced in its introduction. A fourth 'test' of innovation is the extent to which the firm has committed 'sunk costs' to the project. We will take each of these in turn:

[39] Although products are normally exchanged through sale, there are other forms of exchange that also apply. For example, a meal can be provided (as a product) by one individual to another within a household, or a service (product) may be provided within an organisation without any form of direct payment.

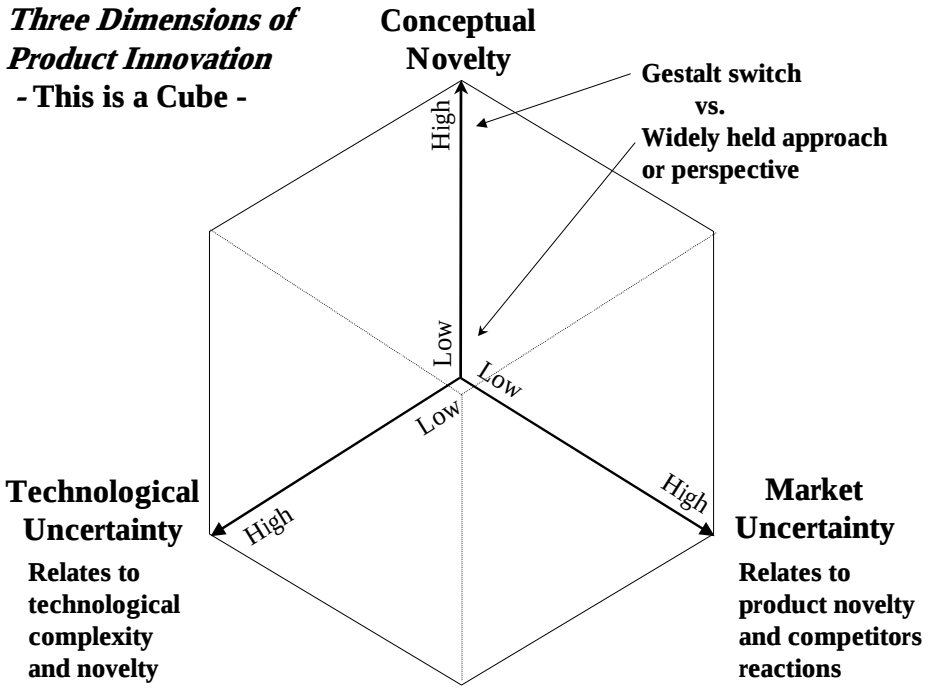
- **Conceptual novelty**. This is perhaps the most difficult aspect of defining an innovation. Generally, however, there are established ways of doing things (or widely shared perspectives of how to develop something that is not currently technically possible). The vacuum cleaner is a good example – basically the same product concept involving suction into a bag existed for over 100 years. Many people used these products with varying degrees of satisfaction, but it was James Dyson who was so dissatisfied with the product that he set about re-conceptualising it. His answer was to use cyclones, and thereby remove the problematic 'bag'. This sort of innovation involves as "gestalt switch" in the conceptualisation of the product. We must stress that this 'switch' does not necessarily occur as a flash of insight – an "Eureka moment" – and even if it does, 'inspiration favours the prepared mind', to paraphrase Louis Pasteur.

- **Technological uncertainty**. This relates to the novelty of the technologies involved – both 'to the world' and 'to the firm', and to the technological complexity of the product – the uncertainty will be lower for simple products than with product systems. Clearly technological uncertainty will be lower if another firm has already achieved the same thing and if the product is simple, than if it is a complex systemic product and a genuine 'world first'.

