Prometheus
Vol. 29, No. 2, June 2011, 207–217

RESPONSE

Beware Greeks bearing steam engines: a response to the Kastelle and Steen proposition

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Introduction

The primary assertion in the Kastelle and Steen proposition is that managers confuse or conflate the invention and implementation stages of innovation by focusing on ideas (or inventions) to the detriment of their firm's process of implementing those inventions. Ideas, they argue, are not innovations, and, following a stage when the ideas/inventions have been gathered, a pre-defined innovation implementation process is on offer – the innovation value chain – which purports to provide a repeatable and reliable path to novel and commercially exploitable improvements, products and services for the firm.

The proposition attempts not merely to distinguish an idea (or act of invention) from the process of innovating it, but to draw a veil over the messy creative process, and replace it with a tidier process termed 'innovation'. The word 'innovation' as used here has taken on implications that are at odds with both Schumpeterian descriptions of innovative entrepreneurial process and also the reality of invention and innovation as illuminated by the historical record. Unfortunately, Kastelle and Steen's espousal of the innovation value chain (Hansen and Birkinshaw, 2007) serves only to confuse the picture further. Ideas and inventions, as they suggest, are not the same as innovations, but this is by no means tantamount to suggesting that even late-stage innovation is not very importantly suffused by ideas and ideational processes. Rather, I would assert that no important innovation can be considered as anything other than a continuous and iterative cycle of inventive and creative actions, which is punctuated by moments when successful applications of it are made. A successful application of any invention can be made at a point when the process of creativity achieves a degree of adequacy. This point represents a moment in the series of inven-

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ISSN 0810-9028 print/ISSN 1470-1030 online

http://dx.doi.org/10.1080/08109028.2011.608551
http://www.tandfonline.com

tive cycles when a solution is temporarily adopted in its current form and the technology awaits the next sequential spurt of invention (Schiffer, 2005).

Much of what managers, and management consultants, prefer to think of as innovation is actually entrepreneurship. The process of entrepreneurship can itself involve acts of creative thinking – or invention – but those purely entrepreneurial activities it entails (networking, resourcing, promotion, evangelism and so on) are perhaps those most easily distinguishable from the creative activities, and consequently those most accessible to the application of training and process.

The chief financial officer's fear of invention

In the mind of a firm's chief financial officer, the word 'invention' summons up an image of an uncertain, unsanitary world, characterized by uncontrollable experts, wild surmises and blue-sky hypotheses. This is understandable, since the pursuit of invention is a potential sinkhole for corporate resources. It is perhaps no coincidence that we find that, in popular usage – at least using the books in Google's Ngram database[1] – the word 'invention' was overtaken by the word 'innovation' at the end of the 1960s, roughly coinciding with a surge of growth in international business consultancy. The Boston Consulting Group was founded in 1963, around the time McKinsey and other consulting firms went global to exploit the market provided by the post-war multinational corporations:

> While globalization is a staple of 21st-century business, its roots are in the lowering of tariff barriers throughout the 1960s. This spurred many major American and European companies to reach beyond their own borders. Many of these early multinationals sought our advice on how to organize as conglomerates. (McKinsey, 2011)

Any offer of certainty (real or apparent) places power in the hands of those offering it. It is reasonable to assume that one of the objectives of a business consultancy is to reduce a manager's anxiety. An important way of removing some of the manager's anxiety about the future is to provide – or even merely to appear to provide – a reliable process to manage it, as a substitute for creative chaos. Innovation, when presented as the act of getting new things done, presents a busy image of continuous positive action, a more soothing, reassuring prospect than invention – the single and highly uncertain act of pulling a good idea out of airy nothingness. Perhaps the business executive's anxiety is further sharpened by Schumpeter's coining of the term 'creative destruction' in 1942 – in the middle of a most destructive global conflict – to depict the process of radical innovation as the tearing down of the large corporate edifice by entrepreneurial activity promoting new ideas. There may even be a darker Oedipal resonance.

