The contract Theory of Patents

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I. Introduction

Two distinct theories of patents to justify the patent system

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\begin{align*}
&\text{“reward theory”} \\
&\text{“contract theory”}
\end{align*}
\]

1) “Reward theory” focuses on the “non-exclusive” nature of technological knowledge and states that the function of the patent system is to remunerate successful innovators so as to encourage R&D effort.

2) “Contract theory” emphasizes the “non-rival” nature of innovation. A temporary property right is granted to innovators in exchange for disclosure. It states that the function of the patent system is to promote the diffusion of innovative knowledge.
. Besides patents, “trade secret law” is also an effective tool to protect innovations.

. By comparing the costs and benefits of patents versus trade secrecy, the authors provide an economic analysis of the contract theory of patents as legal devices to induce firms to disclose their innovation to the public.

. Their main finding is that the disclosure motive alone suffices to justify the grant of patents. The optimal patent duration should strike a balance between the incentive to induce disclosure and the aim of limiting the monopoly distortion induced by patents.
II. The Model

There is a continuum of patentable innovations. Each innovation occurs in a separate industry, with linear demand function $P(Q) = a - Q$.

For each innovation, there is an innovator (she) and a potential duplicator (he).

The innovator can choose which type of protection to adopt ("patent" or "trade secrecy").

1) If she patents, she becomes a temporary monopolist. By setting $p_m = \frac{1}{2}a$, she gets monopoly profit $\pi_m = \frac{1}{4}a^2$ for the duration of patent $T$. 
2) If she relies on trade secrecy, there is a risk of “secret leakage” which occurs with probability $1 - z \in (0, 1)$, and a risk of independent rediscovery by the duplicator, which occurs with probability $y \in [0, 1]$.

The parameter $Z$ (“strength of secrecy”) is exogenous. The duplication probability $y$ is chosen by the duplicator who faces a duplication cost $\frac{1}{2} \alpha y^2$, $\alpha$ has a cumulative distribution function $F(\alpha)$.

If the duplicator manages to replicate the innovation, he in turn has to decide how to protect it. (use patents or trade secrecy)
The timing of the game played by the firm is as follows:

① First, the innovator decided whether or not to patent

② Second, if the innovator has not patented, the duplicator decides his duplication effort.

③ Third, upon successful duplication, the duplicator decides whether or not to patent.

④ If neither the innovator nor the duplicator patent, Nature determines whether the innovation leaks to the public or not.
At the beginning:

① The law-maker chooses the patent policy, i.e. a patent length \( T \) so as to maximize expected social welfare. Define \( \tau \equiv 1 - e^{-rT} \), which can be seen as a “normalized” patent length.

② The “law-maker” doesn’t know the marginal duplication cost \( \alpha \) of each innovation, but knows the distribution \( F(\alpha) \)
III Firm’s behavior

The authors start by considering the decision problems of the innovator and the duplicator, for any given level of $\alpha$. At this stage, the normalized patent duration $\tau$ is taken as an exogenous parameter.

*The duplicator’s problem:*

Upon successful duplication, the duplicator must decide whether or not to patent.

If he doesn’t patent, his expected payoff is $\nu = z(\pi_d / r)$: discounted duopoly profits times the probability that the innovation does not leak to the public.
If he patents, he has to share the market with the first innovator until the patent expires,
\[ \nu = \int_0^T e^{-rT} \pi_d \, dt = \tau (\pi_d / r) . \]

The duplicator’s payoff is therefore
\[
\mathcal{U} = \begin{cases} 
Z \frac{\pi_d}{r}, & \text{for } \tau < Z \\
\tau \frac{\pi_d}{r}, & \text{for } \tau \geq Z
\end{cases}
\]

Moving one stage back, the duplicator chooses optimal research effort \( y \) so as to maximize
\[ \pi = y \nu - \frac{1}{2} \alpha y^2 \]
If $\nu / \alpha < 1$, the optimal duplication effort is

$$y^*(\alpha) = \frac{\nu}{\alpha} = \begin{cases} 
  z \frac{\pi_d}{r \alpha}, & \text{for } \tau < z \\
  \tau \frac{\pi_d}{r \alpha}, & \text{for } \tau \geq z
\end{cases}$$

If $\nu / \alpha \geq 1$, then $y^*(\alpha) = 1$
**The innovator’s problem:**

The innovator must decide whether or not to patent.

