An Innovation Perspective on Design: Part 1

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Introduction

This paper analyzes innovation and design from a management and economic perspective. The management sciences, innovation studies, economics, and the social sciences in general have, traditionally, paid little attention to design as a core creative industrial and economic activity. This situation is now changing as innovation and management studies increasingly recognize the technical and wider role of design in business and economic activity. Within the social sciences, including management studies, one might think that one of the natural "homes" of design research and teaching would be innovation studies—a well-established subject area that focuses on the role of research and development (R&D), engineering, science, and technology in the economy. However, with the exception of a stream of important product development and design management research, this expectation is not fulfilled.[1] As this paper makes clear, within mainstream innovation studies, design has been largely absent from theory, teaching, textbooks, and research.

The purpose of this paper is therefore to provide an "innovation studies" perspective on design, focusing on design in business and the economy. This approach can be seen as part of a broader question of where design could be positioned within the social sciences as the subject expands across an increasingly wide range of business and social activity. Design potentially might thrive in many areas within the social sciences, including strategy, entrepreneurship, and marketing in the business management area, as well as in sociological, organizational science, and economic fields.

In this paper we argue that by developing an innovation perspective on design, and a design perspective on innovation, both fields stand to gain. The idea of the paper is to critically examine the role of design in business and the economy from an innovation viewpoint. First, we provide definitions and perspectives on the terms, "design" and "innovation," helping to define the boundary conditions of both subjects. Second, we assess the treatment of design in innovation studies. More often than not, design is either treated in passing or entirely overlooked. This section also asks why this neglect happens, given the recognized importance of design in innovation. Finally, we assess the design discourse from an innovation and social science perspective, showing how design

1 The classic product development studies include K. B. Clark, "The Interaction of Design Hierarchies and Market Concepts in Technological Evolution," *Research Policy*, 14:5 (1985), 235–51; K. Ulrich, "The Role of Product Architecture in the Manufacturing Firm," *Research Policy*, 24:3 (1995), 419–40; and C. Y. Baldwin, and K. B. Clark, *Design Rules, Vol. 1: The Power of Modularity* (Cambridge, MA: MIT Press, 2000). Design management texts include, for example, R. Cooper, and M. Press, *The Design Agenda: a Guide to Successful Design Management* (Chichester: John Wiley and Sons. 1995); and M. Bruce and J. Bessant, *Design in Business: Strategic Innovation Through Design* (Essex: Pearson Education, 2002). Also see two recent practice-oriented teaching textbooks on design management and strategy K. Best, *Design Management: Managing Design Strategy, Process and Implementation* (Lausanne: AVA/Academia Publishing SA 2006); B. von Stamm, *Managing Innovation, Design and Creativity* (Chichester, John Wiley and Sons. 2008). These are discussed in Part 2 of this article (forthcoming).

as a human-centered, core creative activity in business challenges the overly scientific, rational view of the firm and many of the standard intervention tools of innovation management. Part 2 of this paper (in an upcoming issue of *Design Issues*) builds on this analysis to illustrate the gains that can be achieved by bringing the fields of innovation studies and design/design thinking closer together.

Definitions and Perspectives

Clearly defining the terms "design" and "innovation" is important for achieving the purposes of this paper, as well as for establishing the boundary conditions of the paper. Neither term is unproblematic, and both have changed over time. In innovation studies, innovation has traditionally been defined as the successful introduction of a new or improved product, process, or service to the world or marketplace.[2] However, this definition does not capture the incremental innovations that can lead to large gains in productivity and product quality. These innovations are often a major source of structural change and economic growth.[3] In developing countries, and sometimes in advanced nations, incremental innovation tends to occur from "behind the technology frontier," defined by leading firms in the advanced countries and usually measured by the ratio of R&D to sales. Therefore, following Nelson and Rosenberg and Schmookler, we define innovation as a product, process, or service new to the firm—and not just new to the world or marketplace.[4] This broader definition encompasses the stream of minor innovations that follow from radical new products and processes. Thus, innovation is not only a product but also a *process*—one that involves the lengthy development and application of new knowledge and skills, rather than being an easily identifiable event. In this paper, we stick mainly to this "Schumpeterian" definition. However, it should be noted that, in recent times, the definition is often reduced and simplified into "the application of a new idea to create value." Sometimes, the term is broadened beyond technological innovation to include organizational innovation[5]—because the two often go hand in hand.[6]

The meaning of design has also changed over time. Tether[7] provides a review of dozens of, often contradictory, definitions. One key agreement is that design should no longer be seen as "styling," but as a core technical element or activity, central to industry and services throughout the economy. Herbert Simon's general definition is useful as foundation: "Design is the transformation of existing conditions into preferred ones."[8] However, this paper follows Sir George Cox's definition because it also involves the needs of the customer or user: "Design… shapes ideas to become practical and attractive propositions for user or customers. Design may be described as creativity deployed to a specific end."[9] Also note that the concept of design, like innovation, has recently broadened to include non-technical areas of human activity, such as policy, organization, and social issues.