Mintzberg's discussion of the various political games played within organizations includes his definition of the expertise game:

> [the] use of expertise to build power base, either by flaunting it or by feigning it; true experts play by exploiting technical skills and knowledge ... non-experts play by attempting to have their work viewed as expert, ideally to have it declared professional so they alone can control it. (Mintzberg, 1985, p.137)

The expertise game may be as conveniently played by experts from without the organization as within. They offer to the hard-pressed manager an attractive transaction where stability, reliability and the appearance of greater certainty can be purchased for a fee. In addition, how is the manager to decide, when examining the outcomes of a complex process like innovation – where success or failure may be determined by any of a multiplicity of variables – who is a real and who a feigned expert?

What is innovation?

A good plan (or a good idea) never survives its first encounter with the enemy (or with reality and the laboratory bench). Therefore, our innovative path requires us to have not merely one idea, but a series of ideas, or a period of sustained creativity that is always connected with reality. Thus, innovation is an iterative process where we constantly return to reshape and modify our first thoughts in the light of our experience. As the examples below will show, invention and innovation – ideas and experience – are intertwined in a dialectical relationship.

Part of our confusion about the roles of inventor, innovator and entrepreneur is that a single individual may be all three and more besides (inventor James Dyson is a good example). Another confusing element is Schumpeter's apparent identification of the whole process of innovation with a major part of the role of the entrepreneur:

> The inventor produces ideas, the entrepreneur gets things done, which may but need not embody anything that is scientifically new. Moreover, an idea or scientific principle is not, by itself, of any importance for economic practice: the fact that Greek science had probably produced all that is necessary in order to construct a steam engine did not help the Greeks or Romans to build a steam engine; the fact that Leibnitz suggested the idea of the Suez Canal exerted no influence whatever on economic history for two hundred years. And as different as the functions are the two sociological and psychological types. (Schumpeter, 1947, p.152).

What Schumpeter seems to conflate here are the roles of the entrepreneur and innovator, or rather, the role of the innovator is subsumed into that of the entrepreneur, leaving the inventor standing alone, not only with a different function, but as a different 'sociological and psychological' type. In this definition of the role of the entrepreneur in society, Joseph Schumpeter hands to the entrepreneur one of the tasks that we would now assign to the innovator: to take an initial idea and turn it, after due passage of time, into a viable product or service. But although he adverts to it in his throwaway phrase 'may but need not', Schumpeter makes insufficient allowance for the acts of continuous invention that are demanded of innovators to achieve viable products or services. His use of the term 'entrepreneur' and his distinguishing of this from inventor seem to imply that the work of the inventor largely ceases when the entrepreneur/innovator picks up the traces. But this is increasingly unlikely in a world of growing technological complexity.

Schumpeter's proposition about Greek science is frequently presented as convenient shorthand to illustrate the difference between invention – requiring inspiration, scientific knowledge and research – and innovation/entrepreneurship – requiring vision, willpower and determination. There is almost an implication that his Greek and Roman societies merely lacked entrepreneurs to bring into being a revolutionary technology 2000 years ahead of its time. The debate about Schumpeter's ideas:

> led to the transfer of the concept of innovation from the realm of speculative reasoning in the laboratory to a functional model of the capitalist process allowing for both new firms and the rise of new men to business leadership. (McDaniel, 2000).

This new concept of the meaning of innovation was grasped and applied by the management consultancies of the 1960s, and a continuation of this attitude probably leads us to Hansen and Birkinshaw's (2007) innovation value chain.

The Greek steam engine

It is of great importance to any posited distinction between invention and innovation to consider what kind of steam engine Greek entrepreneurs might have constructed if, in a flash of inspiration, they had conceived its real benefits and were presented with a clear application for the use of steam power. Since we cannot re-run the historical tape with a few variables altered, the best guess at what they might have achieved with the science at their disposal may be derived from what we know of the actual history of the development of the steam engine and the long cycles of creative insights and inspirations this reveals. The main (modern) cycle probably commences in 1606 with Giambattista della Porta and his demonstration that steam could be used to move water 'either by forcing it or by drawing it into a vacuum formed by condensing steam' (Kerker, 1961, p.382). The process of test, further discovery and insight, continued through Huygens's and Pappin's prototyping efforts, was followed by Newcomen's breakthrough with the atmospheric engine, Watt's condensing chamber, Hornblower's compound engine, Parson's steam turbine and, for all we know, continues to this day. Entrepreneurs have made use of the ideas and improvements produced at some crucial stages and – commencing with Newcomen's rudimentary design – have found commercial applications for some of the major developments. But at which point on this long and continuous stream of ideas can we definitively pinpoint the core 'idea' for the steam engine or one of the many improvements? Every step taken needed to be enhanced by a set of experiments, prototypes, and validations as creative and as replete with ideas as the first one (Robinson, 1947).

