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Technology Licensing and Innovation – A Correction on Two-Part Tariff Analysis

Yuanzhu Lu

Swapnendu Banerjee

Sougata Poddar

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Yuanzhu Lu
Central University of Economics and Finance, China Economics and Management Academy, Beijing 100081, CHINA

Swapnendu Banerjee
Jadavpur University, Department of Economics, Kolkata 700032, INDIA

Sougata Poddar
Chapman University, Argyros School of Business and Economics, Orange, CA 92866, USA

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Abstract:

The main purpose of the note is two-fold (i) Correcting an error in the two-part tariff licensing contract, and (ii) Altering one of the main results following the two-part tariff analysis in Mukherjee, A. and Mukherjee S., (2013), *Economics Letters*. This also strengthens the primary conclusion of Mukherjee and Mukherjee (2013).

Key Words: Licensing; Innovation; Two-part Tariff

JEL Classification: D43, D45, L13

Mukherjee and Mukherjee (2013) (henceforth MM (2013) showed that in a Cournot framework, under a fixed-fee licensing contract if the licensor and the licensee bargain over the licensing fee, licensing decreases (increases) innovation incentives vis-a-vis no licensing for low (high) cost innovation. This is an interesting result to see the impact of licensing on innovation incentive of competing firms. MM (2013) also claims that a two-part tariff licensing always increases innovation incentive regardless of innovation cost. We believe this second result is not correct and revise the result here.

More specifically, the main purpose of this note is two-fold. (i) Correcting an error in the two-part tariff analysis in MM (2013). In particular, we show that the optimal licensing contract derived in the section 3.2 (page 501) is not correct and we provide the correct solution. (ii) This also leads to a correction of Proposition 4, one of the main results of their paper regarding innovation incentive of the firm(s). This correction and revision further strengthens the main research findings of MM (2013). It also makes the main result more robust and consistent in the sense that in this framework, innovation incentives of firm(s) qualitatively remains unchanged under different licensing contracts.

We refer to MM (2013) for the basic model of the analysis and keep all the notations same here to be consistent. We only focus on those parts of the paper of MM (2013) which need to be addressed. The rest of the analysis and findings in MM (2013) remain unchanged.

Licensing of Innovation

Two-Part Tariff Analysis (Discussed in section 3.2 in MM 2013)

As in MM (2013), without loss of generality, let us assume firm 1 to be the innovating firm with bargaining power α $(0 \leq \alpha \leq 1)$ and firm 2 to be the non-innovating firm with bargaining power $(1-\alpha)$. Firm 1 offers a two-part tariff licensing contract (F, r) to firm 2, where F is the fixed fee and r is the per unit royalty.

The problem for firm 1 can be expressed as

$$max_{F,r}[\pi_1(0,\mathrm{r}) + \mathrm{r}q_2^*(0,\mathrm{r}) + \mathrm{F} - \pi_1(0,\mathrm{c})]^{\alpha}[\pi_2(0,\mathrm{r}) - \mathrm{F} - \pi_2(0,\mathrm{c})]^{(1-\alpha)}$$

$$\Rightarrow max_{F,r}\left[\frac{(\mathrm{a}+\mathrm{r})^2}{9} + \mathrm{r}\frac{(\mathrm{a}-2\mathrm{r})}{3} + \mathrm{F} - \frac{(\mathrm{a}+\mathrm{c})^2}{9}\right]^{\alpha}\left[\frac{(\mathrm{a}-2\mathrm{r})^2}{9} - \mathrm{F} - \frac{(\mathrm{a}-2\mathrm{c})^2}{9}\right]^{(1-\alpha)}$$

Denote: $A = \frac{(\mathrm{a}+\mathrm{r})^2}{9} + \mathrm{r}\frac{(\mathrm{a}-2\mathrm{r})}{3} + \mathrm{F} - \frac{(\mathrm{a}+\mathrm{c})^2}{9} = \frac{1}{9}(-5\mathrm{r}^2 + 5\mathrm{ar} - \mathrm{c}^2 - 2\mathrm{ac}) + \mathrm{F}$

$$B = \frac{(\mathrm{a}-2\mathrm{r})^2}{9} - \mathrm{F} - \frac{(\mathrm{a}-2\mathrm{c})^2}{9} = \frac{4}{9}(\mathrm{r}^2 - \mathrm{c}^2 + \mathrm{ac} - \mathrm{ar}) - \mathrm{F}$$