2 N. S. Dorfman, *Innovation and Market Structure: Lessons from the Computer and Semiconductor Industries* (Cambridge, MA: Ballinger, 1987); M. I. Kamien and N. L. Schwartz, *Market Structure and Innovation* (Cambridge: Cambridge University Press, 1982).

3 R. R. Nelson: "The Simple Economics of Basic Scientific Research," *Journal of Political Economy* 67:3 (1959): 297–306; A. Phillips, "Patents, Potential Competition and Technical Progress," *The American Economic Review*, 56:1/2 (1966): 301–10.

4 R. R. Nelson and N. Rosenberg, "Technical Innovations and National Systems," in *National Innovation Systems: A Comparative Analysis*, ed. R. R. Nelson (New York: Oxford University Press, 1993); J. Schmookler, *Invention and Economic Growth*, (Cambridge, MA: Harvard University Press, 1966).

5 Organizational innovation can include beneficial changes to structure, finance, marketing and distribution, and human resources. However, this paper focuses mainly on technological issues, including R&D and value-enhancing changes to products, services, and processes.

6 R. Stata, "Organisational Learning—the Key to Management Innovation," *Sloan Management Review*, Spring (1989), 63–74; D. A. Garvin, "Building a Learning Organization," *Harvard Business Review*, July–August (1993), 78–92.

7 B. S. Tether, "Think *Piece" on the Role of Design in Business Performance* (London: Department of Trade and Industry (DTI), HM Government, 2005).

8 M. Jahnke, *Innovation Through Design Thinking: an Experimental Study of the Implementation of Design Thinking in Non-designerly Firms; Report for the Doctoral Education Seminar on 25% Level* (Gothenburg, HDK, School of Design and Crafts, Business & Design Lab, The Faculty of Fine, Applied and Performing Arts University of Gothenburg, 2009), 13.

9 G. Cox, *Cox Review of Creativity in Business: Building on the UK's Strengths* (London, HM Treasury, 2005), 2.

Juxtaposing these two sets of evolving definitions is useful in that there is clearly considerable overlap, with design as a technical activity playing a central role in the broader innovation process. Indeed, by any reasonable modern definition, design is a central part of industrial innovation.

The Treatment of Design by Innovation Studies

When we examine innovation studies as a medium-sized subject area that conducts research and teaches innovation around the world, we see that design is either treated in passing or, more often, is entirely overlooked, apart from within specialized groups.[10] This oversight applies not only to teaching (e.g., there are 156 post-graduate Business Management courses in the UK alone that include innovation in their title or module content), but also to research, textbooks, theorizing, and other educational activities.[11] To answer "why should this be," it is helpful to look briefly at the way innovation studies has evolved.

The field of innovation studies developed after World War II and has now spread to most corners of the world.[12] It has two main sources: (1) economists and other social scientists, frustrated with the way mainstream economics deals with the economy (e.g., usually in highly theoretical, abstract models, with little notion of history, institutions, science, or technology); and (2) engineering schools that began by teaching the management of technology to their students. Both sources now teach technology and/or innovation management, with masters courses proliferating during the past 20 years or so.

The theoretical and research side of innovation studies is dominated by "renegade" economists. They look in detail at the role and effect of technological innovation in the wider economy, in the industrial sector, and in individual firms. Joseph Schumpeter, the pioneer of the idea of creative destruction, attributed a paramount role to technology in economic cycles. Professors Richard Nelson, Sidney Winter (in the United States), and Christopher Freeman (in the United Kingdom) followed in Schumpeter's footsteps, providing us with a much better understanding of the importance of innovation in economic activity of all kinds. There are now dozens of scholarly journals and hundreds of social scientists working on almost all aspects of innovation. Today, innovation studies goes beyond technology, looking at innovation in organizations, business strategy, and government policy.

