Economics Bulletin

Volume 29, Issue 4

University-industry technology transfer options: licensing or research joint venture?

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Abstract

In recent years there has been an increasing trend in various forms of collaboration and technology transfer between industry and universities, such as licensing, spin-offs and research joint ventures. In this paper, I provide an explanation for the choice of licensing versus research joint venture as technology transfer options by a firm.

I wish to thank the ESRC for financial support, grant number RES-000-22-0340.
Citation: Joanna Poyago-Theotoky, (2009) "University-industry technology transfer options: licensing or research joint venture?", *Economics Bulletin*, Vol. 29 no.4 pp. 2582-2591.
Submitted: Aug 06 2009. **Published:** October 14, 2009.

1 Introduction

In recent years there has been an increasing trend in research collaboration and technology transfer between firms and universities primarily resulting from the U.S. Bayh-Dole Act of 1980 and similar laws recently introduced in Europe and elsewhere (for surveys see, e.g., Poyago-Theotoky et al., 2002 and Siegel et al., 2007). This technology transfer has taken a number of different formats. Technology transfer offices (TTOs) in universities are a key player in the commercialization process (Siegel et al., 2007) and act between industry and university researchers in trying to find the most appropriate format for the technology transfer to take place. A big chunk of technology transfer is effected via exclusive or non-exclusive licensing of the patents acquired by university researchers (Phan and Siegel, 2006, Thursby and Thursby, 2003, 2007) but not uniquely so. Other formats include university equity holdings (Feldman et al., 2002), the creation of industry-university research centers (Adams et al., 2001), spin-out companies (Franklin et al., 2001, Wright et al., 2006), research joint ventures (Caloghirou et al., 2001, Link and Scott, 2005, Motohashi, 2005), start-ups (Powers and McDougall, 2005) and the establishment of university research parks and incubators (Link and Scott, 2007, Grimaldi and Grandi, 2005).

The vast majority of the literature on the topic is empirical or selective surveys (e.g., see papers cited above). Nevertheless, to gain a deeper understanding of the issues involved in technology transfer there is a concomitant need for theoretical analysis. A limited number of theoretical approaches have been proposed to explain the recent trend of increased licensing by universities and the role of the TTOs (Jensen and Thursby, 2001, Macho-Stadler et al., 2007, 2008).

However, to the best of my knowledge, there is very little available in explaining the options an innovating firm has in pursuing technology transfer with a university. This paper is an attempt to partially fill this gap. In particular, by way of a simple model, I try to explain the choice an innovating firm has between licensing from the university and entering into a joint venture with the university. As it is the innovating firm that makes the first move in deciding how to proceed in developing an innovation it makes sense to concentrate on the two technology transfer options of licensing or entering into a joint venture with the university.

2 The Model

Consider a simple set-up with one firm (F) and one university[1] (U) - both engage in research activities. The firm is aware that the university has created knowledge that may lead to

[1] e.g., this could be the technology transfer office (TTO) or a university scientist.

an innovation of value V following further development. This value can be thought of as a generic value; how much worth the innovation is to society (e.g., the innovation could be a new vaccine). The generic value V is an objective measure of the worth of the innovation; it is not the same as e.g., the profit that the firm could earn from commercializing the innovation, π, or the revenues that the university could obtain from licensing. The firm has the following options available: (i) it can engage in research on its own and develop the innovation, (ii) it can engage in technology transfer with the university that has already done research in the relevant area but there is a need for further development to make the university's discovery commercially viable. In this latter case there are two subcases: (a) the firm licenses the university's discovery and undertakes further development or, (b) the firm and the university work together on further development within a *university-industry research joint venture* (U-I RJV thereafter). The firm offers the university to cooperate and the university either accepts or rejects this offer. I model this situation as a sequential game, as illustrated in Figure 1.

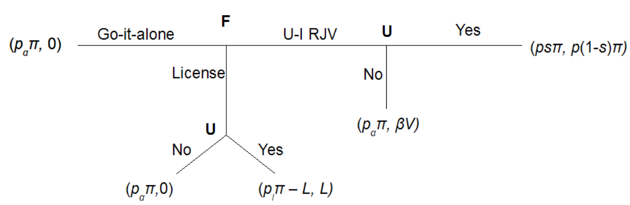

Figure 1: Different outside options

The firm's objective is to maximize expected profit. By contrast, the university is interested in the revenue associated with licensing, or, in sharing the firm's profit from participating in the U-I RJV. In what follows, I present two versions of the game: (1) the case of different outside options for the two types of technology transfer and (2) the case where the outside options are the same. Outside options refer to the options that the university has when it declines the offer of technology transfer by the firm. The two versions are different due to institutional factors, e.g., licensing involves patenting whereas setting up an U-I RJV may not, potentially making it easier to find another partner for a RJV relative to a licensee hence differing outside options.

