

# Understanding the Innovation Cycle

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This paper proposes a framework for understanding the progression of an innovation over time, from research to incorporation as part of a public infrastructure. While this framework is broadly generalized and does not reflect the course of all such progressions, we believe it is a useful model for understanding the development and market forces that characterize the various stages of creation and utilization of innovations. Moreover, while this model has been developed with reference to the information technology industry, we believe that the underlying principles are applicable to innovations in other industries having similar characteristics, particularly those industries in which there is a likelihood that some subset of innovations will become part of a public (or quasi-public) infrastructure.

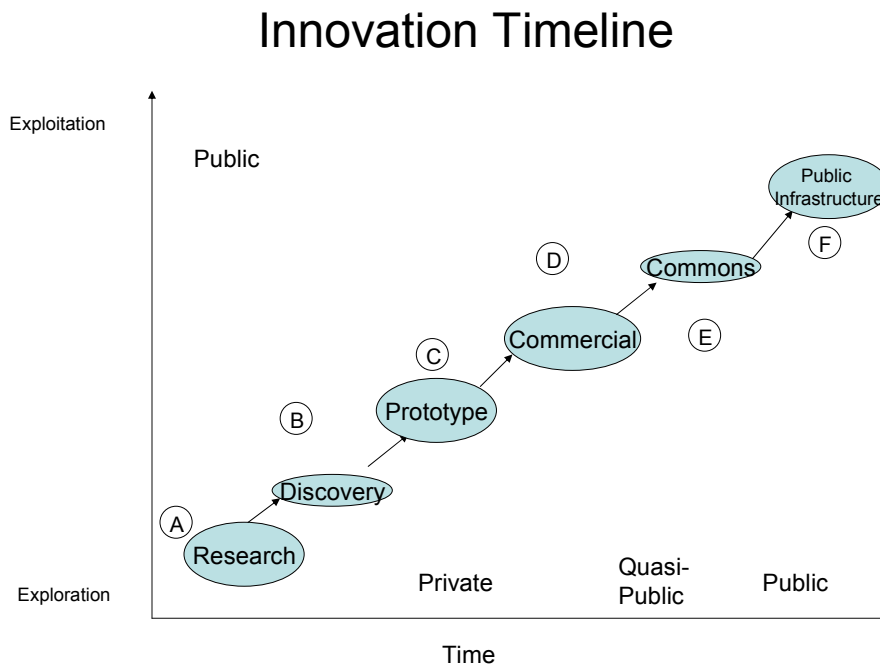


Fig. 1 The Innovation Timeline

The innovation timeline (Figure 1) illustrates a typical progression of an innovation over time; from its inception as a result of research (exploration), through its broad adoption as part of a public infrastructure (exploitation) upon which further innovations are built. This progression may be viewed as the traversal of a series of stages, which is driven by either public or private interests. The traversal between stages can be accelerated or

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decelerated by factors such as increasing or decreasing investment, market demand, standardization, and regulation. The timeline will also be used to show how the public value of an innovation may eventually exceed the private commercial benefits that accrue to the innovator. The timeline is informed by the well-accepted Abernathy & Utterback model described in, “Patterns of Innovation In Industry”<sup>2</sup> which details various patterns of technology innovation.