However, when we look for a sensible or systematic treatment of design, we find it curiously absent. Design is sometimes mentioned, usually as one of the sequences of productive activity running from R&D to engineering, manufacturing, branding, marketing, and finally to distribution. Often it is not even mentioned in this sequence. Sometimes it is treated as a subset of the "D" of R&D, or more often, as one of the engineering sub-tasks that goes on within firms. Research and R&D are given prominence in research,

10 The classic product development studies include K. B. Clark, "The Interaction of Design Hierarchies and Market Concepts in Technological Evolution," *Research Policy*, 14:5 (1985), 235–51; K. Ulrich, "The Role of Product Architecture in the Manufacturing Firm", *Research Policy*, 24:3 (1995), 419–40; and C. Y. Baldwin, and K. B. Clark, *Design Rules, Vol. 1: The Power of Modularity* (Cambridge, MA: MIT Press, 2000). Design management texts include, for example, R. Cooper, and M. Press, *The Design Agenda: a Guide to Successful Design Management* (Chichester: John Wiley and Sons. 1995); and M. Bruce and J. Bessant, *Design in Business: Strategic Innovation Through Design* (Essex: Pearson Education, 2002). Also see two recent practice-oriented teaching textbooks on design management and strategy K. Best, *Design Management: Managing Design Strategy, Process and Implementation* (Lausanne: AVA/Academia Publishing SA 2006); B. von Stamm, *Managing Innovation, Design and Creativity* (Chichester, John Wiley and Sons. 2008). These are discussed in Part 2 of this article (forthcoming).

11 There are many "pockets" of design and new product development management research (e.g., the management of design/new product development and design management in small and médium-sized firms). However, these pockets tend not to feed into mainstream innovation theory, management, or policy.

12 No single agreed-on title is used for this field of study. It began as science and technology policy studies and now overlaps considerably with evolutionary and institutional economics, as well as energy, environmental, management, and organizational studies.

measurement, theory, teaching, and policy. The Frascati Manual of the Organisation for Economic Cooperation and Development (OECD) traditionally has provided agreed upon international definitions and measurements of R&D, and within it, government policies (more often than not) are all about research, with R&D usually synonymous with innovation.[13] For example, the main EU policy for innovation and competitiveness, to which member states agreed and then enshrined in the Lisbon Treaty, called for EU investment in R&D to increase to 3% of GDP by 2010. There is no mention of design.

As a result, the social sciences in general and innovation studies in particular have a very poor conceptualization of design as a creative economic activity at the firm, industry, and wider economic levels. We have few systems of measurement (especially compared with, say, R&D), and in leading innovation texts, we find scant treatment of design, which is reflected in most graduate and post-graduate innovation courses. For this paper, we reviewed ten of the most highly cited recent textbooks on innovation. None has a chapter exclusively on design, and most have only a few references to design in the index pages. Design is certainly researched and taught in other subject areas (e.g., especially in design schools). But surely a subject called "innovation studies," which purports to teach, consult, educate, and advise business and government, should also deal systematically with design—and place design at the heart of theory and research.

One source of this problem may be the theoretical orientation of innovation studies. As Hatchuel points out,[14] the dominant approach to innovation is based on Herbert Simon's idea of human problem-solving within "bounded rationality."[15] This Nobel Prize-winning idea was a breakthrough at the time in that it overturned the mainstream economic assumption of perfect rationality. However, by treating innovation in general and design in particular as processes of solving problems, design as a core creative activity seems to have been left on the sidelines. As a result, much of innovation theory and teaching is appropriate for operational (e.g., routine) activities, but not for understanding creative and routine-breaking activities—of which design is one of the most important. Several important contributions now make this point in different ways.[16]

However, just noting this absence does not provide the whole picture. Identifying why design is not dealt with properly in innovation studies is actually quite hard. There is certainly no opposition to the idea of design, and there are, in fact, a few extremely good innovation papers on design that stress its central importance in business innovation.[17] In addition, a tradition of design management research and teaching is centered on product and process design in large and small firms.[18]

One possibility is that, in the face of hostility from educational structures and single-discipline subjects, innovation studies (which

13 This perspective is changing with the OECD Oslo manual, which introduces non-technical and non-R&D innovation measures, such as marketing and organizational innovation. In fact, a recent study shows that design contributes 17% to innovation, compared with only 11% for R&D in the UK, during the period from 2000 to 2007, with innovation accounting for two thirds of UK private sector labor productivity (see, NESTA, *The Innovation Index: Measuring the UK's Investment in Innovation and its Effects* (London: National Endowment for Science, Technology and the Arts, 2009).

14 A. Hatchuel, "Towards Design Theory and Expandable Rationality: the Unfinished Programme of Herbert Simon," *Journal of Management and Governance*, 5:3–4 (2002), 260–73.