2.1 Different outside options

The firm can perform research and develop the idea: with probability p_a development is successful and the firm obtains profit, π (net of development costs). The firm's expected payoff is $p_a\pi$. The university obtains nothing in this case so its payoff is 0 (*Go-it alone branch* in Figure 1). In the case of technology transfer, the firm can pursue with the university the 'licensing' option. If the university declines then the firm proceeds alone and obtains payoff $p_a\pi$ and the university obtains 0. If the university accepts to transfer knowledge to the firm, then the firm and the university together bargain over the terms of the transfer price (license fee) , L. The firm buys the knowledge from the university and bears the cost of development to bring it to market. It is assumed that, because of this interaction, the probability of successful development by the firm increases, $p_l > p_a$, i.e., interaction with the university is beneficial. Payoffs are then $p_l\pi - L$ for the firm and L for the university. Note that the difference $p_l - p_a$ can be interpreted as a notion of the firm's absorptive capacity or learning capability due to technology transfer (*licensing branch).* Alternatively, the firm can invite the university to participate in an U-I RJV to exploit the innovation together. If the university declines the offer it obtains a fraction of the value of the innovation, βV, $\beta \in [0, 1]$. In particular, $\beta = 0$ can be interpreted as a situation where the university has not interest in developing the innovation any further or, as a situation where the knowledge discovered by the university is at such an embryonic state that it is not possible to achieve its social value; $\beta = 1$ corresponds to the case where the university can engage in further development (either on its own, or, by creating a spin-off, or, joining forces with another firm so that the social value of the discovery is captured); intermediate values of β are interpreted similarly. If the university accepts the offer of cooperation, then together with the firm it has to decide (bargain) on the division of the profit; i.e., they have to decide on a share s. (*U-I RJV branch*). In this case, let p_u denote the probability that the university adapts the discovery to the firm's needs successfully. Assuming that the probabilities p_u and p_l are independent, the probability of success of the U-I RJV is $[1 - (1 - p_l)(1 - p_u)] = p_l + p_u - p_l p_u \equiv p$.

Next, I proceed to solve the game. First, I deal with the two instances where the firm and the university bargain either on the license fee, L, or, on the division of profit, s. I use the simple Nash Bargaining solution to determine L and s.

In the case of *licensing* the Nash product is $(p_l\pi - L - p_a\pi)(L - 0)$. Maximizing this with respect to L yields $L^* = \frac{(p_l - p_a)\pi}{2}$. Using L^* in the relevant payoffs gives for the firm, $\pi_f = (p_l + p_a)(\pi/2)$, and for the university, $\pi_u = (p_l - p_a)(\pi/2)$. In the case of the *U-I RJV* the Nash product is $(ps\pi - p_a\pi)[p(1 - s)\pi - \beta V]$. Maximizing with respect to s gives $s^* = \frac{(p_a + p)\pi - \beta V}{2p\pi}$, where $p = p_l + p_u - p_l p_u$. Using s^* in the relevant payoffs results in $\pi_f = \frac{(p_a + p)\pi - \beta V}{2}$ and $\pi_u = \frac{(p - p_a)\pi + \beta V}{2}$. It is then straightforward to solve for the SPE of this game. The following proposition summarizes (the proof is in the appendix.)

Proposition 1 *The firm chooses not to develop alone; the university and firm engage in technology transfer. In particular, there are two types of equilibrium: type A occurring for* $(p - p_a)\pi < \beta V$, *with the university and the firm engaging in licensing and type B occurring for*

$(p-p_a)\pi > \beta V$, where the university and the firm engage in licensing if $p_u(1-p_l) < \beta(V/\pi)$ while they enter into an U-I RJV if $p_u(1-p_l) > \beta(V/\pi)$, and in addition $\pi \geq \beta V$.

Thus a U-I RJV forms when the profit is at least as big as the social value of the innovation weighted by the state of knowledge ($\pi \geq \beta V$). This is due to the reward structure in the two channels of technology transfer and the structure of the outside options. In addition, note that (see also Figure 2) for smaller values of β the area of an U-I RJV increases which means that for more embryonic states of innovation the U-I RJV is preferred to licensing.[2] Moreover, for given β the area of cooperation increases for higher profit, π, or lower social value, V.