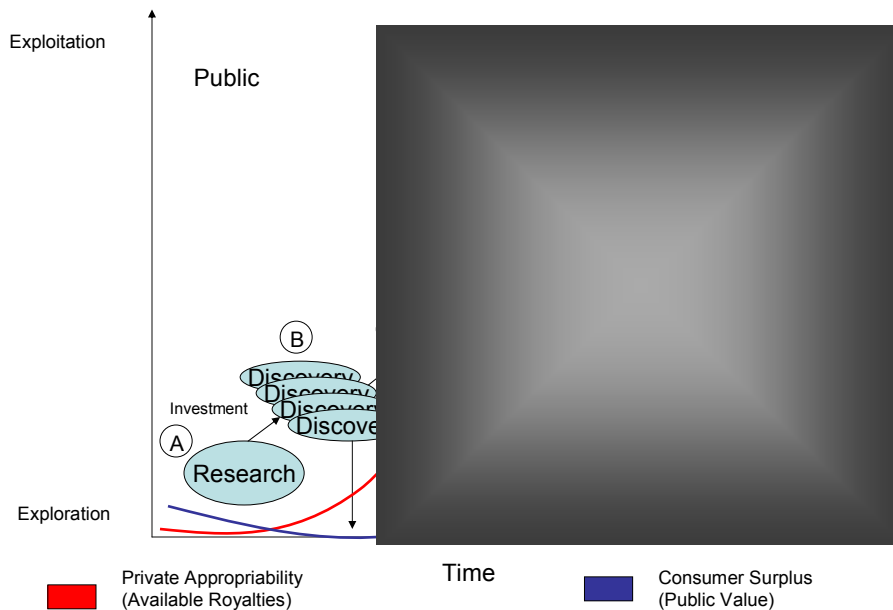


Figure 2 Research and Discovery Stages

During the first stage of progression shown in Figure 2, innovation begins as a result of research (A), leading to a set of discoveries (B). We consider research to be investigation and experimentation in a field of endeavor, while discovery is the result of such research and entails the realization of a previously unknown concept, idea, principle or phenomenon. For purposes of this timeline we define and illustrate research as an activity that is focused on the development of knowledge (in the form of discoveries) in a particular speculative area. Since there is typically an indirect connection between investment in research and commercial benefit, research is more likely to be publicly, rather than privately, funded. More significantly, as discoveries are likely to be in the form of laws of nature, abstract ideas and physical phenomena, they will likely be published and made freely available to the public rather than held as proprietary intellectual property. Thus, the research and discovery stages are both represented in the timeline as public domain activities.

<sup>2</sup> William J. Abernathy and James M. Utterback, “Patterns of Innovation in Industry,” *Technology Review*, Vol. 80, No. 7, June-July 1978, pp. 40-47.

Private appropriability (represented by the red line in Figure 2 and corresponding, e.g., to available royalties from proprietary innovations) is understandably minimal during this stage since the types of discoveries we describe are not susceptible to private ownership. Although we have characterized research and discovery as public domain activities, interestingly consumer surplus (represented by the blue line and corresponding to public value) is also low during this stage. This is because, while the results of this stage are typically freely available to the public, they have not been transformed into innovations that can be of significant practical public use.

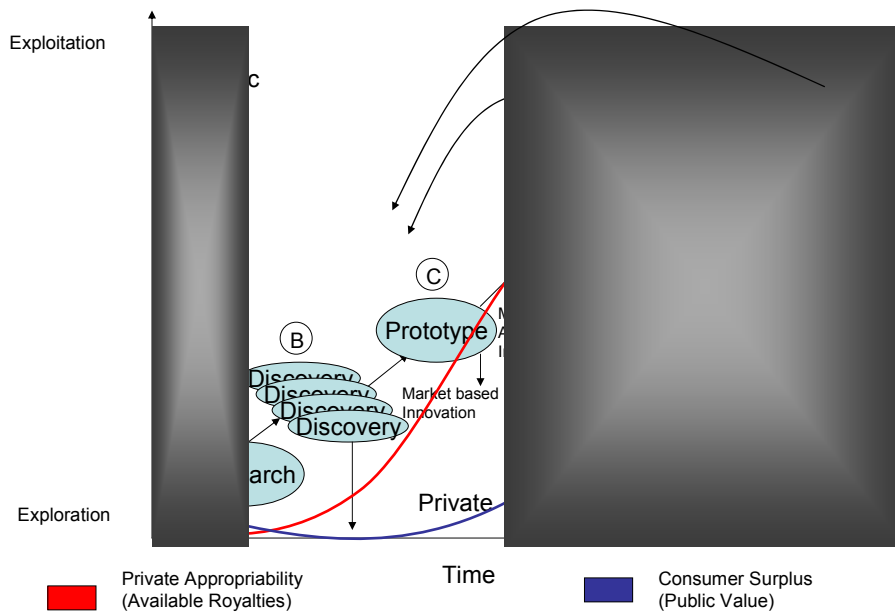


Figure 3 The Prototype Stage

The next stage in the progression is the prototype stage (C), shown in Figure 3. While discoveries may result from research that is not directed at solving a particular problem, these discoveries may nevertheless form the basis for solutions to problems. It is the existence of a problem or need that drives the application of a discovery (knowledge) to form a prototype solution. Private markets typically determine and prioritize such needs, notwithstanding the fact that some needs (e.g., military, public health) are more public in nature. In the move from discovery to prototype, the innovation therefore tends to be focused through the lens of market based needs.