15 H. A. Simon, "A Behavioral Model of Rational Choice," in *Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in a Social Setting*, ed. H. A. Simon (New York: Wiley, 1957).

16 For example, R. Buchanan, "Wicked Problems in Design Thinking," *Design Issues*, 8:2 (Summer 1992), 5–21; F. Collopy, *Firing on All Eight Cylinders, Position Statement for the Conference: Convergence: Managing and Designing* (Cleveland: Weatherhead School of Management, June 2010), 17–9; R. J. Boland, F. Collopoy, K. Lyytinen and Y. Yoo, "Managing as Designing: Lessons for Organization Leaders from the Design Practice of Frank O. Gehry," *Design Issues* 24:1 (Winter 2008), 10–25.

17 V. Walsh, "Design, Innovation and the Boundaries of the Firm," *Research Policy* 25:4 (1996), 509–29; Tether, "Think Piece."

is inherently multi-disciplinary) took to focusing on and modelling what could be more easily measured. R&D spending as an input to innovation is recorded by firms and governments internationally, while patents as a major output of R&D are also filed and recorded, leading to a great deal of theorizing, measurement, and techno-econometric modelling of R&D performance at the firm, sector, and economic levels.[19] Perhaps the popular notion of organizational "routines"[20] and capabilities (defined as bundles of routines), drew attention away from design as a creative process, central to business success and renewal.[21]

At the business practice level, there is little research on how designers work together creatively to develop solutions to complex, seemingly intractable, multi-disciplinary problems. One exception is Bucciarelli, who delves inside the real world of designers.[22] Another insightful book on engineering design is Vincenti, who shows how engineering knowledge differs fundamentally from scientific knowledge but is no less valid.[23] Conklin reveals how successful design teams work together.[24] They do not "rationally" plan in advance a complex new product or system, beginning with a concept or specification and choosing among solutions, in a Herbert Simon problem-solving fashion.[25] On the contrary, by recording and analyzing the discussions of designers at work, Conklin shows that multi-disciplinary design teams tend to begin with a very rough approximation of the "problem" (e.g., a new product) and then "leap" forward to generate possible solutions. They then move rapidly back to re-framing and re-specifying the problem, repeating this process again and again. Not only do they not move forward in a rational, linear fashion; they also design within teams, in a social process, which includes other specialists and potential users who provide immediate feedback, negative and positive, so they can all eventually arrive at a practical, agreed-upon way forward.

Design and Innovation Management Studies

Increasingly, management scientists and organizational theorists are recognizing and so re-conceptualizing the role of design and design thinking in business, generating a new sub-field of academic inquiry and graduate and post-graduate teaching.[26] Few take an explicit social science innovation perspective, although organizational psychologists, notably Karl Weick, historians of technology such as Vincenti and others have much to say about the creative, ambiguous, and "messy" processes of design.[27] Within innovation studies, the role of design in business is typically viewed as a technical activity, rather than as a strategic activity of wider relevance to management. Even in this narrower domain, design is poorly understood. As Tether shows, design is usually treated as a sub-function in firms (e.g., within engineering), sometimes "hidden" within R&D or between the R&D and marketing functions (see Figure 1).

18 In the context of innovation studies, Walsh offers "...a first attempt at analysing the design function from a variety of disciplinary perspectives: economic, sociological and management" (509). This study remains one of the few design studies that offers a social science/innovation perspective. For design management teaching and research, see R. Roy and S. Potter, "The Commercial Impacts of Investment in Design," *Design Studies*, 14:2 (1993), 171–93; von Stamm, "Managing Innovation"; For new product development studies, see Bruce and Bessant, "Design in Business"; R. Cooper and E. Kleinschmidt, "Benchmarking Firm's New Product Performance and Practices," *Engineering Management Review* 23:3 (1995), 12–120; and R. Cooper, M. Bruce , A. Wootton, D. Hands and L. Daly, "Managing Design in the Extended Enterprise," *Building Research and Information* 31:5 (2003), 367–78. Research on design in small firms includes: S. Brazier, "Walking backward into Design: Support for the SME," *Design Management Review* 15:4 (2004), 61–70; G. Cawood, A. Lewis and G. Raulik, "International Perspectives on Design Support for SMEs," *Design Management Review*, 15:4 (2004), 71–6. M. Bruce, R. Cooper, and D. Vazquez, "Effective Design Management for Small Businesses," *Design Studies* 20:3 (1999), 297–315 and K. Jeffrey and D. Hunt, "Design in small manufacturing companies in Scotland," *Design Studies* 6:1 (1985), 18–24.

