Intro for Managing in a Modular Age

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In the course of research for “Standards Wars” we investigate several historical examples of such wars, including railroad gauges, AC v DC power, and telephone networks. Our reading of these episodes confirmed our believe that “technology changes, economic laws do not.” The same forces that were at work in the telephone battles of 1910 show up in Internet backbones in 2000, albeit in somewhat different forms.

One striking fact that emerges from the historical record is that standardization is difficult. The first attempts to standardize parts for arms manufacture occurred in the 1770s in France. Thomas Jefferson was quick to recognize the potential of interchangeable parts, and pushed for this technology in the US.

The Springfield armory, Eli Whitney, Samuel Colt, and other legendary 19th century inventors tried their hand at making interchangeable parts, but progress was slow. In fact, it really wasn't until Henry Ford and the advent of mass production that interchangeable parts became commonplace. Much of the difficulty in realizing the dream of interchangeable parts was technological: the relatively primitive measurement and manufacturing technology required that parts be laboriously hand fitted in order to mesh together smoothly. When Henry Ford announced in 1926 that “there is no fitting in mass production” he was signaling the end of more than a century of effort.

But, in a way, the conquest of the technological dimension of interchangeable parts led directly to the socio-economic problem of making parts that were interchangeable not only *within* a particular product, but even *across* manufacturers. It is these forces that are the most interest to us as economists.

Between 1904 and 1908, more than 240 companies entered the fledgling automotive business. In 1910 there was a mini-recession, and many of these entrants went out of business. Parts suppliers realized that it would be much less risky to produce parts that they could sell to more than one manufacturer. Simultaneously, the smaller automobile manufacturers realized that they could enjoy some of the cost savings from economies of scale and competition if they also used standardized parts that were provided by a number of suppliers.

Guess which two players were *not* interested in parts standardization? The two largest companies in the industry: Ford Motor Company and General Motors. Why? Because they were well able to achieve strong economies of scale in their own operations, and had no interest in ``interconnecting'' with anyone else: standardization would (partially) level the playing field regarding economies of scale at the component level. As usual, then and now, standardization benefits entrants, complementors, and consumers, but may hold little interest for dominant incumbents.

The Society of Automotive Engineers worked tirelessly to standardize part design. Eventually, Ford and GM did sign on to this effort, initially for products that they did not manufacture (oil, gasoline) but eventually for most generic parts. Recently, several auto firms have found it attractive to spin off their part suppliers, presumably to achieve procurement cost savings via competition and perhaps even greater returns to scale. As the design of the automobile has stabilized, the some of the need for differentiation via unique parts has been eliminated.

The more we look at the history of technological change, the more we have become aware of what we like to call "combinatorial innovation," a concept closely related to what Martin Weitzman calls "recombinant growth." The idea is that every now and then a set of standardized parts or components comes along, triggering a wave of experimentation by innovators who tinker with the many *combinations* of these components. The result: a wealth of new products build on the newly available components. Weitzman's example is the Wright brothers: they took kite technology, bicycle technology, and the gasoline engine and combined them to create a totally new invention: the flying machine.

Moving to more modern times, the personal computer was essentially an accident. Intel's 4004 chip and its successor, the 8080, could only do basic computations; they were designed for use in calculators, cash registers, automatic teller machines, and other industrial products. However, some engineers at a small company named MITS recognized that the 8080 was powerful enough to be used in a general purpose programmable device and in 1974 they released the Altair, the world's first personal computer.

Intel never envisioned the 8080 being used for this purpose. In fact, when the Altair was released, Gordon Moore himself thought personal computers had no future. This is a telling illustration of the startling and unexpected fruits that can be harvested from a set of components capable of being re-purposed for uses entirely different from those envisioned by their original designers.[1]

We believe that the same forces that drove the Wright brothers and the personal computer have been at work in the last five years. And now, at the turn of a new century, we've seen component parts like TCP/IP, HTTP, HTML, CGI, and so on being combined and recombined to create new inventions: web pages, chat rooms, online

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[1] http://www.thetech.org/exhibits_events/online/revolution/moore/i_c.html

auctions, exchanges, search engines, and so on. The difference between *this* burst of recombinant activity and the earlier episodes is that now the components are all *ideas*, many of which are no more tangible than a string of computer code technology.[2]

Combinatorial innovation can take place extraordinarily rapidly in the information age, precisely because the components are virtual, not physical. Today's raw material for tomorrow's new products are protocols, software, and collections of bits, all of which can be zapped around the world in fractions of a second, at virtually no incremental cost. Manufacturing lags and parts shortages are just not a problem: there are no capacity and production constraints when information is involved. All of this implies that the recombination of *ideas* today can occur at a much faster pace than the recombination of *physical parts* we saw in previous episodes of innovation. The result: everything moves on Internet time, and we see an incredibly rapid pace of innovation: similar in form to what we have seen in historical episodes, but moving much more rapidly.

The benefits from having a robust set of component parts can hardly be overestimated, as they provide the basic infrastructure for innovation. But, as we said earlier, standardization is hard, both from the engineering viewpoint of design, and from the economic point of aligning incentives. Standardization involves the age-old problem of seeking consensus from very different individuals and organizations who may have sharply different interests. Today's technology, built on ideas, is poised to rocket ahead, but there is no reason to think that the economic and political obstacles to standardization can be solved more rapidly in the 21st century than in the 19th century. The implication: the economics of standardization may serve as the limiting or gating factor determining the pace of adoption and diffusion of new information technologies over the decades ahead.

In our article, we provide a framework for understanding and managing the economic forces at work in standardization, especially in situations where market conditions are critical to the bargaining positions of different players in the standardization process. For the reasons just given, we see standardization as one of the key factors determining the pace and direction of adoption of information technologies in the next decade. We hope we have contributed something to the understanding of this critical phenomenon.

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[2] Of course, modern technological miracles are hardly confined to software and the Internet. We see parallel combinatorial innovation taking place in a number of industries today, ranging from photonics to biotechnology to magnetic data storage technology.