The prototype stage corresponds roughly to the “fluid” pattern of innovation described by the Abernathy & Utterback model<sup>3</sup>, wherein the focus is on the creation of a functional product for which the scope of innovations required may be radical (Abernathy &

<sup>3</sup> Id. at 42.

Utterback classify the scope of innovative activities as ranging from radical innovations to incremental innovations) and the risk of failure is accordingly high. More pragmatic issues such as cost of production and the like are subordinated to the creation of a functional prototype. The typical organization that promotes this type of radical product innovation tends to exhibit an informal and entrepreneurial organizational control.<sup>4</sup>

With its focus on product functionality, the prototype stage tends to be market-driven. The need to innovate radically so as to be first to market with a functional solution fosters a high risk environment in which it is not uncommon for investments in innovations to yield negative results. Due to the high risk investment environment and the potential for reward for those first to market, innovation results in the prototype stage are well suited to proprietary control via patent, trade secret or other intellectual property protection mechanisms.

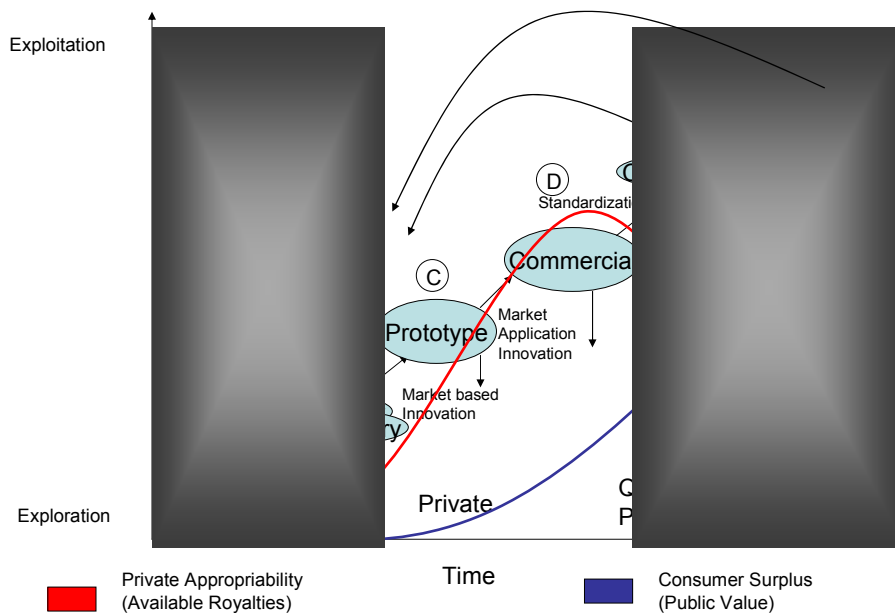


Figure 4 The Commercial Stage

The commercial stage (D) of the innovation timeline is shown in Figure 4. During this stage the functional prototype has been created and focus shifts to adapting the prototype for commercial exploitation. Creation of the processes required for efficient manufacture and market delivery of a commercial product based upon the prototype characterizes innovation in the commercial stage. Innovative emphasis shifts from product function to process development and refinement. Process focused innovations during this stage are likely to be radical rather than incremental, since commercial production of the prototype

<sup>4</sup> Id. at 40.

is often novel and will commonly require entirely new manufacturing and/or delivery processes.

The commercial stage of the innovation timeline corresponds to the transitional pattern of innovation from the Abernathy & Utterback model which is characterized by the emergence of a broadly accepted “dominant design”<sup>5</sup> from the product based innovation in the fluid pattern. In the transitional pattern, process-focused innovation is emphasized and consequently the production process for the product becomes more rigid as compared to the fluid pattern.