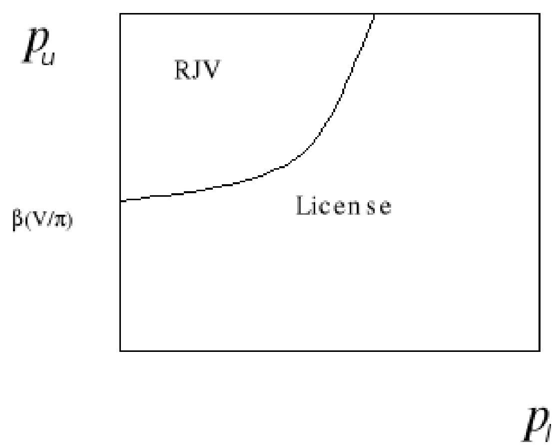

Figure 2: Type B equilibrium (see Proposition 1)

2.2 Equal outside options

In this section I use the same game structure as in the preceding section the only difference being that now the outside options for the university in case it declines technology transfer are the same, and equal to βV (due to institutional factors as mentioned previously). The game tree is thus modified as shown in Figure 3.

[2] In the limit, as $\beta \to 0$, the U-I RJV is the only outcome.

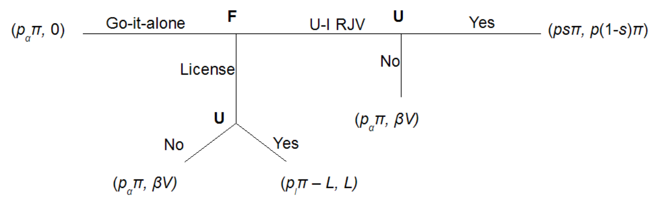

Figure 3: Equal outside options

In line with the previous section, in the case of *licensing* the Nash product is now $(p_l\pi - L - p_a\pi)(L - \beta V)$ yielding $L^* = \frac{(p_l - p_a)\pi + \beta V}{2}$. Using this the payoffs become $\pi_f = p_l\pi - L^* = \frac{(p_l + p_a)\pi - \beta V}{2}$ for the firm and $\pi_u = L^* = \frac{(p_l - p_a)\pi + \beta V}{2}$ for the university. The *U-I RJV* branch remains the same as in section 2.1. It is then straightforward to establish the following result (the detailed derivation is in the Appendix).

Proposition 2 *In the case of equal outside options there are two types of equilibrium outcome:*
Type 1, where the firm develops alone; for this to occur it is sufficient that $(p - p_a)\pi < \beta V$*;*
Type 2, where the firm offers the university a U-I RJV and the university accepts; this occurs for $(p - p_a)\pi \geq \beta V$*.*

So in contrast to the case of different outside options there are now instances where the university rejects licensing. In fact, licensing is never part of an equilibrium. Either a U-I RJV forms or independent development occurs in equilibrium. This is clearly due to the fact that the outside options are the same for the university; as a result, the university would always prefer the U-I RJV because of the sharing in the profits and the decision of the firm is guided by the relative size of expected profit to social value.

3 Concluding Remarks

The simple model I have presented in this paper, explores some of the conditions that explain the choice of technology transfer channel available to a firm, in particular, whether the firm will opt for licensing from a university or whether it will form a collaborative venture with the university. It turns out that whether the outside options for the university are the same or not is a driving force in this choice. I should stress at this point that the paper has only considered two possible options of technology transfer out of many (mentioned in the Introduction). Further research is needed to address the full choice of options available, combine this with the extant empirical evidence and draw policy implications.

4 Appendix

4.1 Proof of Proposition 1

I solve the game backwards by starting with the nodes where the university makes a choice.

RJV branch Compare payoffs $\frac{(p-p_a)\pi+\beta V}{2}$ with βV. So, $\frac{(p-p_a)\pi+\beta V}{2} \gtreqless \beta V$ or, $(p-p_a) = (p_l+p_u-p_lp_u-p_a)\pi \gtreqless \beta V$. Two cases to consider depending on whether $(p-p_a)\pi \gtreqless \beta V$ (i) if $(p-p_a)\pi \geq \beta V$, university accepts the offer to participate in RJV and (ii) if $(p-p_a)\pi < \beta V$, university rejects RJV.

Licensing branch The university compares payoffs $(p_l-p_a)(\pi/2)$ with 0. So, given the assumption $p_l > p_a$, $(p_l-p_a)(\pi/2) > 0$, hence the university never rejects the demand for a licence by the firm; the 'No' branch is dominated.

Next, I consider what the firm will do, given the university's optimal play as described above.

There are two cases to consider depending on what the university does at the RJV node, i.e. whether $(p-p_a)\pi \gtreqless \beta V$.

