Economics 354 **Spring 2011**
Homework Solutions

1. Consider the model whose game tree is depicted in Scotchmer's Figure 5.4. This model assumes that Firm 1 chooses to invest in the basic research that is needed for the application to be discovered and that Firm 2's investment in the application is contingent of being able to earn positive profits from the project. Innovation pairs are characterized by the parameters (x, y, c_1, c_2). Other variables in the model are the profit share under patent protection π, the discounted patent length T, and the deadweight loss share ℓ.

Suppose that $T = 10$, $\pi = 0.5$, $\ell = 0.25$, and $r = 0.05$. Consider the four innovation pairs I, II, III, and IV with parameters shown in the table below:

Innovation pair	x	y	c_1	c_2
I	500	1000	2000	2000
II	0	1000	2000	2000
III	0	1000	2000	2700
IV	0	1000	2500	2700

For each of these pairs, calculate:

i. the total net social benefit from the innovation pair if both innovations are put in the public domain,

$$\text{Net social benefit} = \frac{1}{r}(x+y) - c_1 - c_2$$

ii. the total benefit to users if the two innovations are undertaken under patent protection,

$$\text{User benefit under patent} = \left(\frac{1}{r} - (\pi + \ell)T\right)(x+y)$$

iii. the total net benefit to a combined firm undertaking both innovations under patent protection,

$$\text{Net benefit to joint firm} = \pi T(x+y) - c_1 - c_2$$

iv. the threat points of each firm under (1) ex-post licensing and (2) ex-ante licensing,

$$\text{Firm 1 ex-post and ex-ante threat point} = \pi T x - c_1$$
$$\text{Firm 2 ex-post threat point} = -c_2$$
$$\text{Firm 2 ex-ante threat point} = \begin{cases} -c_2 \text{ if } \tfrac{1}{2} y\pi T > c_2, \\ 0 \text{ otherwise.} \end{cases}$$

v. the total gains to the two firms from (1) ex-post licensing and (2) ex-ante licensing,

$$\text{Total gains ex-post} = \pi T y,$$
$$\text{Total gains ex-ante} = \pi T y - c_2$$

vi. the payoffs to each firm under ex-post licensing assuming Nash bargaining: that the total gains from licensing are divided equally,

$$\text{Ex-post payoff for } 1 = \pi T\left(x + \tfrac{1}{2} y\right) - c_1$$
$$\text{Ex-post payoff for } 2 = \tfrac{1}{2}\pi T y - c_2$$

vii. the payoffs to each firm under ex-ante licensing assuming Nash bargaining.

$$\text{Ex-ante payoff for } 1 = \begin{cases} \pi T\left(x + \tfrac{1}{2} y\right) - c_1, \text{ if } \tfrac{1}{2}\pi T y > c_2 \\ \pi T\left(x + \tfrac{1}{2} y\right) - c_1 - \tfrac{1}{2} c_2, \text{ otherwise} \end{cases}$$
$$\text{Ex-ante payoff for } 2 = \begin{cases} \tfrac{1}{2}\pi T y - c_2, \text{ if } \tfrac{1}{2}\pi T y > c_2 \\ \tfrac{1}{2}\left(\pi T y - c_2\right), \text{ otherwise} \end{cases}$$

Based on these calculations,

a. Would this innovation pair be socially beneficial if a government performed both innovations (using tax money raised through lump-sum taxes) and offered the resulting products free?
b. Would this innovation pair be profitable under the current patent regime if both innovations were done jointly by the same firm?
c. Would it be feasible for this innovation pair to emerge through ex-post licensing between two firms?
d. Would it be feasible for this pair to emerge through ex-ante licensing between two firms?

What outcome do you predict in each case? Who gains and loses the most in each case relative to the ideal outcome?

Calculations in table below:

Innovation pair:	I	II	III	IV
Net social benefit	26,000	16,000	15,300	14,800
User benefit under patent	18,750	12,500	12,500	12,500
Net benefit to joint firm	3,500	1,000	300	−200
Firm 1 threat point	500	−2,000	−2,000	−2,500
Firm 2 ex-post threat point	−2,000	−2,000	−2,700	−2,700
Firm 2 ex-ante threat point	−2,000	−2,000	0	0
Total gains ex-post	5,000	5,000	5,000	5,000
Total gains ex-ante	3,000	3,000	2,300	2,300
Firm 1 ex-post payoff	3,000	500	500	0
Firm 2 ex-post payoff	500	500	−200	−200

Firm 1 ex-ante payoff	3,000	500	−850	−1,350
Firm 2 ex-ante payoff	500	500	1,150	1,150

Case I: It is social beneficial both through public domain and joint-firm innovation. Ex-post licensing is feasible and that will be the outcome. Although Firm 2 would do better if it could get Firm 1 to share costs, Firm 1 will not be willing to do any worse that it would do with ex-post bargaining, hence Firm 2 cannot extract any better deal ex-ante than it could get ex-post. Consumers lose quite a bit here relative to the public-domain solution (if that were feasible). Firm 2 doesn't gain much out of its valuable innovation, but then it couldn't have been done without Firm 1, which gets most of the benefit.

Case II: Similar general outcome to Case I, but Firm 1's profit position is weaker here. In both cases it gets all the direct gains from its own innovation and some of the gains from Firm 2's, but here there are no gains from its own innovation. Each firm gets an equal payoff here.

Case III: A more interesting case. The innovation pair is socially beneficial. Firm 2 won't do ex-post licensing here and Firm 1 knows it. The fact that Firm 1 has (by assumption) already made its discovery but Firm 2 has not yet done its R&D puts the latter at an advantage. Firm 1 has no bargaining power here because if there is no bargain at all it is out the entire 2,000 it spent on R&D and gets no revenue without the follow-up innovation. Firm 1 clearly loses out in this case. If it had known what it was getting into, it would not have done the initial innovation without an "ex-ante ex-ante" agreement to share the collective gains (300). However, the Scotchmer model assumes that Firm 1 has already invested.

Case IV: Another interesting case. The innovations are clearly socially beneficial, but with the prevailing discounted patent length and profit rate, even the two firms working together would not find it profitable to undertake the pair. In this case, there is no licensing scheme that is profitable to Firm 1, so it should not do R&D. However, if Firm 1 has already foolishly bumbled into its innovation, it can recoup some of its sunk cost through ex-post licensing with Firm 2.

2. As noted in the previous problem, Scotchmer's Figure 5.4 model assumes that the basic research has already been done by Firm 1. The difference between ex-ante and ex-post licensing is whether it is done before or after Firm 2 invests. What would be the outcome of before-basic-research licensing if the two firms were to bargain before either had invested? Is there ever a case where this outcome would be better than either after-basic-research bargaining scheme can achieve? Explain.

Discussed above with respect to III and IV.