The competitive landscape during the commercial stage is characterized by product variation between competing firms, each focused on bringing to market their versions of the product. Since product differentiation in terms of function and cost may well determine the market winners, the commercial stage represents the pinnacle of private value for the innovation timeline as shown by the peak in the private appropriability curve in Figure 4. Firms vying for market advantage are likely to rely on closed development and proprietary intellectual property protection mechanisms to garner and sustain market advantage. Nonetheless, as competitive firms begin to increasingly make innovative products available to the public at competitive prices, the net benefit to the public from such innovations begins to rise significantly as shown by the increasing slope of the consumer surplus curve in Figure 4.

This net public benefit is seen most significantly in the form of so-called network externalities (or network effects) that arise as a result of the proliferation of certain types of new products into a market.<sup>6</sup> Network effects are particularly seen in markets for products that exhibit a high degree of interoperability. A classic example of the operation of network effects can be seen in the market for fax machines. As more consumers purchase fax machines the value of a given consumer’s previously purchased machine grows due to the expanding network of fax users available to that consumer. Thus, network effects arise from the synchronization value of the product due to its proliferation among consumers.<sup>7</sup> Synchronization value is therefore a form of consumer surplus brought about by network effects. It is important to note that the public benefit (consumer surplus) resulting from synchronization value grows in proportion to the rate at which the product proliferates in the market.

As innovations progress along the timeline toward exploitation as public infrastructure, the public value derived from forces such as these network effects begins to approach and eventually surpasses the value to private manufacturers and individual consumers. Accordingly, these network effects drive the increasing public value of the innovation toward its exploitation as public infrastructure.

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<sup>5</sup> Id. at 44.

<sup>6</sup> S.J. Liebowitz, and Stephen E. Margolis, “Network Externalities (Effects)”, *The New Palgrave’s Dictionary of Economics and the Law*, MacMillan, 1998; see also, <http://www.utdallas.edu/~liebowit/palgrave/network.html>

<sup>7</sup> Id.

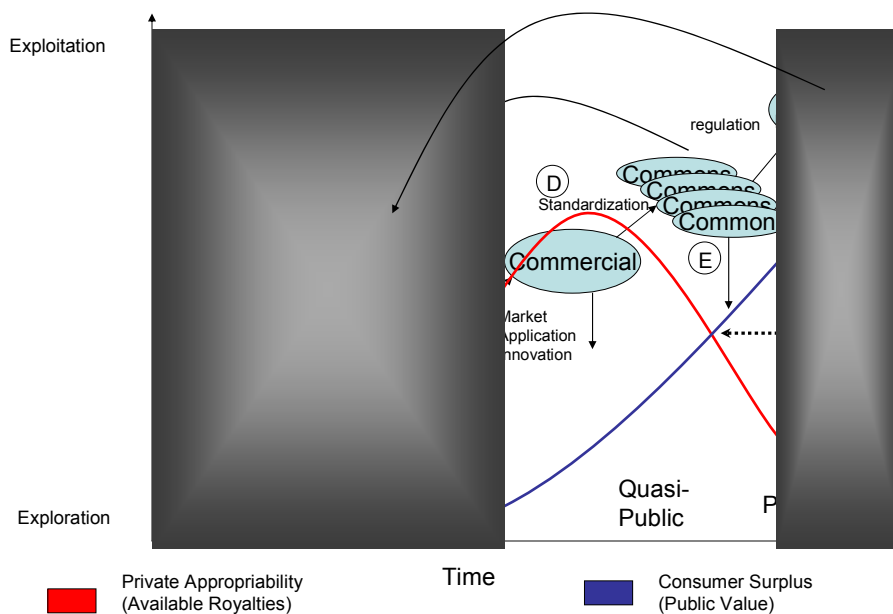


Figure 5 The Commons

The focus on process-based innovations continues through the commons stage (E) illustrated in Figure 5. Recall that innovations in the commercial stage are directed toward producing marketable versions of the “dominant design” product emerging from the prototype stage. As more firms begin to market the dominant design product, the first mover advantage is eroded and competition shifts to price and usability considerations. Accordingly, the product begins to take on the character of a commodity, and the private value of the innovation to the manufacturer decreases.