19 K. Pavitt, "Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory," *Research Policy* 13:6 (1984), 343–73.

20 R. R. Nelson and S. G. Winter, *An Evolutionary Theory of Economic Change*, (Cambridge, MA: The Belknap Press of Harvard University Press, 1982); for review, see M. C. Becker, N. Lazaric, R. R. Nelson, and S. G. Winter, "Applying Organisational Routines in Understanding Organisational Change," *Industrial and Corporate Change* 14:5 (2005), 775–91.

21 G. Dosi, R. R. Nelson and S. G. Winter, eds.: *The Nature and Dynamics of Organizational Capabilities* (Oxford: Oxford University Press, 2000).

22 L. L. Bucciarelli, *Designing Engineers* (Cambridge MA: The MIT Press, 2004).

23 W. G. Vincenti, *What Engineers Know And How They Know It: Analytical Studies From Aeronautical History* (Baltimore: John Hopkins University Press, 1993).

24 J. Conklin, "Wicked Problems and Social Complexity" Chapter 1 in *Dialogue Mapping: Building Shared Understanding of Wicked Problems*, J. Conklin (London, Wiley, 2005).

25 Interestingly, rational and linear models also dominate in industry; e.g., in software engineering and quality improvement programs. See M. Hobday, and T. Brady, "Rational vs. Soft Management in Complex Software: Lessons from Flight Simulation," *International Journal of Innovation Management*, 2:1 (1998), 1–43.

26 H. Clark and D. Brody, eds. *Design Studies: a Reader* (Oxford: Berg, 2009); C. L. D Ym, A. M. Agogino, O. Eris, D. D. Frey and L. J. Leifer, "Engineering Design Thinking, Teaching and Learning," *Journal of Engineering Education* 94:1 (2005), 103–20; R. J. Boland and F. Collopy, "Design Matters for Management" in *Managing as Designing*, eds. R. J. Boland and F. Collopy (Stanford, CA: Stanford Business Books, 2004).

27 K. E. Weick, "Rethinking Organizational Design," in *Managing as Designing*, eds. R. J. Boland and F. Collopy (Stanford, CA: Stanford Business Books, 2004); K. E. Weick, "Designing for Throwness," in *Managing as Designing*, eds. R. J. Boland and F. Collopy (Stanford, CA: Stanford Business Books, 2004).

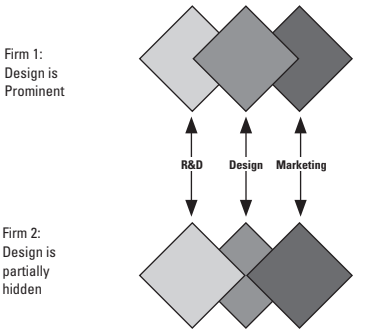
28 B. S. Tether, "Think *Piece" on the Role of Design in Business Performance* (London: Department of Trade and Industry (DTI), HM Government, 2005).

29 R. Rothwell, "Towards the Fifth-generation Innovation Proces," *International Marketing Review* 11:1 (1994), 7–31.

30 E. von Hippel, "Lead Users: a Source of Novel Product Concepts," *Management Science* 32:7 (1986), 791–806.

31 G. M. P. Swann and T. Watts, "Visualisation Needs Vision: the Pre-Paradigmatic Character of Virtual Reality," *The Virtual Society? Technology, Cyberbole, Reality*, ed. S. Woolgar (Oxford: Oxford University Press, 2002).

The Importance of Design—A Matter of Perspective?



Adopted from Tether (2005)

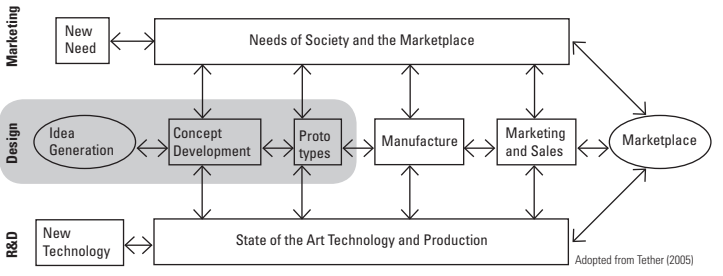
Tether presents evidence to argue that companies that invest in design perform better against most indicators.[28] He also notes that design activities within firms are underreported because "who does design" is often unclear: Is design strictly a professional activity, or is it undertaken by a range of non-recognized and unqualified personnel?

