The goal of improving patent quality remains elusive both from an economic and process perspective.

“Some ... may think there should be no patents on software-related inventions. Whatever the merits of this position, the debate in the U.S. has shifted from this issue to that of patent quality.”
—Pamela Samuelson [9]

To gain competitive advantage in an increasingly digital economy many firms engage in costly research and development activities to develop innovative software applications. At the same time recent advances in software reengineering techniques have reduced the cost and time to imitate these innovations, making it more difficult for innovators to recoup their costs and, therefore, reduce their incentive to innovate. Increasingly, software innovators have turned to the patent system to attain protection from cheap, quick imitation [1, 10]. The goal of the patent system is to provide innovators with profit-incentive, beyond that provided by a free market, to develop substantial innovations that benefit consumers. To achieve this goal,

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policymakers must address the following questions:

- What is the target of feasible patent policies that will provide innovators profit-incentive to seek a patent?
- Which policies within the target are good (or socially beneficial) and which ones are bad (or socially detrimental)?
- Which policy on the target is socially optimal?
- What process issues may prevent the policymaker from properly identifying the target and hitting the optimal (or even a good) policy on the target?

In order to address these questions, two major policy reports [4, 7] have recommended that the patent authority, made up of patent examiners, the courts, and the legislature, incorporate more economic insights in their decision making. In response, economic models have been developed that critically examine the ongoing debate over software patent policy design [11, 12]. In this article, we summarize the critical findings of these models and assess the viability of applying patent law to software products.

**Modeling Software Patent Policy**

Patent law requires that an innovation be new, useful, and nonobvious to a person of ordinary skill in the relevant field. Once a patent is awarded, it provides the patent holder with a scope of protection from imitation for a maximum of 20 years. In this article, the novelty and nonobvious requirement is referred to as the *patent height*. Once a patent has been awarded, the level of imitation allowed by the patent is referred to as the *patent imitation level*. Finally, the duration of patent protection is referred to as the *patent length*, or the proportion of the product life for which the patent is enforced. A patent policy is defined by the combination of patent height, imitation level, and length set by the patent authority.

The software patent model considers two software providers, an innovator and an imitator, competing in product improvements to a well-known software product. The patent authority sets a policy and the innovator decides whether or not to seek a patent. The innovator then designs and develops its improvement to the well-known product at a substantial fixed cost. The imitator, using software reverse engineering technology, then observes the innovation and decides to what extent it will cheaply imitate the innovator’s product. Finally, both firms price their products and offer them to the market. The critical observations derived from this software model include the following:

1. The patent policy target (or the patent outcome region (POR)) is defined as the policies that, if set by the patent authority, provide the innovator profit incentive to seek a patent.
2. Some policies within the POR encourage the innovator to attain patents that:
   a) Induce both the innovator and imitator to produce larger software improvements than they would under free market competition, which is socially good.
   b) Induce both innovator and imitator to produce smaller software improvements than they would under free market competition, which is socially bad.
   c) Induce the innovator to produce a larger improvement and the imitator to produce a smaller improvement than they would under free market competition, which may be socially good or bad.
3. The socially optimal policy is one that maximizes the patent length and that sets patent height and imitation levels to moderate levels.
4. The costs associated with properly identifying the POR and hitting a good policy on the target may be greater than the potential benefits.
The critical analytical artifact generated by this model is the POR, or the software patent policy target, as illustrated in Figure 1a. The quality of the well-known software product is represented at the origin of the figure. The vertical (horizontal) axis represents the innovator’s (imitator’s) improvement to the product. The imitator’s best response curve represents the imitator’s best response to each potential improvement made by the innovator under free market competition. The market outcome (MO) represents the product improvement levels made by both firms under free market competition. Finally, the POR defines the combinations of patent height and patent imitation level that provide the innovator profit incentive to meet the height and patent its product for a given patent length. To clarify, assume that the patent authority sets a patent policy at Point $a$ in Figure 1a. In this case the innovator would design an improvement that meets the height, patent its product, and constrain the imitator to the patent imitation level for the duration of the patent. After the patent expires the innovator would keep its product on the market but the imitator would be allowed to respond optimally according to its best response curve as shown at Point $b$.

