What can the social sciences gain from the science of design?

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As we contemplate the possibility of a "science of design," we should remember that researchers in economics and sociology as well as law, management and public policy have already created fields whose central focus is technology and innovation. Researchers in these fields are using powerful scientific tools—modeling, simulation, statistical sampling, hypothesis formulation and testing, formal inference—to arrive at new insights. Their findings are being used to guide public and private investment decisions, public policy, and the law. In addition, managers are creating companies and organizational units whose purpose is to create new designs and capture the resulting economic value. In other words, the "social sciences of design" already exist.

I believe the social sciences of design have much to gain from a newly organized and more formal science of design. In place of the crude proxies now used by social scientists and managers to capture design processes and measure their performance, a science of design can provide useful and valid schemes for representing the structure of designs, describing their lineage, and indicating likely paths of design evolution.

Today most researchers in the social sciences study designs and design processes at one remove. As one example, for many social scientists a critical source of data on designs and their evolution is the US Patent and Trademark Office's patent database. This massive, machine-readable database provides information on each patent's inventors, assignees, technical classifications, citations of prior art, and other useful and countable things. For social scientists, the USPTO database is the equivalent of a fossil record. It is incomplete, of course, but it exists in a usable form and can be approached using well-known tools—correlation, regression, analysis of variance, and most recently, network analysis. In contrast, if one tries to approach real designs as a social scientist, it is easy to get lost in a maze of technical details and minutiae. Thus patent records can be the subject of legitimate social science research at this point in time, but the actual designs described in the patent filings cannot.

The indirect way in which many social scientists approach designs has some unfortunate consequences. First, when social scientists and their students in business, government and law formulate policies and recommendations, the coarseness of their knowledge can easily compromise the soundness of their advice. The tools of the social sciences are blunt. Regressions on large samples using proxies for design quality such as the age or size of a firm, do not result in very refined models of complex causal relationships. Thus using the facts and empirical relationships from social science research to design business strategies and government policies for innovation and technology is a little like trying to reshape a porcelain figurine with a sledgehammer—one only hopes the blow will miss.

Compounding this problem is the fact that many social scientists, business leaders and policy makers misunderstand the nature of designs and design processes in fundamental ways. For example, many believe that the process of creating a large, complex design is rational, orderly, and deterministic. Designers and others close to the actual processes know that such processes are creative, messy, and have highly uncertain outcomes. It is a fact that uncertain and open-ended processes require radically different institutions, organizations and incentives from deterministic processes: the factory approach will not work for designs. Nevertheless misconceptions about design processes have led to the creation of scores of institutions, organizations and incentive schemes (both corporate and government-sponsored) that are poorly matched to the design activities they are supposed to foster. Sometimes mismatched institutions and incentives lead to underinvestment in new designs, sometimes to overinvestment. (The Internet bubble and crash of the late 1990s were the result of overinvestment.) In either case, society loses.

In fact, skilled designers do many things to manage uncertainty and guarantee that their processes will converge to arrive at useful and valuable designs. Yet they cannot always explain what they do in

language that makes sense to social scientists, managers, and policy makers.

Specifically, in every domain of design that I have studied, skilled designers approach large, complex designs by first working on the structure and/or architecture of the overall system, including its boundaries, modular organization and option values. Unfortunately at this time within the social sciences design structure and/or architecture are not widely recognized as valid concepts. Proxies for design structure do not naturally fall out of the standard databases. Therefore, from the perspective of many social scientists (especially those seeking tenure at top universities), questions about how the structure of designs affects outcomes (including the social and economic outcome) are simply not researchable issues. They are not within the purview of these researchers' scientific methods.

Within the science of design, I would argue that these *are* researchable questions, and an important ones at that. However, in order to address these questions systematically, those who aspire to be scientists of design need to develop standard ways of representing the objects they hope to study. Forty odd years ago, in his chapter on "The Science of Design," Herbert Simon spoke about the need for generalized abstract representations. Ever the optimist, he predicted that the translation of designs into computer-based languages would automatically solve the representation problem. And indeed today there are many abstract, software-encoded design representations. In fact, there are too many—each design domain has its own special code, logic or computer language that is useful only within the domain.

What is lacking is a way of representing designs that permits comparisons across domains. For example, in terms of modular structure, option value, and the ability to evolve, how does the design of a supply chain compare with the design of a factory, a large codebase, or a microprocessor? (These are all "software intensive designs.") Answering this question requires a general scheme for representing designs that can be applied consistently and cost-effectively to supply chains, factories, large codebases and microprocessors. In our book *Design Rules: The Power of Modularity* and in subsequent work, Kim Clark and I have argued that designs have a universal structure which includes parameters and interdependencies; thresholds; a minimal system; modules; and options. We have also argued—and offered evidence from the computer industry—that large groups of related designs evolve in structured ways that can be formally characterized within John Holland's theory of complex adaptive systems. From these (refutable) hypotheses, it follows that the economic value of a complex design can be described in terms of products, sums and extreme values discounted for time and risk. Additional interesting results can be obtained by combining this formal representation with well-known social science tools such as option theory and game theory.

But, here is the problem. We and other social scientists can propose representation schemes that work in tandem with social science methods, but we cannot validate them. For validation to occur, *designers in each domain where the representation scheme is applied must certify that the scheme works for their class of designs*. In other words, the representation scheme must be faithful to reality in each domain of application, and designers in the domain must be prepared to say so. This in turn requires designers to step out of their particular areas of design expertise and grapple with formal design representation, commonalities of design structure, and patterns of design evolution across domains. From such efforts, a legitimate science of design may emerge.

Until this happens, however, social scientists must continue to rely on crude proxies when studying designs and design processes, and their insights will be correspondingly weak. Happily, this unsatifactory situation can be remedied by new work in the science of design. I believe that many social scientists would applaud such work, and some are eager to participate in it.

Biographical Note: I am a financial economist by training and I teach at a business school. Fifteen years ago, my coauthor, Kim Clark and I set out to answer the question, what is the financial value of one design vs. another? Everything I've done since then has involved translating "what designs are" and "what happens to designs" into the formal language of finance and economics.

References

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