Tether also shows how design maps onto so-called Third Generation innovation "coupling" models,[29] whereby a role for lead users is envisaged for product specification, design, and re-design (see Figure 2).[30] Here again, design is viewed as a bridging function, located somewhere between R&D and manufacturing/marketing.

Using data from the UK Design Council's National Survey of Firms, Tether shows that, in the UK, only 33% of firms view design as a strategic business tool (e.g., for company differentiation) and a contributor to bottom-line performance.

Tether provides an interesting collection of modern definitions of design; however, a commonly agreed-on definition or a clear taxonomy of different kinds of design (e.g., architecture, product design, service design, and graphic design) is not yet apparent. No doubt, each category has its own professional trajectory and stage of maturity. The design fields appear mostly to be at a pre-paradigmatic (or pre-disciplinary) stage.[31] This interpretation is confirmed by Poggenphol et al., who show that little agreement emerges on the meaning of key design terms,[32] or on what constitutes core

The "Coupling Model" of Innovation with Design as a Bridging Function



Adopted from Tether (2005)

knowledge, and that a reasonably coherent research infrastructure is lacking. However, because design is so human-centered and situated in practice, one possibility is that some fields of design may never become a professional discipline in the sense of engineering or accountancy.[33] It may always be subject to evolution, diversity, and inter-disciplinarity, relying on human imagination, rather like software engineering.[34]

A key omission in the field is an understanding of how different design fields map onto various sectors and industries, including the many service sectors. Much of the design management literature focuses on manufacturing, whereas the service sector is a far larger proportion of most economies. To illustrate, manufacturing accounts for around 13% of GDP in the United Kingdom, 12% in the United States, and 13% in France, compared with around 75% for services.

In addition, a highly significant literature on design has emerged in the product development field, a branch of innovation management. Clark[35] introduces a new theoretical framework to examine the relationship between design decisions and choice of customers, using examples from automobiles and semiconductors. Clark argues that the logic of problem solving leads to a hierarchical structure for the evolution of design, which, in turn, has a shaping influence on the dynamics of competition.

Building on the work of Clark and others, Ulrich[36] integrates ideas from design theory, software engineering, and other fields to illustrate how product architecture operates as a scheme by which the functions of the product are allocated to physical components. Ulrich examines, in depth, the far-reaching implications of the role of product architecture across manufacturing, showing how it relates to various aspects of firm performance.

Design and innovation are also approached from a product platform perspective in the product development literature. For example, Baldwin and Clark develop the concept of design rules,[37] whereby design occurs within a product or system, and the design limits imposed by the increasing complexity of artifacts are overcome through the product or system's modularization. In their study of computer design, using the case of IBM's System/360, they attribute design evolution to the application of six modular operators: splitting a system into two or more modules, substituting one module design for another, augmenting (or adding a new module to a system), excluding a module from a system, inverting to create new design rules, and porting a module to another system.[38] Innovation occurs when a design becomes "truly modular," in that changes in one module do not affect other modules. In other words, as long as designers follow design rules pertaining to the architecture of the artifact, they are free to innovate without reference to the product architecture.

32 S. H. Poggenpohl, P. Chayutsahakij and C. Jeamsinkul, "Language Definition and its Role in Developing a Design Discourse," *Design Studies* 25:6 (2004), 579–605.

33 L. Kimbell, "Manifesto for the M(B)A in Designing Better Futures," forthcoming in *The Handbook of Design Management*, eds. R. Cooper, S. Junginger and T. Lockwood (Oxford: Berg, 2010).

34 M. Hobday and T. Brady, "Rational vs Soft Management in Complex Software: Lessons from Flight Simulation," International Journal of Innovation Management, 2:1 (1998), 1–43.

35 K. B. Clark, "The Interaction of Design Hierarchies and Market Concepts in Technological Evolution," Research Policy, 14:5 (1985), 235–51.

36 K. Ulrich, "The Role of Product Architecture in the Manufacturing Firm," Research Policy, 24:3 (1995), 419–40

37 C. Y. Baldwin, and K. B. Clark, *Design Rules*, Vol. 1: The Power of Modularity (Cambridge, MA: MIT Press, 2000)

38 Ibid., 12–3.

Baldwin and Clark's contribution is significant in that they also seek to quantify the effect of modularization in terms of system value. They introduce the concept of the modular cluster to represent firms and markets that are host to the "evolution of a set of modular designs."[39] Such firms benefit from reductions in transaction and agency costs and from collaboration and distributed working.