The POR is the target the patent authority must hit to give the innovator profit incentive to seek a patent. If the patent authority sets any policy outside of the POR then the innovator will not seek a patent and the firms will compete in a free market, resulting in the MO. For example, if the patent authority sets patent height or patent imitation level too high it will miss the target altogether, rendering the policy impotent. This result is driven by the substantial fixed costs that the innovator incurs to develop large software improvements.

As illustrated in Figure 1b, policies set in Area A of the POR induce the innovator to produce a larger improvement than it would under free market competition. In addition, these policies constrain the imitator to produce a smaller improvement (while the patent is enforced) than it would in the MO. Area A represents the traditional perception of the impact of patent policy on product innovation. However, policies set in Area B induce both firms to produce larger improvements than they would in the MO, a result valued by consumers and the imitator. Finally, policies set in Area C induce both firms to produce smaller improvements than they would in the MO, a result that is of great concern for consumers. The possibility of innovators attaining patents in this area has driven much of the public debate over the social value of software patents.

The Good, the Bad...

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under free market competition.

By definition, any policy set within the POR improves the innovator’s profit when compared to the MO. Bad policies lie below the consumer and social welfare iso-curves. These policies will benefit the innovator at the expense of consumers and will adversely affect social welfare when compared to the MO. These policies are generally characterized by lower patent heights. In fact, the policy in the POR that generates the lowest level of social welfare has the lowest feasible height combined with a full scope of protection from imitation. This area of the POR is consistent with many critics’ characterization that the patent system is being used inappropriately by software innovators to capture monopoly power, without providing the consumer the value of substantial innovation. As such, legislation and court decisions that have lowered the patent height for software products over the past two decades [5, 6] may be socially detrimental.

The mixed policies lie above the social welfare iso-curve but below the consumer’s curve. These policies also benefit the innovator at the expense of consumers; however, in this case total social welfare increases. Although these policies may be more palatable because of the net gain in social welfare, the patent authority may still have concerns about setting a policy that simultaneously limits competition and adversely affects consumers.

Finally, the good policies lie above both iso-welfare curves. These policies will improve the welfare of both the innovator and consumers, resulting in an improvement in social welfare. These policies are generally characterized by higher patent heights than the bad policies. Interestingly, this area shows that providing the innovator with monopoly use of its product may benefit consumers and improve social welfare, even when patent length is set to 100%, as long as the patent height is set sufficiently high. This suggests that recent legislation and court decisions that have decreased the patent imitation level for software products [8] may not be harmful to society unless the existing patent height is set too low. Clearly, the patent authority must be concerned not only with locating and hitting the POR, but also with where to aim within the POR in order to avoid the harmful outcomes.

To this point we have only considered the POR for a given patent length. However, there is a family of PORs over the range of patent lengths. Figure 3a illustrates that an increase in patent length expands the POR—that is, it increases the feasible combinations of patent height and patent imitation level that give the innovator profit incentive to seek a patent. The line rst through the POR maps the combinations of patent height and imitation level that maximize social welfare for each patent length. When the patent length is set sufficiently short, social welfare is maximized at the upper left corner of the associated POR (see line rs in Figure 3a). That is, the optimal policy is to set the highest patent height and to give the innovator monopoly use of its product. However, when patent length is set sufficiently long it is best to allow some level of imitation under the patent (see line st). On the other hand, it is no longer socially optimal to set the highest patent height in the POR due to the substantial costs incurred by the innovator to produce such large product improvements.