The Greeks, we may surmise, having had the initial idea, would have encountered something like the dilemmas that all later experimenters and inventors met. It seems unlikely that they would have got any further than, or even as far as, della Porta. Steam power might have entered our racial memory early on, as a failed avenue of exploration, or invention.

To underline the point that the core idea or invention must be followed by many other ideas and inventions, all equally important, it is worth considering examples of abandoned technologies. An alternative steam engine design, a vacuum approach (following della Porta) was pioneered by Thomas Savery in the late 17th century. Savery's engine was not adopted at the time, not because of an inherent flaw in the design, but because of imperfections in the construction of the machine that made it lethal when attempts were made to exploit its full power (Landes, 1969, p.100). We can imagine a scenario where, if the science of the Greeks had got as far as Savery with the materials and construction technologies available to them, their flash of inspiration would have become an altogether different kind of flash.

In a similar vein, previously abandoned or sidelined alternatives to the internal combustion engine, like the gas-powered or electric car, are now being re-considered and explored. Papin had ideas in plenty: for the pressure cooker, a steam engine for pumping water from mines, a steam-driven paddle ship, a blast furnace, not one of which was he able to carry through to a stage sufficient to make him any money (Robinson, 1947, p.50). It is precisely the problem of achieving perfection sufficient to be of use that is at the heart of any discussion about the variations in meaning of the words 'invention', 'innovation' and 'entrepreneurship'. The list of ideas commonly associated with Leonardo Da Vinci includes: the helicopter, the tank, concentrated solar power, the calculator, hydraulic pumps, finned mortar shells and the steam cannon, but no sufficient perfection of any of these ideas appeared in the inventor's lifetime, nor for a long time afterwards. It is clear that the process of achieving sufficient effectiveness is the major work of the innovation process, and embeds within it multiple acts of creativity, invention and chance discovery that are impossible to foresee at the outset.

If Schumpeter was correct that entrepreneurship was about getting new things done, it is equally the case that a proper definition of innovation must include the idea of making new things do-able and, as such, its rightful place is as a framework for inventive activity, not as a subset of entrepreneurial activity. Inventive activity does not stop, but only commences with its first idea. Thus, the innovation value chain, while it may bring temporary relief to the firm's financial managers for those small number of product development projects with a limited range and ambition, is also likely to mask the firm's most creative and inspirational capabilities. The firm will fail to exploit these or to make the necessary further discoveries to perfect its technology – until competitors have led the way.

Additional support for this view of continuous invention comes from the fields of anthropology and archaeology, where a cascade model of invention has been identified. The cascade model of the invention and development of what have been called 'complex technological systems' (CTSs) closely mirrors the true innovation process as suggested above:

> In a nutshell, the cascade model posits that, during a CTS's development, emergent performance problems – *recognized by people as shortcomings in that technology's constituent interactions* – stimulate sequential spurts of invention. As adopted inventions solve one problem, people encounter new and often unanticipated performance problems, which stimulate more inventive spurts, and so on. The result is a series of 'invention cascades'. (original emphasis) (Schiffer, 2005, p.486)

A fine example of the kind of second or third stage invention needed to achieve fully marketable technology is visible in the well-known and regularly referenced example of Percy Shaw's invention of reflective road studs, or catseyes. Shaw's key invention is usually described in the romantic terms of a flash of inspiration:

> ... one foggy night in 1933 he was driving back to his home in the Boothtown area of Halifax from nearby Bradford when he hit a perilous stretch of road with a sheer drop down a hillside to the right of the road ... It was so dark and foggy that Shaw could not see where the road ended and the hillside began, until suddenly he spotted in the darkness the reflections of his car headlamps in the eyes of a cat sitting by the road. (Design Museum, 2011)

