

When technologies converge

SHANE GREENSTEIN
s-greenstein1@nwu.edu

.....Pregnancy makes expectant parents nervous. Much medical technology plays to their anxiety and medical needs. Since my wife and I have recently gone through this for a second time, I know something about it, and she fills in the holes in my knowledge when I ask. (She's a physician.)

New medical technologies let expectant parents and their doctors probe, record, and investigate many details about an unborn child's ultrasound has received much attention from commentators. In practice, most expectant parents see only the tip of the technological iceberg during an ultrasound exam. Here, I consider only that tip. More to the point, ultrasound technology motivates my discussion about technological convergence.

Convergence and markets

Two products converge in substitutes when users consider the products to be interchangeable. This happens when a product develops features increasingly similar those of other products. It also occurs when users put together common components to perform functions already performed by existing products.

Two products converge in complements when they increasingly work together better than they worked alone. This occurs when different firms develop products or subsystems within a product that forms a larger system. The system's output can potentially exceed output from the sum of the parts.

A modern PC performs most of a type-

writer's functions. A modern cell phone performs most of the same functions as a landline phone. At a simple functional level they are examples of convergence in substitutes.

Modern medical imaging equipment, such as an ultrasound or CT scanner, combines advanced processing capabilities with traditional sensor devices. This marriage of capabilities provides an example of convergence in complements.

Convergence in complements is often associated with the creation of new capabilities. Yet, rarely is such creation not associated with at least some convergence in substitutes. For example, the increasing replacement of the X ray by the CT scanner is an example of convergence in substitutes. At the same time, the CT scanner evolved so as to permit many functions previously unobtainable with even the best X-ray technology.

In most markets convergence is difficult to date because there is always unavoidable ambiguity about the feasibility of specific products at a particular price at any given time. In addition, these products often are technically complex, so they produce an inherent ambiguity about what users know and when they know it. Similar issues arise in dating progress in the diffusion of new innovations through their life cycles. As such, the issues are not unique to convergence.

System and market levels

Convergence may occur simultaneously at the functional and system levels.

In a particular instance, convergence may be construed as convergence in complements at one level of analysis and, equally appropriately, as convergence in substitutes at a different level. For example, an operating system (say, Windows) may be a complement to a particular hardware platform (say, an Intel x86 chip), together performing the functions of a server. At the system level, different combinations of operating systems and hardware may also perform similar server functions. Hence, the Wintel-based servers converge with servers using older operating systems such as mainframes.

In a "network of networks" system such as those linked by Internet protocols, convergence typically occurs over time due to the actions of different decision makers. This happens because the necessary scope and breadth of technical and market expertise are widely dispersed among firms and users, raising the possibility of initiatives for technological or market convergence from many corners.

For example, the Internet was first used primarily for electronic mail and later for World Wide Web applications. The first developers and users of these capabilities were academics and researchers. Developments in commercial applications, which exploded with the Internet's privatization by the US National Science Foundation, came from different sources and were aimed at nontechnical users. These new capabilities replaced some old communication methods and also offered