- **Market uncertainty**. Generally there are also two dimensions to this. Firstly, will the innovation sell? Secondly, how will competitors react to its introduction? The uncertainty of will it sell will be much lower for customised products that are 'made to order' under contract than for standardised mass-market, speculative products, as it will be for an imitative as opposed to truly novel product. Firms will also have imperfect knowledge of how their competitors will react to the introduction of the new product. Certainly they may fear that if the product proves successful competitors will quickly introduce their own versions, thus sharing the new market without having taken the initial risk with introducing the new product concept. A firm may be certain that a product will sell, but also certain that it will be immediately copied, and thereby dissuaded from innovating because the firm considers that it has nothing to gain.[40]

[40] Incumbents, however, are frequently blind to the potential of new product concepts. IBM famously thought there would not be a large market for PC's, and wrote contract with Microsoft and Intel that it would not have written if it had realised the scale of the market involved. Xerox also failed to appreciate the inroads into the photocopier market made by Japanese manufacturers who produced desktop photocopiers. Henderson and Clarke discuss these as architectural innovations. (Henderson, R. and Clarke, K. (1990) 'Architectural Innovation:

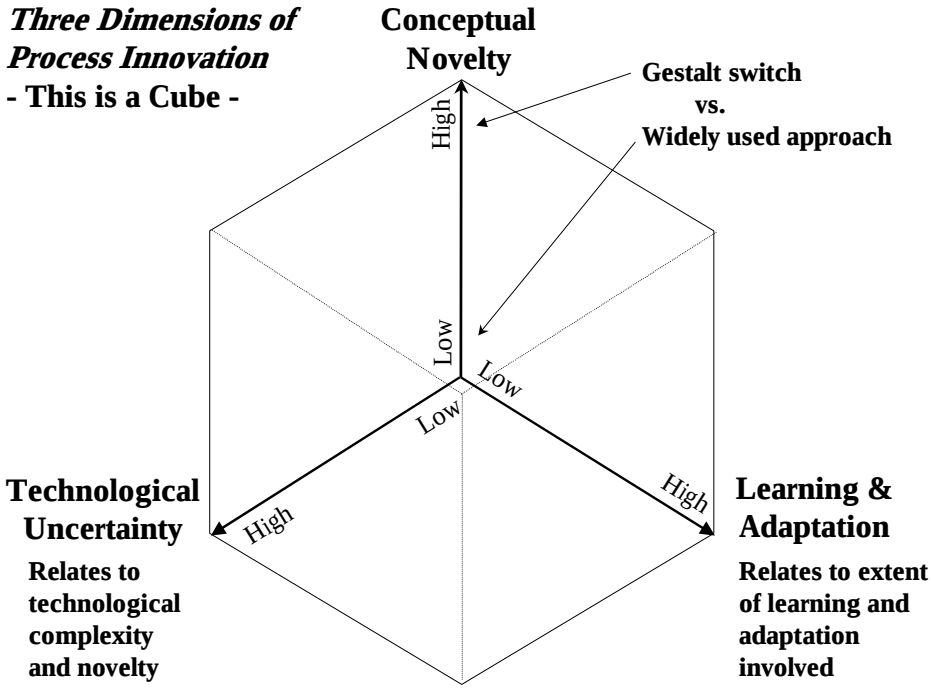
- **Sunk costs:** Sunk costs are those costs that are irretrievable once committed. Innovation, we consider, involves sunk costs (although not all sunk costs, which includes expenditures on advertising and training, for example, are directly related to innovation). Recall the example cited earlier of the restaurant that introduced gaming machines, which the Oslo Manual considered to be an innovation. We argued that it was not, or not likely to be, and this is because of the sunk costs involved. If her experiment with gaming machines in the restaurant did not work out then the owner could retrieve most of her investment by cancelling the agreement with the supplier, or selling them on. Although some money may be lost, the loss is likely to be small. Little is really being risked. Similarly with the introduction of a slide by the pool in the island resort that we discussed earlier. By contrast, the building of a bridge between the island and the mainland is likely to involve a much bigger irretrievable investment – there is little if any market for second hand bridges! Sunk costs are not innovations, but they are symptomatic of innovation



Reconfiguration of Existing Product Technologies and the Failure of Existing Firms', *Administrative Science Quarterly*, 35, pp. 9-30.)