Another version is less romantic, but may be more plausible:

> Percy Shaw sometimes told a more pedestrian version of the story in which his inspiration came from spotting reflective road markers beside a road. (Design Museum, 2011)

This second, pedestrian, version of the story is all the more plausible when we consider that, by 1930, the problems of night driving were already quite well known and not confined to the countryside around Halifax in the UK. Others were at work on the problem. Most notably, in September 1933 the prolific inventor David Ross[2] – founder of Purdue University's Purdue Research Foundation – had actually been issued with a patent for a reflective device very similar to Shaw's, over half a year before Shaw submitted his application to the UK Patent Office in April 1934 (Shaw, 1935). It is true that Ross's (1933) reflector did not contain the crucial improvement of a small rubber blade to wipe the glass lens clean, saving considerable resources in maintenance, but then neither did Shaw's 1934 version. The lens cleaning improvement, which probably made the original idea viable for general commercial use, was not introduced until Shaw's (1936) second patent was filed in May 1935:

> Having hit upon the idea of inventing a reflective road marker, Shaw spent several years developing it. His challenge was to create a device which would be bright enough [to] illuminate the roads for drivers at night, but would work in all weathers and be robust enough to cope with cars and trucks driving on top of it. To make matters even more complicated, as the markers would be installed in thousands of miles of road the need for maintenance had to be minimized . . . Aiming for minimal maintenance, Shaw even devised a way for his Catseyes to clean themselves. The cast iron base collected rain water and whenever the top of the dome was depressed, the rubber would wash rainwater across the glass beads to clear away any dust or grime that had gathered there, just as the human eye can be cleansed by tears. (Design Museum, 2011)

The story now contains all the elements previously pointed to. The initial idea is followed by prototyping and development, with the expense of trial and error assumed and driven by a committed individual, possessing resources equal to the task, until a level of perfection is achieved sufficient to persuade investors and legislators that the main problems have been solved, and that the utility of the invention has been adequately demonstrated. Perhaps if Ross had persisted, or had been driving on roads as perilous as those around Halifax, his invention rather than Shaw's might have been the beneficiary of the necessary testing and improvement.

The 'unperceived need'

Kastelle and Steen cite West (2002), who uses the 3M Post-it note case to support the proposition that the innovation process is front-loaded with ideas, by suggesting that 3M engineer Art Fry's major task, as soon as his bookmark idea had occurred to him, was not an inventive, but an intrapreneurial one.

Fry's inventive efforts occurred in the 1970s but, to jump back in time, it is arguable that 3M's development of an environment conducive to the Post-it note invention began as early as 1925, when automobile painters were seeking a light sticky medium to attach spray-painting masks to a car body with an adhesive that did not damage the finishes already applied (Petroski, 1992, p.107). To meet this clearly articulated customer need, 3M developed a glue of lower than normal tack applied to strips of crepe paper, later called Scotch tape, or masking tape. In 1968, a researcher in 3M, Spencer Silver, produced a glue with exceptionally low adhesive power. Perhaps influenced by the Scotch tape example and its impact on the company's fortunes, and believing that it must have some commercial application – which he was unable to articulate at the time – Silver personally evangelized his adhesive at company seminars for five years or more, presumably seeking a problem or a need among his colleagues that could be met by this solution.

In 1974, yet another 3M employee, Art Fry, received a description of the weak adhesive from a colleague who had attended one of Silver's seminars. Fry was a chemical engineer who sang in his church choir and who used pieces of paper to mark the relevant pages of his hymnal for rapid and easy access. The plain paper inserts in his hymnal often fell to the ground during the service, leaving him struggling to find the words of the hymn. He needed a bookmark that would stay put and he realized that, in a manner similar to the solution 3M had produced for the auto painters of 1925, a low-tack adhesive might deliver a bookmark with that minimal staying power. Thus a series of ideas, conscious or subconscious, led to Fry's insight based on personal experience.

