Innovation in Software

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April 2018

1 Introduction

Patents are bad solution for the innovation incentive problem in software for several reasons: (i) High transaction costs and unproductive prisoner's dilemma patent hording (ii) The extremely high cost of reverse engineering outweighs the benefit of violating intellectual property (iii) information asymmetry between all parties etc. The patent system is incompatible with the modern software industry where open sourced innovation is a mainstream practice. Instead of attempting to fix an already broken system, this paper presents an incentive compatible mechanism that incentives innovation and investing.

2 Desired Properties

Regulators attempting to use patents to improve welfare are at a huge comparative disadvantage, they lack technical expertise and are face significant informational asymmetry. It's time for them to step up to their strengths and use their excellence in collecting taxes, regulating quantities and subsidizing who they think needs money. In order for regulators to cheaply and easily asses the allocation of these resources, they will need an incentive compatible mechanism, a mechanism that places companies in a position where best-responding is revealing their true information. The revelation principle[3] states that this class of mechanisms covers all possible configurations. For this case however, studying this class of mechanisms will imply cheap implementation costs. When all parties involved are truthful, many transaction costs are eliminated (such as lawyers). The intent is to provide a theoretical alternative to traditional patents and to analyze producer competition under investment potential.

3 The Model

Given N producers, the current state of nature θ and a demand curve $D(q)$. Producers will play a four-stage game. In the first stage, each producer receives a private signal $\theta + \epsilon_i$ where ϵ_i is drawn from publicly known, i.i.d, twice differentiable, continuous and strictly decreasing CDF $F : (\underline{\epsilon}, \overline{\epsilon}) \rightarrow (0,1)$ with mean zero. The variable θ is meant to capture relevant publicly known technological and economic factors, ϵ_i captures variations in research efficiency. Each producer i chooses v_i, the amount they will invest in R&D. In the second stage, research is completed and each producer discovers a new innovation that lowers the cost to $c_i = \theta - v_i + \epsilon_i$. In the third stage each firm submits their true cost c_i to the government and receive a payment $t : c_i \rightarrow \mathbb{R}$ in a form of a subsidy or tax. The transfer amount will be selected such that each producer best responds by reporting their private information, and gets a fixed utility based on their truthfully reported ϵ_i. Let $G(c_i) = P(max\{c_{-i}\} \leqslant c_i)$ given firm i submits cost c_i, and $\overline{c}$ is the highest cost such that $G(\overline{c}) = 0$. The cost variable c_i could represent any parameter in any cost function as long as lower c_i imply lower cost for all possible quantities. Since we want to reward lower costs, we can use Riley and Samuelson[4] to determine the appropriate expected utility of producer with cost c_i. If we maintain the reward should increase with lower costs and that the allocation is efficient we are left with one unique choice given by:

$$\left(\text{Expected Utility for Producer with Cost } c_i\right) = \int_{\overline{c}}^{c_i} G(x)dx \tag{1}$$

In the final stage the government could share the best innovation making every firm's marginal cost $C = min\{c_i\}$, if it does so we will assume that it is common knowledge with the beginning of the first stage. If quatnties supplied are given by $q = (q_1, q_2...q_n)$, producer $i's$ utility is given by:

$$U(c_i, C) = \pi_{cournot}(q_i, q_{-i}) - t(c_i) - v_i = \int_{\overline{c}}^{c_i} G(x)dx \tag{2}$$

$$t(c_i) = \pi_{cournot}(q_i, q_{-i}) - v_i - \int_{\overline{c}}^{c_i} G(x)dx \tag{3}$$

We can derive a BNE by backward inducting over every stage. In stage (4), outcomes will be a regular cournot oligopoly given N and $C = (c_1..c_n)$. In order to avoid intractability issues that come with the introduction of an extra choice variable, we will just assume that the mechanism designer will mandate that cournot quantities are produced given C. This setup maintains that truthful reporting is a best response since both t and $\pi_{cournot}$ are maximized at c_i and C respectively. Over-reporting c_i or under-reporting will make producer i worse off given the incentive constraint from (1).

4 Model Discussion

The equilibrium presented in the previous section is unique since both t and F satisfy strict monotonicity in the choice variable v_i by Myerson's lemma[2]. We note that the transfer function subsidizes all research investments and the "information rent" an amount only dependent on how well did each producer out compete other producers in expectation and this is the minimum amount of surplus that we could allocate to producer while maintaining incentive compatibility and investments. Furthermore, since this analogous to a Vickrey Auction, investment choices are welfare maximizing.

The described mechanism maximizes revenue for the mechanism designer and incentivizes investment on the part of the producers and all players make ex ante weakly positive profit. Analyzing equation (2) it is unambiguously bad for the mechanism designer for firms to raise investments when $\frac{\delta\pi}{\delta v_i} > 0$ since as total utility goes up and both profit and investment cost go down the only way to make up the difference is to get subsidized more while producing and investing less:

$$U(c_i, C) \uparrow \implies \pi_{cournot}(q_i, q_{-i}) \downarrow (-t(c_i)) \uparrow (-v_i) \downarrow$$

Under full subsidization of innovation costs and with the presence of only producer competitive pressure we can identify a limit at which further investment is impossible. There is no pareto efficient outcome with N producers where producer with cost c_i given prior F invests more than v_i in expectation because the equilibrium of an incentive compatible vickrey auction is unique.

On the other hand, if we have $\frac{\delta\pi}{\delta v_i} < 0$ at low investment values. Which shows the appeal of gaining a first mover advantage. The model can be re-framed to explore many best/worst case scenarios where an agent attempts to trade with asymmetric information. For example, if a cournot oligopolist wanted to buy a specific type of patent and faced N different patents offered by different people. He will have a natural ranking for them but he will still have to pay the redundant minimum utility to all of them in expectation. His costs even increase with the number of people holding similar patents due to screening and transaction costs. Even when having the advantage of being a price discriminating monopsonist, patents are still a significant redundant cost.

Future Work A similar subsidy based mechanism can be generalized to a multi product case with capacity for compliments and differentiated substitutes. Just we reversed the regular single item auction, any socially efficient multi item auction can be reversed such that producers are subsidized the least as possible with enough investment to produce the bundle they get matched with at the right price. VCG, or more novel approaches like the online clinching auction[1] can be modified to incentivize the right level of investment and maintain incentive compatibility.

References

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