Case A $(p-p_a)\pi < \beta V$. The firm has to consider the following payoffs from the three available actions: $p_a\pi, p_a\pi, (p_l+p_a)(\pi/2)$. So, I need to check whether $(p_l+p_a)(\pi/2) \gtreqless p_a\pi$. Given the assumption that $p_l > p_a$, $(p_l+p_a)(\pi/2) > p_a\pi$ so the firm chooses to go for a license. The equilibrium in this case is for the firm to ask the university to license its knowledge and the university to accept.

Case B $(p-p_a)\pi \geq \beta V$ (university accepts to participate in RJV if asked to do so). The firm needs to compare $p_a\pi$, $\frac{(p_a+p)\pi-\beta V}{2}$ and $\frac{(p_l+p_a)\pi}{2}$. $\frac{(p_l+p_a)\pi}{2} \geq p_a\pi$, given that $p_l > p_a$ (by assumption). Further, as $(p-p_a)\pi \geq \beta V$, it is also the case that $\frac{(p_a+p)\pi-\beta V}{2} > p_a\pi$. So the go-it alone is dominated and thus not chosen by the firm. Hence, the firm has to compare $\frac{(p_a+p)\pi-\beta V}{2}$ with $\frac{(p_l+p_a)\pi}{2}$. $\frac{(p_a+p)\pi-\beta V}{2} \gtreqless \frac{(p_l+p_a)\pi}{2} \Rightarrow (p-p_l)\pi \gtreqless \beta V \Rightarrow p_u(1-p_l) \gtreqless \beta(V/\pi)$. Thus, if $p_u(1-p_l) > \beta(V/\pi)$ and, in addition, $\pi \geq \beta V$, the RJV will form and if $p_u(1-p_l) < \beta(V/\pi)$ a licensing contract will be preferred.

4.2 Proof of Proposition 2

Solving the game backwards, at the *university subgame* and the *RJV branch* there are two cases: (i) if $(p-p_a)\pi \geq \beta V$, the university accepts the U-I RJV, (ii) if $(p-p_a)\pi < \beta V$, it rejects it. Note that $p = p_l + p_u - p_lp_u$. In the *licensing branch* $\frac{(p_l-p_a)\pi+\beta V}{2} \gtreqless \beta V \Rightarrow (p_l-p_a)\pi + \beta V \gtreqless 2\beta V \Rightarrow (p_l-p_a) \gtreqless \beta(V/\pi)$. Hence, if $(p_l-p_a)\pi \geq \beta V$ the university accepts licensing; if $(p_l-p_a)\pi < \beta V$ it rejects licensing. Note that $(p-p_a) > (p_l-p_a)$. Next, consider the *Firm subgame.* There are a number of cases to check depending on how the university responds at the subgames it moves:

1. U will reject both licensing and the U-I RJV iff $(p_l - p_a)\pi < \beta V$ and $(p - p_a)\pi < \beta V$; given that $(p - p_a) > (p_l - p_a)$ it is sufficient to $(p - p_a)\pi < \beta V$. So, the firm *develops alone* and obtains $p_a\pi$, while the university is not offered any option in the SPE and thus obtains 0 (type 1 equilibrium).

2. U accepts U-I RJV, U rejects licensing if $(p - p_a)\pi \geq \beta V$ and $(p_l - p_a)\pi < \beta V$, which is equivalent to $(p_l - p_a) < \beta(V/\pi) < (p - p_a)$. The firm has to compare the following payoffs: $p_a\pi$, $p_a\pi$ and $\frac{(p+p_a)\pi - \beta V}{2}$. Then, $\frac{(p+p_a)\pi - \beta V}{2} > p_a\pi \Rightarrow (p - p_a) > \beta(V/\pi)$. So the equilibrium outcome here is for the firm to offer the university the U-I RJV and for the U to accept, *U-I RJV* is the outcome (type 2 equilibrium).

3. U will accept either option if offered by the firm; this requires that both $(p - p_a)\pi \geq \beta V$ and $(p_l - p_a)\pi \geq \beta V$ hold, and as above it is sufficient that $(p_l - p_a)\pi \geq \beta V$ holds. So the firm has to compare the following payoffs: $p_a\pi$, $\frac{(p_l+p_a)\pi - \beta V}{2}$ and $\frac{(p+p_a)\pi - \beta V}{2}$. So U-I RJVs preferred by the firm over licensing and go-it-alone. The equilibrium here is for the firm to offer the university a U-I RJV and the university to accept, so *U-I RJV* is the outcome (type 2 equilibrium).

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