West now concludes that Fry:

> was constrained not by technology (the adhesive properties required for the product were already available), but by the resistance and incredulity of others in the organization. His creative strategy was to provide Post-it notes to the secretaries of senior managers, and they in turn began to demand more of the product, so persuading the Marketing and Production departments of the value of the idea. Thus, creativity is primarily required at early stages of the innovation process. (West, 2002, p.358).

But this is wrong in a most revealing and crucial way. In reality the exact adhesive properties were not available since initial tests left adhesive deposits on the hymnal's pages, and Fry later surmised that:

> 'some of those hymnal pages I tested my first notes on are probably still stuck together'. But since it is 3M's policy (and that of other enlightened companies) to allow its engineers to spend a certain percentage of their work time on projects of their own choosing, a practice known as 'bootlegging', Fry was able to gain access to the necessary machinery and materials and to spend nearly a year-and-a-half experimenting and refining his idea for sticky – but not too sticky – slips of paper ... (Petroski, 1992, p.110)

Continued creative effort is required to achieve sufficient effectiveness. Note that, because of his position and the attitude of the firm, Fry had the resources to improve his ideas, to a large extent below the firm's resource allocation radar. But Fry had other problems to solve, and these, too, demanded creativity and imagination:

> When Fry thought the stick-and-remove notes were ready, he took samples to the company's marketing people, who had to accept the idea as commercially viable and likely to meet a market need before any substantial amount of the company's own time or money could be committed to the product. There was a general lack of enthusiasm for something that would be more costly than the scratch paper it was intended to replace, for it was felt that the greatest commercial application for Fry's invention was removable notes rather than sticky bookmarks. Fry was committed to his brainchild, however, and he finally convinced an office supply division of 3M to test-market the product that "met an unperceived need". Early results were not promising, but in those cases where samples were distributed, customers became hooked. (Petroski, 1992, p.110)

West argues that Fry's immediate problem was not a technological or inventive one, but makes exactly the opposite point. The example suggests that the problematic conflation is not, as Kastelle and Steen propose, between invention and innovation, but between innovation and entrepreneurship, since the effort required of Fry to see his invention brought to market was partly the work of the inventor/innovator and partly the work of the entrepreneur. Even in the entrepreneurial phase, West refers to Fry's 'creative strategy' in distributing the product within the company to seed a base of early adopters with influence (West, 2002, p.358). Fry was clever, in other words, about ideas for persuading the marketing side of the organization to get behind the project, and in his seeding of the market. We are left with the overwhelming feeling that no inexorable innovation process was at work, but that Fry's individual ingenuity, creativity, inventiveness and belief in the product were tested, and were capable of producing a creative solution, at each key stage. At any one of these stages, including the long period of pure invention where the adhesive was being perfected, Fry could simply have given up. The case echoes the earlier example of penicillin, where Alexander Fleming, having discovered penicillin's antibacterial properties, attempted to grow it in quantities adequate for treatment. He was unsuccessful in these early efforts and abandoned the goal as (at least temporarily) unachievable. The task was later assumed by Howard Florey and a team at Oxford University, and a long process incorporating further creative experiments and inventions by Ernst Chain, Norman Heatley, financial contributions from the US government, and technologies developed by the US firms of Pfizer and Merck, saw it to successful completion (Kingston, 2000; Evans, 2004; Sidebottom, 2004).

It is worth noting that the Post-it case is a good example of why it is a mistake for creativity to be constrained by the parameters defined by market research and needs identification processes. The 3M marketing people were correct in identifying Fry's solution as being for an unperceived need, but novel solutions are very likely to have such unperceived and unrecognized needs; and if the customers cannot see them, it is not very likely that a market research process will discover them. Recognition of the value of pursuing any innovation path is often subconscious, an outlier rejected by orthodox opinion whose adoption is driven by champions, and whose justification is often retrospective. As Hamel (1999) puts it:

> Typical is the logic a senior car company exec gave me for his firm's initial reluctance to invest in minivans: 'There was no segment there, so how could we invest? We couldn't make a business case'. By the time the company amassed enough evidence to assure itself that the minivan opportunity was real, it was a million units behind Chrysler, the minivan pioneer. (Hamel, 1999, p.80)