If she patents, she get:

\[ V_p(\tau) = \int_0^T e^{-rt} \pi_m d_t = \tau \cdot \frac{\pi_m}{r} \]

If she relies on trade secrecy, her payoff depends on the duplicator’s behavior. Thus,

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V_{TS}(\alpha) = \begin{cases} 
[(1-y^*(\alpha)]z \cdot \frac{\pi_m}{r} + y^*(\alpha)z \cdot \frac{\pi_d}{r}, & \text{for } \tau < \tau \\
[(1-y^*(\alpha)]z \cdot \frac{\pi_m}{r} + y^*(\alpha)z \cdot \frac{\pi_d}{r}, & \text{for } \tau \geq \tau
\end{cases}
\]
Who patents in equilibrium?

There are three possible outcomes:

. nobody patents

. the innovator patents

. the duplicator patents

They prove that the third outcome can not be part of a sub-game perfect equilibrium of the game. And there is the following proposition:

**Proposition 1:**

Independent of the nature of the innovation, if the first inventor does not patent, neither will the duplicator.
Using the fact that the duplicator never patent in equilibrium, they conclude that the duplicator’s payoff is \( \nu = z(\pi_d / r) \). The optimal duplication effort is

\[
\begin{align*}
  y^*(\alpha) = \begin{cases} 
    z \frac{\pi_d}{r\alpha}, & \text{for } z \frac{\pi_d}{r\alpha} < 1 \\
    1, & \text{for } z \frac{\pi_d}{r\alpha} \geq 1 
  \end{cases}
\end{align*}
\]

Duplication is more likely to take place if duopoly profits are larger, the discount rate is lower, marginal duplication cost is lower, and if the innovation can be more easily concealed from the public.
Which innovations are patented?

When deciding whether or not to patent, the innovator will compare patent profits

\[ V_p(\tau) = \tau \cdot \frac{\pi_m}{r} \]

with secrecy profits

\[ V_{TS}(\alpha) = z[(1 - y^*(\alpha)) \cdot \frac{\pi_m}{r} + y^*(\alpha) \cdot \frac{\pi_d}{r}] . \]

\[ V_{TS}(\alpha) \] is non-decreasing in \( \alpha \). So, there is a patenting threshold \( \hat{\alpha}(\tau) \), if \( \alpha < \hat{\alpha}(\tau) \), the innovator will patent.

They prove that for intermediate values \( \tau \), i.e. for \( \tau_0 < \tau \leq z \), solving

\[ V_{TS}(\alpha) = V_p(\tau) \]

yield

\[ \hat{\alpha}(\tau) = \frac{z^2}{z-\tau} \cdot \frac{\pi_d}{r} \cdot \frac{\pi_m - \pi_d}{m} \]

with \( \frac{\partial \hat{\alpha}(\tau)}{\partial \tau} = \frac{\hat{\alpha}(\tau)}{z-\tau} \geq 0 \)
Using the linear demand function, they obtain an explicit expression for $\hat{\alpha}(\tau)$:

$$\hat{\alpha}(\tau) = \frac{z^2}{z - \tau} \cdot \frac{1}{r} \cdot \frac{1}{2} [k(1-k)\alpha^2 (1-2k(1-k))]$$

**Proposition 2:**

The innovation is more likely to be patented if it can be duplicated at a lower cost, it is less easily protected from public disclosure (if $\tau < \frac{1}{2}z$), it yields greater monopoly profits, and it yields greater duopoly profits (as this makes duplication more likely).
A larger discount rate tilts the balance in favor of secrecy, as it slows down duplication. With a linear demand function, innovations are more likely to be patented if they are big (large $a$) and if competition is soft (small $k$).
IV Optimal patent length

The optimal patent length $\tau^*$ maximizes expected social welfare, which is defined as the expected value of the discounted social returns from the innovation less the duplication costs. They prove that:

$$\frac{dw(\tau)}{d\tau} = \frac{\pi_m}{\pi_m - \pi_d} \cdot \frac{\Delta d}{r} \cdot \hat{\alpha} f(\hat{\alpha}) - \frac{\Delta m}{r} \cdot F(\hat{\alpha})$$

The optimal patent length must strike a balance between the incentive to induce disclosure (captured by the first term) and the aim of limiting monopoly distortion induced by patents (the second term).
**Proposition 4:**

The optimal patent length must strike a balance between the incentive to induce disclosure and the aim of limiting the monopoly distortion induced by patents. The optimal patent life is not shorter than $\tau_0 > 0$, so that at least the weakest innovations are disclosed (i.e. those which are duplicated for sure).

Hence, it is socially desirable to set patent life so as to induce disclosure at least of the innovations that can by more easily duplicated.