5.2 A Suggested Approach to Identifying Process Innovations

Processes are essentially mechanisms of transformation, which are generally undertaken within firms, rather than exchanged between firms (or between firms and individuals). Our definition of process innovation is similar to that of product innovation with the exception that we replace the market uncertainty dimension with a learning and adaptation dimension. This is because process innovation is generally internal to an economic unit – there is little market uncertainty in the sense of "will it sell?" because that the adopting unit is the same as the supplying unit. There may however be uncertainty as to how quickly competitors might copy the approach, but because processes are internal to economic units knowledge about them tends to diffuse much more slowly than knowledge about new products.



- **Conceptual novelty**. Here the conceptualisation is not about what is produced, but how to produce. Otherwise the idea is the same as that for product innovation.

- **Technological uncertainty**. This is again the same as with product innovation, but with the difference that what is being considered is the means of production rather than the end point, that is what is produced. Otherwise, the novelty and complexity of the technologies deployed are an important consideration.

- **Learning and adaptation of behaviour.** We consider that it is deliberate commitments to learning and the adaptation of behaviour which distinguishes process innovation from

technological adoption. If an enhanced technology is used simply as a replacement for the previous technology (say Windows 2000 for Windows 98) there is no significant learning involved, and no adaptation in behaviour. Therefore, no matter how advanced the technologies adopted, this constitutes technological adoption but not innovation.

- **Sunk costs:** Finally, irretrievable sunk costs associated with process change are an indicator of the commitment to process innovation just as those spent on new products are an indicator of product innovation. Again, sunk costs are not innovation, but are symptomatic of innovation.

5.3 Conclusions

Ultimately, there is no single, simple definition of innovation, and of a new product or a new process in particular. Judgement is required. That judgement, we consider, will be enhanced if innovation is better understood. In this paper, we have tried to aid the conceptualisation of innovation in several ways:

- **Emphasising the distinction between innovation as achievement and the impact or consequences of achievements**. The unintended consequences of innovations especially should not be used to judge innovations. Innovation can also be a disposition towards being 'alive to change' – this too is different from innovation as achievement.

- **Emphasising the hierarchical decomposability of technological systems**. A major innovation at a sub-component level may provide only a minor improvement at the system level. Unfortunately, various technologies decompose differently and it is not possible to assign all technologies unproblematically to various levels.

- **Innovation should be distinguished from technological adoption**. In itself, the latter may involve little if any learning and need not result in changes in behaviour. Learning and adaptation of behaviour may well occur, but often these will lag considerably the adoption of the technology.

- **Innovation is multi-dimensional. Conceptual novelty, technological and market uncertainty, and learning and adaptation are key dimensions to innovation.** Unfortunately, these are hard to measure. Irretrievable investments, or sunk costs, are also symptomatic of innovative activity.

We hope that this paper will be helpful to firms, policy makers and students of innovation who, in their own context, are interested in determining the basis for judgments as to what does and what does not constitute innovation. We end with one warning, that measuring innovation can be misleading. If firms are to be supported financially (and the performance of an economy measured) by the number of new products and processes introduced, then there is a danger that firms will effectively differentiate for the sake of the support. This is likely to increase the number of imitations, with little genuine innovation. Clearly that may be a good thing in some circumstances, but it will not be so in all.

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[41] This paper is a working paper, based on continuing comparative research in Europe, the USA and Brazil. The research is at an early stage, and, for Brazilian genomics and bioinformatics, is part of a longitudinal study in co-operation with GEOPI at Unicamp, Campinas, Brazil, to whom we express gratitude for all the help and support. The European and USA research is a project 'Bioinformatics and Economies of Knowledge in Europe and the USA' funded by a grant from the ESRC, in addition to the funding for CRIC.

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