Another notable body of research in information systems deals with design science. One prominent example is Hevner et al.,[40] who show how the field of design science tries to extend the boundaries of organizational and human capabilities through the creation of designed artifacts. Hevner et al. show how design science can produce artifacts in the form of a construct, a model, or a method, with the goal of creating technology-based solutions to business problems. In effect, this move provides a rigorous, research-based approach to process innovation through the use of information systems in organizations.

In the field of innovation management, some researchers have tried to show how design can be more effectively deployed in business, treating design as a definable resource that needs purposeful management. Meanwhile, Walsh points to the diffuseness and variety of design types, which renders the conversion of design into a strategic asset for firms very difficult. Design clearly covers a wide range of fields, activities, and tasks, including product performance, process efficiency, cost, ease of manufacturing, aesthetics, user friendliness, durability, and ergonomics. It remains an ill-defined activity in terms of organizational boundaries, often resulting in difficulties for managers as they try to coordinate it and for teams as they try to work together effectively.

In contrast, Whyte et al. argue that design can be used as a strategic resource within a firm;[41] they draw from new models of innovation management, central to which are advanced simulation and prototyping tools. They argue that the latter can enable design teams—particularly those working on complex, large-scale projects—to coordinate development activities inside and outside the firm, engaging clients in the design process and presenting ideas to end-users, clients, managers, funding institutions, and planners.

In an effort to identify key factors that work against the effective use of design in businesses, Whyte et al. offer an extensive checklist drawn from innovation studies, including continuous improvement, lean manufacturing, teamwork, and new product development tools.[42] Whyte et al. argue that there is no guaranteed recipe for success in design,[43] but there is consistency among researchers about the kinds of factors that support the management of any process, including design. These factors include:

- Top management commitment;
- Clear concept definition;
- Voice of the customer (e.g., dedication to the market and customer inputs throughout the project);

39 Ibid., 16.

40 A. Hevner, S. March, J. Park, and S. Ram, "Design Science in Information Systems Research," *Management Information Systems Quarterly* 28:1 (2004), 75–105.

41 J. Whyte, J. Bessant and A. Neely, *Management of Creativity and Design Within the Firm* (London: DTI, 2005).

42 Their list is drawn from: J. Bessant and S. Caffyn, "High Involvement Innovation Through Continuous Improvement," *International Journal of Technology Management* 14:1 (1997), 7–28; Bruce and Bessant, "Design in Business:" Cooper, et al "Managing Design in the Extended Enterprise."

43 J. Whyte, J. Bessant and A. Neely, Management of Creativity and Design Within the Firm (London: DTI, 2005).

- Product advantage (e.g., differentiated unique benefits, superior customer value);
- Well-planned and adequately resourced launch;
- Tough decision points and stage gate model, with close monitoring at each stage;
- Overlapping/parallel working;
- Concurrent or simultaneous engineering to aid faster development, while retaining cross-functional involvement;
- Choice of structure (e.g., matrix, line, project) to suit conditions and task; and
- Cross-functional team working, involvement of different perspectives, use of team-building approaches to ensure effective team working and to develop capabilities in flexible problem-solving.

Best and separately von Stamm recommend similar tools from innovation studies, treating design as a function within a firm that can be managed and exploited to good effect and recommending structured processes, stage gate models, and other management processes and tools.

One limitation of this fairly standard innovation perspective is that it tends, implicitly at least, to privilege a particular view of "the firm"—typically a large manufacturing firm or service provider characterized as a rational, "machine-like" entity amenable to process improvement and fine tuning. However, as noted—and paradoxically, from the design field itself—modern design thinking challenges this view of the firm as a decision-making, rational entity.

Also, from a broader social science perspective, we should also acknowledge other competing metaphors for representing business organizations. For example, Morgan compares the dominant "organizations as machines" view with other metaphors of the firm (e.g., as intelligent "organisms" responding to their environment in an open system, rather than as a sealed unit of machinery).[44] He, and many others, point to organizational leadership, intelligence, learning, motivation, ambiguity, informality, power, conflict, and "anxiety" in shaping organizational culture and performance. Indeed, "the firm as a machine" view has its roots in the scientific management approach, pioneered by Frederick W. Taylor.[45] This view has long had its critics, beginning with Mary Parker Follett who, even as a member of the Taylor society, criticized Taylor's perspective, arguing that firms were deeply social and no strictly economic units.[46]

This critical analysis is not to say that structure, order, and management tools cannot be useful. However, they need to be appreciated and deployed within a more holistic, "human" appreciation of the firm, and their limits require acknowledgement, as well as study. Hobday and Brady and Davies and Hobday,[47] in

44 G. Morgan, *Images of Organization* (London: Sage Publications, 1986); R. R. Nelson, "The Simple Economics."

45 F. W. Taylor, *Principles and Methods of Scientific Management* (New York: Harper and Row, 1911).

46 The debate between Taylor and Follett (1918) is discussed by Peter Drucker, who credits many of his own ideas to Follett (see P. Graham, *Mary Parker Follett - Prophet of Management* (Boston, MA: Harvard Business School Press, 1995), 24–31).