The patent policy design that maximizes social welfare over all patent lengths is to set patent length to 100% and patent height and imitation level to intermediate levels as shown at Point r in Figure 3a. Although there is no post-patent competition in this case, the innovator continues to face competition under the patent as allowed by the patent imitation level. This socially optimal policy provides incentives for both the innovator and imitator to develop larger product improvements than they would under free market competition.

Is Patent Length Too Long?

Although recent legislation has increased the length of patents [10], Jeff Bezos, founder and CEO of Amazon.com, has argued, as have many others, that “…business method and software patents should have a much shorter lifespan than the current 17 years—I would propose 3 to 5 years” [2]. We use the patent model to analyze this proposal.

Using Figure 3b we examine the social welfare...
The debate in the U.S. has shifted from whether software patents should exist to what to do to improve software patent quality. However, the goal of improving patent quality remains elusive both from an economic and process perspective.

Implications of shortening the patent length for existing policies in the POR. If the patent authority sets a policy in Area D, then the innovator attains a patent under both patent lengths. Shortening patent length in this area will improve social welfare since the imitator and consumers benefit from a longer period of unrestricted post-patent competition. For policies in Area E the innovator attains a patent if patent length is long, but competes in the free market if patent length is short. Shortening length in this area will reduce social welfare by eliminating the profit-incentive for the innovator to seek these socially beneficial patents.

Interestingly, given our earlier discussion of “The Good, the Bad...” it is the best patent policies that run the greatest risk of being eliminated when patent length is shortened. Finally, for policies in Area F the innovator attains a patent if patent length is long, but does not if it is short. Shortening length in this area will improve social welfare by eliminating the profit-incentive for the innovator to seek these socially detrimental patents.

In summary, the patent authority should shorten patent length only if it believes that both the patent height and patent imitation level have been set too low. In this case, shortening patent length will either eliminate the profit incentive for innovators to attain bad patents or improve the social value associated with bad or mixed patents. Otherwise, shortening patent length runs a high risk of rendering a socially good policy (given a long patent length) impotent since a decrease in patent length contracts the POR.

...And the Messy
Another important insight derived from the model is that the size and location of the POR depends on the efficiency of the innovator’s production capabilities, implying the need for patent policy that is customized across industries and software product categories. It may seem that the patent authority should be able to clearly see the shifting policy target and identify a portfolio of patent policies optimized across products and industries.

However, there are messy implementation issues that affect the patent authority’s ability to see the target and to hit good policies on the target. Even in the context of our simplified model, in order to properly identify the POR the patent authority must collect accurate information about the characteristics of consumer demand, the characteristics and efficiency of the innovator’s cost structure, and the imitator’s best response function. In addition, the patent authority must develop and maintain a complete repository of prior art that enables it to properly assess the novelty of the innovator’s product improvement. Since each of these pieces of information may change over time the patent authority must continuously collect, update, and maintain this vast amount of information to properly identify the size and location of the POR.

In some cases the POR may be impossible to identify since this information may not be available to the patent authority. For example, firms may be unable to accurately determine or be unwilling to disclose their cost structure details to a regulatory body. As another example, the patent authority may be unable to develop and maintain a sufficient database of prior art in the software context [3].

As Samuelson [9] observes, the debate in the U.S. has shifted from whether software patents should exist to what to do to improve software patent quality. However, the goal of improving patent quality remains elusive both from an economic and process perspective.
In this article, we have addressed the issue of patent quality from the economic perspective. The model demonstrates the potential benefits and pitfalls of awarding software patents and also exposes the enormous amount of information required to attain the benefits while avoiding the pitfalls. Given the messy implementation issues, the economic viability of a software patent system must be carefully reassessed. Realistically, the authors believe that at present the time and costs associated with collecting, analyzing, and maintaining the information necessary to identify and implement a good policy likely outweigh the potential benefits. For now, allowing the free market to take its course in stimulating software innovation may be preferred to a shot in the dark—a shot that may result in bad patent policy.

References

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