During the commons stage, focus shifts to maximizing return on commodity products via innovations relating to efficient volume production, delivery and quality control. The characteristics of this stage are similar to those of the specific pattern of the Abernathy & Utterback model, where incremental innovations focused on cost reduction are the norm.<sup>8</sup>

As the product shifts toward commodity status in the commons stage, the emphasis on product differentiation characterizing the commercial stage gives way to usability and interoperability considerations. Market forces urging volume production and interoperability drive manufacturers to adopt standards in order to ensure consumer acceptance and lend stability to product design.

While product stability motivates standardization in volume production environments, manufacturers of highly interoperable products may realize increased returns from

<sup>8</sup> See Abernathy at 40, 45.

standardization enabling such interoperability. This type of standardization maximizes network effects resulting in greatly increased consumer surplus in the form of synchronization value. As we have previously noted, these network effects are most evident in markets for products capable of multi-user interoperability such as in the IT industry as is explained in the following excerpt:

As closed, private networks have been eclipsed by open, public ones, it has become counterproductive for individual companies to continue to develop proprietary IT architectures. As a result, most architectural advances now emerge from vendors, who have enormous economic and competitive incentives to promote the broad adoption of their innovations, turning them into industry standards.<sup>9</sup>

The impetus for standardization in the commons stage encourages competitive manufacturers to create products of uniform character at least to the extent necessary to achieve interoperability. Such standardization often requires manufacturers to agree on common product characteristics. This in turn may necessitate an ‘opening’ of the development process wherein heretofore proprietary elements of each manufacturer’s product are shared with competitive manufacturers to achieve standardization. Legal and business considerations lead manufacturers to seek this standardization through recognized standards bodies.

Typically, standards bodies set rules for the licensing of intellectual property covering certain standardized product or process features.<sup>10</sup> Many companies are willing to license their intellectual property to competitors through these standards bodies if doing so will ensure that adopted standards include key features of their product. A company may have developed sophisticated and expensive manufacturing processes around their design, or may be basing future product designs around a proposed standard design, rendering its adoption as a standard valuable. Thus, in the commons stage a manufacturer’s interest shifts in favor of the creation of greater public value (consumer surplus) versus private appropriability.<sup>11</sup>

Standardization provides consumers with low cost, high quality products as well as the benefits associated with network effects from widely available, highly interoperable products. An additional public benefit is provided by the standard itself rendering public what had been proprietary technology.

The benefits of this public access can be understood in two dimensions: first and most directly, a public standard is a platform or common technology base, agreed upon by industry participants who may thereby raise the focus of their innovation efforts to the

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<sup>9</sup> Nicholas Carr, *Does IT Matter?*, Harvard Business School Press, 2004, see <http://www.darwinmag.com/read/050104/carr.html>

<sup>10</sup> See e.g., W3C Patent Policy at <http://www.w3.org/Consortium/Patent-Policy-20040205/>; OASIS Intellectual Property right (IPR) Policy <http://www.oasis-open.org/who/intellectualproperty.php>

<sup>11</sup> Note that many standards bodies allow participants to charge reasonable royalties for their intellectual property that is essential for the practice of a standard.

creation of new value built upon that common platform; second, an indirect form of benefit is realized by others within and outside of the industry who create new and unforeseen types of innovations on top of this platform. Both of these types of public benefit are graphically illustrated by the feedback arrow in Figure 5.

In an example of the first type of public benefit, after establishing the basic protocols for Internet connectivity such as TCP/IP, industry participants were able to focus development on a new set of innovations such as HTML, which enabled the creation and standardization of the World Wide Web. This in turn created a platform upon which a new set of Web Service protocols such as SOAP and WSDL could be built. An illustration of the second, indirect type of public benefit is the creation new types of businesses such as eBay which owe their existence to the platform provided by the standardized Word Wide Web. Accordingly, standardization in the commons stage produces direct and indirect public value.