47 Hobday and Brady, "Rational *vs* Soft Management"; A. Davies, and M. Hobday, *The Business of Projects: Managing Innovation in Complex Products and Systems* (Cambridge: Cambridge University Press, 2005).

their work on complex software processes and other major high technology projects, argue that management tools and systems need to be combined with practitioner engagement (e.g. in the development of tools), empowerment, motivation, and leadership if the firm is to succeed. Much of the failure of software projects, for example, stems from an overly rational approach to project management.

In the case of small and medium-sized enterprises (SMEs) and micro-entrepreneurial activity, the problems of adopting a process/machine-based analogy is intensified because such firms typically operate much less formally than large firms do. In this context, a "managing the process" approach is even less appropriate. Recognizing this lack of fit is important because these firms actually make up the vast majority of business organizations and account for the vast majority of the employed population.[48]

Unfortunately, research into design and new product development tends to assume a process/rational approach, rather than looking deeply into the social and cultural nature of different kinds of SMEs and the "universe" they inhabit. As Woolgar and Vaux show from an ethnographic perspective,[49] this world is a vastly different from that of the typical perception of an SME. SMEs are typified by limited capabilities and informal character, compared with the model of the rational large firm. Small firms cannot be treated solely as decision-making entities any more than large firms can (and perhaps much less).

Indeed, the idea of design as a human-centered, core creative activity in business challenges the overly scientific, rational view of the firm and, with it, the standard intervention tools of innovation management. The design approach to tackling complex or "wicked" problems raises considerable doubts about the validity of process-based, rational approaches to organizational improvement—calling instead for a human-centered approach that emphasizes leadership, informality, and ambiguity in the organization. From a management perspective, if organizations do not conform to the rational, decision-making view, then standard management tools can be ineffective or even counterproductive. Instead, management approaches should focus on understanding the social life of firms, learning how they manage the "white spaces" between the boxes on the organization chart so as to harness the power of informal organization.[50] At the very minimum, a rebalancing in favor of human-centered management is needed, as shown by the design thinking movement, as we discuss in detail in Part 2 of this article.

Conclusion

In general, design has been poorly conceptualized, researched, and taught by innovation studies. Although the meanings of both innovation and design have changed over time, one key agreement is that design is a core technical and creative activity, central to

48 Typically, around 70% of the employed population works for an SME, and SMEs represent 98% of all enterprises.

49 S. Woolgar and J. Vaux, "Abilities and Competencies Required, Particularly by Small Firms, to Identify and Acquire New Technology," *Technovation* 18:8/9 (1998), 575–84.

50 M. Maletz and N. Nohria, "Managing in the Whitespace," *Harvard Business Review* 79:2 (2001), 102–11; C. I. Barnard, *The Functions of the Executive* (Cambridge, MA: Harvard Business Press, 1938).

industrial and service innovation throughout the economy. However, if we examine innovation studies, design is either treated superficially or entirely overlooked, apart from specialized pockets of research and teaching. This "gap" applies to innovation teaching, research, textbooks, theorizing, and other educational activities. As a result, the social sciences in general, and innovation studies in particular, have a very poor conceptualization of design as a creative economic activity at the firm, industry, and wider economic levels. In addition, few systems of measurement have been developed and applied, especially compared with R&D.

One possible reason is that the dominant approach to innovation conceptualization is based on Herbert Simon's idea of human problem-solving within "bounded rationality," which treats innovation in general and design in particular as processes for solving problems. As a result, design as a creative, generating, change-inducing activity has been "left on the sidelines." Nevertheless, a few extremely good innovation papers on design do reveal its central importance in business innovation and there is also a long tradition of design management research and teaching centered on product and process design which accepts the significance of design.

From an innovation and social science perspective, the treatment of design as a human-centered, core creative activity in business challenges the overly scientific, rational view of the firm and, with it, many of the standard intervention tools of innovation management. In the next segment of this article, we examine the emerging field of design thinking, showing how it promises not only to deal with the creative, ambiguous, and "messy" processes of design but also other domains of complex or "wicked" problems. We also argue that, by combining some of the frameworks and insights of innovation analysis with new approaches to design, both areas stand to gain.