Then we have

$\frac{\partial A^{\alpha}B^{1-\alpha}}{\partial F} = \alpha A^{\alpha-1}B^{1-\alpha} - (1-\alpha)A^{\alpha}B^{-\alpha} = A^{\alpha-1}B^{-\alpha}[\alpha B - (1-\alpha)A]$, and

$$\frac{\partial A^{\alpha}B^{1-\alpha}}{\partial r} = \alpha A^{\alpha-1}\frac{5(\mathrm{a}-2\mathrm{r})}{9}B^{1-\alpha} - (1-\alpha)A^{\alpha}B^{-\alpha}\frac{4(\mathrm{a}-2\mathrm{r})}{9}$$

$$= \frac{(\mathrm{a}-2\mathrm{r})}{9}A^{\alpha-1}B^{-\alpha}[5\alpha B - 4(1-\alpha)A]$$

Possibility 1:

If $\frac{\partial A^{\alpha}B^{1-\alpha}}{\partial F} = 0$ then $\frac{\partial A^{\alpha}B^{1-\alpha}}{\partial r} > 0$. Therefore r should be as large as possible: $r = c$. However, when $r = c$, we get $A = \mathrm{c}\frac{(\mathrm{a}-2\mathrm{c})}{3} + \mathrm{F}$ and $B = -\mathrm{F}$.

Now, F must be 0 (restricting attention to $F \geq 0$), otherwise firm 2 (licensee) would be worse-off after licensing. But then $[\alpha B - (1-\alpha)A] = -(1-\alpha)\mathrm{c}\frac{(\mathrm{a}-2\mathrm{c})}{3} < 0$, and we have a contradiction to $\frac{\partial A^{\alpha}B^{1-\alpha}}{\partial F} = 0$.

Therefore $r = c$ and $F = 0$ cannot be a solution. MM (2013) mistakenly claimed this as the general solution.

Possibility 2:

If $\frac{\partial A^{\alpha}B^{1-\alpha}}{\partial r} = 0$ then $\frac{\partial A^{\alpha}B^{1-\alpha}}{\partial F} < 0$. Therefore F should be as small as possible: $F = 0$.
Given $F = 0$, we have $5\alpha B - 4(1-\alpha)A = \frac{4}{9}[5\mathrm{r}^2 - 5\mathrm{ar} + (1-6\alpha)\mathrm{c}^2 + (2+3\alpha)\mathrm{ac}]$.

Let $5\alpha B - 4(1-\alpha)A = 0$ ($\Leftrightarrow \frac{\partial A^{\alpha}B^{1-\alpha}}{\partial r} = 0$) and solving for r we get

$r = \frac{a}{2} - \frac{\sqrt{5(a-2c)(5a+2c-12\alpha c)}}{10}$.

Therefore, the general Nash-bargained two-part tariff solution is

$F^* = 0$ and $r^* = \frac{a}{2} - \frac{\sqrt{5(a-2c)(5a+2c-12\alpha c)}}{10}$.

Hence, we also show that the optimal licensing contract in this environment is pure royalty. From the expression of r^*, it is also clear that the optimal royalty increases with bargaining power α, an intuitive result.

Given above, the expressions (the 'Innovation' and the 'No innovation' cell) in Table 3 (page 501) in MM (2013) needs to be revised as well since the final pay-offs of both firms will now look different (see below).

Revised Table 3: The Payoffs of Firm 1 and Firm 2

Firm2

Firm1	Innovation	No Innovation
Innovation	$\pi_1(0,0)-k,$ $\pi_2(0,0)-k$	$\pi_1(0,r^*)+r^*q_2^*(0,r^*)-k$ $\pi_2(0,r^*)$
No Innovation	$\pi_1(r^*,0)$ $\pi_2(r^*,0)+r^*q_1^*(r^*,0)-k$	$\pi_1(c,c),$ $\pi_2(c,c)$

More importantly, this correction changes the result in Proposition 4 of MM (2013). The correct statement of Proposition 4 should be as follows.

Proposition 4 (Revised)

(a) If $k \in (X^*, X)$, both firms innovate under no-licensing but only one firm innovates with two-part tariff licensing. Therefore, two-part tariff licensing reduces innovation vis-à-vis no-licensing for a range of low-cost innovation.