The examples above strongly suggest that even that part of the process where we merely recognize an idea as being a good one places special demands on our creative capabilities. To recognize the potential in any idea involves a powerful act of conceptualization, where we create a mental construct of the world as it might be after our invention has been made manifest. Consider the thought experiment that we carry out when someone asks us the question: What would you like for lunch? or What would this room look like with blue walls?. When it comes to food flavours or colour charts, we are firmly grounded in experience, and the feat of imagination required to make us salivate is not great. The act of invention is to conjure up, in imagination, a world complete with entirely new information, or new combinations of existing information. This imagined world is the first act of prototyping, since it allows us to perform a primary test of the validity of the idea at the lowest possible expense. It does, however, leave much to be discovered and perfected.

This has, of course, major implications for that part of the innovation value chain described as selection: screening and initial funding (Hansen and Birkinshaw, 2007, p.124). We must infer that the authors view great ideas not only as easy to come up with, but also as subject to the application of easily defined criteria or old-fashioned common sense.

Desperately seeking certainty

The value chain then, while its title may convey a satisfying ring of reliability, itself offers no robust path to invention or innovation. It is just one more process, like quality certification, holding out the promise of a secure and certain path through an uncertain future. It offers this process as a way of avoiding what evidence suggests is a highly uncertain series of activities dependent on the creative and inspired imagination of individual people. But in offering managers this process, it provides them with only a representation of what is aspired to, a substitute for the real thing. The imaginative act of combining ideas in our mind to produce a new and unexpected result depends on our ability – at least temporarily – to set aside the tried and trusted, the habitual, the very reliability of the process that a value chain typifies.

A similar representation of quality is employed in the use of patent counts and patent statistics by firms and universities as a metric for the quality of their innovation process. Firms counting their portfolio of patents therefore have an illusion of innovative success and ignore the implementation of inventions. Kastelle and Steen have correctly drawn attention to the widespread, but mistaken, practice of using patent counts as a measure either of invention or innovation. However, it is imperative to point out that this is not the activity of scholars in the field of patent research, but of business managers, university technology transfer officers and politicians concerned with public relations. If the questionable nature of the practice were more widely acknowledged, it would save firms and universities both time and expense and allow researchers to focus their abilities and skills on activities more useful than writing patent applications. As Scherer and Harhoff assert:

> A small minority of innovations yield [sic] the lion's share of all innovations' total economic value. This implies difficulty in averting risk through portfolio strategies and in assessing individual organizations' innovative track records. (Scherer and Harhoff, 2000, p.565).

However, it is equally important to add that this abuse of patent statistics neither discredits these as a valuable tool for analysis, nor lends any support for Kastelle and Steen's primary assertion that invention and innovation are discrete activities or phases. This is equally true of the misuse of patents themselves and the annexation, by large and powerful interests, of a system originally intended to encourage invention by individuals and small firms. Patents, in as far as they record the behaviour of firms and individuals, are not a full record of invention or creativity (Lanjouw *et al*., 1998). Patent records, when used carefully and correctly, are a valuable indicator of relative technological, not creative, capability (Kingston and Scally, 2006).

The Kastelle and Steen proposition rejects the use of patent counting as a simple measure of the innovation of a firm. Academic researchers in the field do not generally use the data in this way but understand that patents are a record of inventors' actions and beliefs and, for all their problems, are at least some measure of the *output* of the inventive activity. It is far more absurd to promote, as Kastelle and Steen do, a mechanistic, innovation-by-numbers process like the value chain as an *input* to creative activity. People are creative; processes are not. The task for good managers is not to shirk their responsibility by attempting to buy certainty in the form of a pre-packaged process solution, but to grapple bravely with, and try to comprehend, the complex and exciting relationship between creativity, imagination, invention and innovation.

Notes

1. To view the results directly, see http://ngrams.googlelabs.com/graph?content=invention%2Cinnovation&year_start=1900&year_end=2008&corpus=0&smoothing=3
2. Purdue Research Foundation maintain a page devoted to David Ross at http://www.prf.org/about/history.asp

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