As the public value of a standardized product increases and the private value falls during the commons stage, we indicate a point (shown in Figure 5) at which the value to the public will meet and thereafter exceed the value of the product to any private entity. This cross-over point represents the Safe Harbor Threshold, where the public value outweighs the value to any private holder of a proprietary right. It is at this point where we believe it may be appropriate to provide a set of incentives to encourage the holder of an intellectual property right to provide public access to such intellectual property to advance the public interests relating to the standardized product.

This set of incentives should be tailored to discourage a right holder from substantially impeding the standardization process by denying access to their intellectual property. We believe that these incentives are warranted at this cross-over point because they properly recognize the relatively high public value of the standardized product and prevent an undue windfall to a right holder whose intellectual property would otherwise enjoy a private benefit, related to adoption of the standard, disproportionate to its intellectual contribution to the innovation.

Although it is beyond the scope of this paper to quantify the point at which the relative public and private benefits will justify invoking the safe harbor, we advance the need for such a mechanism in a related as yet unpublished paper entitled: *Toward An Open Standards Based Innovation Economy*. It is important to note that this Safe Harbor only applies to those entities that possess applicable intellectual property rights but are not part of the relevant standards body.

The commons stage thus is characterized by a quasi-public development environment in which aspects of product design are made available to the public through the standardization process. Moreover, the private value of the product to an individual manufacturer declines, while the value to the public associated with cheap, high quality, uniform, and enhanced functionality products, increases. Public exposure to increasingly standardized product design may form the basis for the creation of new innovations (feedback arrow) either in the same industry as the product or across different industries.



not fast enough or in the right way, the government may step in if the public interests are significant enough.

## CONCLUSION

The framework developed in this paper demonstrates how an innovation may progress over time, from research to incorporation as part of public infrastructure. We have described this progression as being driven by certain market forces including investment, standardization and regulation. We have also shown that at a certain point during this progression from exploration to exploitation, the value to the public arising from an innovation will exceed the value to any private rights holder. This public value is realized both in the form of network effects and in the use of the innovation as part of the infrastructure upon which further innovations may be based. Understanding the interaction between these market forces and the progressive stages of innovation may provide the basis for affecting the creation of an environment optimally conducive to innovation.

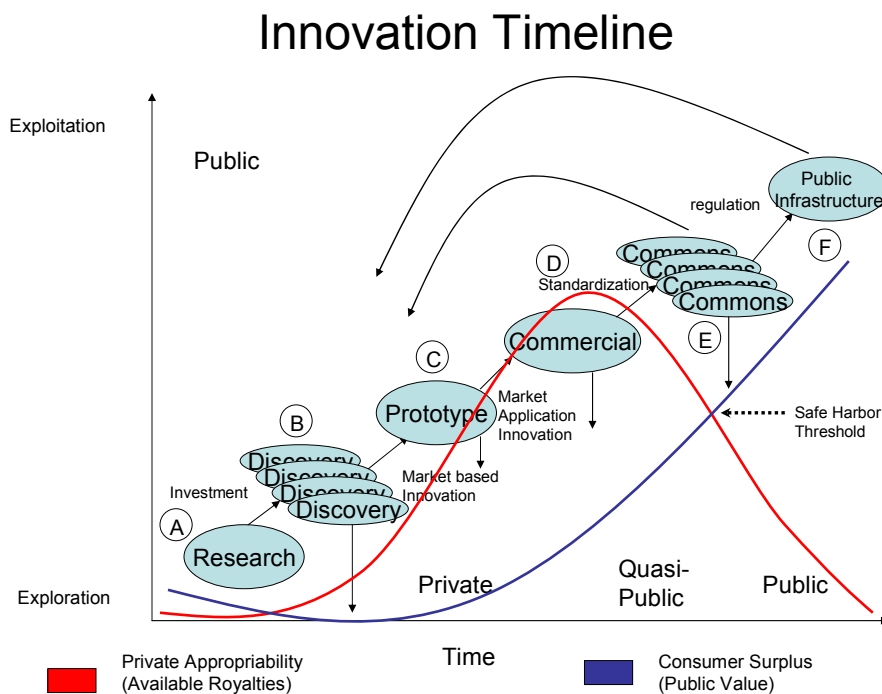


Figure 7 The Innovation Timeline