(b) If $k \in (Y,\ Y^*)$, neither firm innovates with no-licensing whereas exactly one firm innovates with two-part tariff licensing. Therefore, two-part tariff licensing increases innovation vis-a-vis no- licensing for a range of high-cost innovation.

Proof: See Appendix.

Thus the effect of bargained two-part tariff licensing on innovation incentive is qualitatively similar to the bargained fixed fee licensing given in Proposition 3 in MM (2013).[1] Note that if $\alpha = 1$, $r^* = c$ and therefore we get $X = X^*$. Only in this situation, under two-part tariff licensing, technology transfer increases innovation unambiguously. Thus Proposition 4 of MM (2013) holds only for $\alpha = 1$ and not for $\alpha \in (0,1)$.

The innovation incentives under two-part tariff licensing compared to no licensing is shown in the figure below:

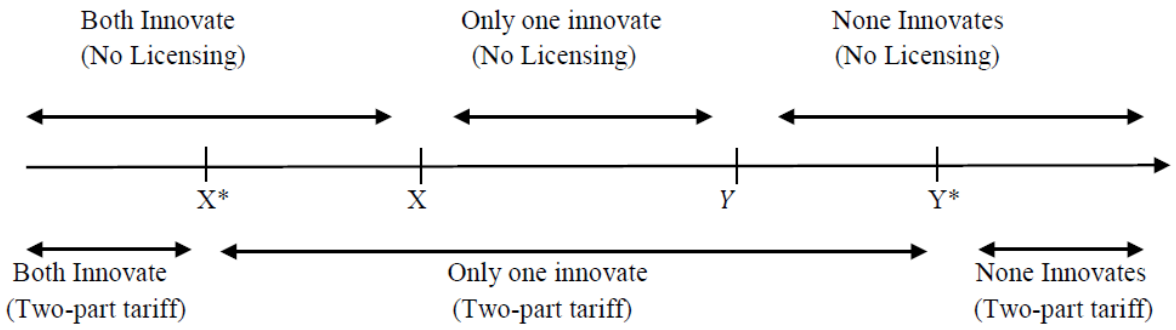

Figure 1: Innovation Incentive under two-part tariff licensing compared with no licensing
(Cost of innovation increases towards the right)

In the Appendix (page 502) of MM (2013), where the welfare analysis is done under two-part tariff licensing, some revision is in order. In particular, the statement "consumer surplus remains the same" needs to be corrected. Under the correct two-part tariff analysis there would be an increase in consumer surplus as the price of the good will fall as long as $\alpha < 1$ and therefore, overall welfare will indeed increase compared to no-licensing case.

[1] However, it is now clear that bargained fee fixed fee licensing in MM (2013) is suboptimal in a complete information model for the innovator which was not identified in MM (2013). Nevertheless, it is well understood that if implementing a royalty licensing is difficult due to observational issue of the licensee's output, then fixed fee licensing is the only feasible licensing arrangement.

Appendix

Proof of Proposition 4:

We need to check the innovation incentive under the two-part tariff contract. To fix ideas consider the incentive for firm 1 (similar argument will hold for firm 2 as well).

From Table-3, we get that both firms will invest in R&D if $k \leq \pi_1(0,0) - \pi_1(r^*,0) \equiv X^*$. Now since $r^* < c$ for $\alpha \in (0,1)$, we get $\pi_1(r^*,0) > \pi_1(c,0)$. Therefore $\pi_1(0,0) - \pi_1(r^*,0) = X^* < \pi_1(0,0) - \pi_1(c,0) \equiv X$. Thus the range for which both firms innovate shrinks compared to the no licensing case.

Again the range of R&D cost for which only one firm innovates is

$$X^* = \pi_1(0,0) - \pi_1(r^*,0) < k \leq \pi_1(0,r^*) - \pi_1(c,c) + r^* q_2^*(0,r^*) \equiv Y^*$$

Since r^* comes from a bargained solution and $\alpha \in (0,1)$, it must be the case that $\pi_1(0,r^*) + r^* q_2^*(0,r^*) > \pi_1(0,c)$, i.e., post bargaining two-part tariff contract the innovator must be better-off compared to no licensing. Therefore, $Y^* = \pi_1(0,r^*) + r^* q_2^*(0,r^*) - \pi_1(c,c) > \pi_1(0,c) - \pi_1(c,c) \equiv Y$.

Note that given the demand and cost specifications, we have $X < Y$. This completes the proof.

References

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