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Licensing Out as a Form of Myopic Management *

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Abstract

In recent years, financial analysts have affected the way that managers run their businesses. The consequences of failing to meet analysts' expectations have been so severe that managers increasingly focus on the short term, using activities that inflate current earnings at the expense of long-term firm performance. Licensing out the company's intellectual property can be one of these short-run strategies. In this paper, we propose hypotheses that relate companies' licensing strategy to their financial situation and present a simple microeconomic model to address this relationship. The licensing decision depends on three key elements: the probability of accomplishing analysts' forecast; the company-competitor relative R&D productivity; and, the fixed fee-royalty licensing contract. Our model helps to explain why licensing contracts signed in a pressure situation contain a distorted payment scheme. Specifically, we find the fixed fee to be greater than optimal and the royalties to be lower than optimal, as compared to those contracts signed in a non-pressure situation.

Keywords: Technology Licensing, Intellectual Property, Real Activities, Myopic Management, Markets for Technology, Fixed Fee, Royalties.

JEL Codes: O32, O33

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In the past two decades, licensing agreements have grown at an unprecedented rate, making their management a core competence issue, especially for high-tech companies (Kamiyama et al., 2006; Zuniga et al., 2009). The main reason for these expanded activities is the revenue that licensing generates. In particular, in a survey conducted by Zuniga et al. (2009), 51% of European companies and 53.6% of Japanese companies noted that their main motivation for licensing out their technology in the previous three years was revenue. However, although licensing has positive short-term effects, as companies increase their revenues, licensing also entails costs: companies might lose market share and/or suffer from lower price margins because of the additional competition in the product market (Arora et al., 2003; Fosfuri, 2006). Therefore, licensing decisions require caution to balance short-term earnings against potential long-term harm because firms that underestimate the potential negative effects could put their competitive advantages at risk.

At the same time, financial analysts exert increasing influence on companies' strategies, leading to disproportionate consequences for firms that miss forecasts, even by a small amount. For instance, in December 1997, *Oracle* saw its stock price decline by 29% due to falling short of analysts' forecast by 0.04, although this result was 4% above EPS for the same quarter in the previous year (Skinner et al., 2002). Also, *Procter & Gamble* saw its stock price fall by 30% when its managers warned that the company would not beat analysts' forecast in the first quarter of 2000.¹ Therefore, financial analysts have affected the way that managers run their businesses in recent years. Since managers' compensations, evaluations and, as a consequence, their job continuity usually rely on their companies' current stock price (Mizik, 2010), the consequences of failing to meet analysts' expectations are so severe that managers increasingly focus on the short term. Thus, with greater creativity, they inflate current earnings with activities that usually come at the expense of long-term firm performance. (Aaker, 1991; Bartov, 1993; Herrmann et al., 2003; Moorman et al., 2008; Roychowdhury, 2006).

In this paper, we propose three hypotheses that relate companies' licensing strategy to their financial situation and present a simple microeconomic model to address this relationship. Initially, we link the theoretical literature on licensing and on myopic management by proposing three hypothesis:

1. Companies are more likely to license out their intellectual property under pressure to meet analysts' forecast;
2. Companies that have increased the number of licensing contracts under a pressured situation will experience a stronger reduction in their market share in subsequent years; and,
3. Licensing contracts established under pressure to meet analysts' forecasts present a distortion in the fixed fee and in the royalties.

¹A similar warning before the second quarter of the same year generated an additional decrease in the stock price of 10% and resulted in the CFO's dismissal (Duncan, 2001).

Then, we delineate our model that accounts for these three hypothesis by characterizing the optimal licensing decision of the manager and the optimal R&D investment. We present a two-period model –representing the short term and the long term– in a sector operated with firms whose R&D activities affect their market share. We consider any of these firms endowed with a level of intellectual property and headed by a manager that receives a bonus proportional to the firm’s profits in the period –the prevalent type of compensation in the real world. The manager will keep heading the firm in the second period –i.e., in the long run– if she is able to accomplish analysts’ forecasts, an outcome achieved with an exogenous probability. The manager has to decide in the first period whether or not license out a share of the firm’s intellectual property. If she decides to, then the firm will receive a flow of short-run and long-run income, in the form of a fixed fee and royalties. However, licensing out will reduce the firm’s market share in the second period, as the intellectual property licensed becomes a public good, so both the firm and its competitors are able to conduct further R&D research based on this knowledge. Accordingly, in our model, the licensing decision depends on three key elements: the probability of accomplishing analysts’ forecast; the firm’s and the competitor’s marginal productivity of R&D activities; and, the fixed fee and royalties established in the licensing agreement.

Our main results relate the company’s financial situation to its licensing strategy. Hypothesis 1 can be interpreted, in terms of our model, as the consequence of the inability of the manager to accomplish analysts’ forecasts (and, thus, the likelihood of being fired). In the case of full inability, the manager will license out all of the firm’s intellectual property (Proposition 2). As the probability of meeting analysts’ expectations increases –i.e., the more likely it is that the manager keeps her job–, the firm will be involved in less licensing (Proposition 3). Hypothesis 2 can be interpreted in our model as the effect of licensing on the firm’s market share. The more likely it is that the manager will accomplish the analyst’s forecast, the more aligned the manager’s and owner’s incentives will be. Therefore, the manager will be more interested in higher R&D investment to increase her compensation in the long run (Lemma 4). On the contrary, if the analysts’ forecast is not going to be met, the manager will tend to license out intellectual property, which reduces the firm’s market share (Proposition 5). However, the firm’s and the competitors’ R&D technology play a key role in the trade-off between the firm’s revenue gains through licensing (the *revenue effect*) and the revenue losses through a decrease in the market share (the *rent dissipation effect*), an issue that has not been sufficiently explored in the literature.

Finally, our setting considers the licensing contract exogenously given. Yet Hypothesis 3 can be addressed within our model by undertaking a comparative statics analysis. In the set of licensing contracts –i.e., the fixed fee-royalties space– as the probability that the manager will be fired increases, full licensing becomes a more likely optimal strategy (Proposition 6). If allowed to choose among optimal licensing contracts, the manager will be biased towards contracts with higher fixed fees and lower royalties, a result (Proposition 7) that becomes a formal statement of Hypothesis 3.

2 LITERATURE REVIEW

In this section, we present a literature review that provides theoretical background for licensing and myopic management.

2.1 *Licensing Theory*

Modern companies have moved from fully protecting their knowledge to licensing it out (Vishwasrao, 2007; Yanagisawa et al., 2009). Yet the most important motivation for licensing out technology is the revenue it generates, equal to the present value of the fixed fee or the royalties that licensees pay to the licensor and known as the *Revenue Effect* (Gambardella et al., 2007, Robbins, 2009, and Zuniga et al., 2009). However, the importance of licensing revenues actually should be balanced against the extent of the *Rent Dissipation Effect*. That is, through licensing, licensors grant access to secrets about the company's technology and allow licensees to use it. By internalizing and understanding how the licensed technology works, licensees can invent around the technology, imitate the licensor, and compete directly with the licensing company in the product market, which would eventually reduce the licensor's market share and/or the price/cost margin. The *Rent Dissipation Effect* reflects this decrease in the licensor's benefits, as a consequence of additional competition in the product market (Arora et al., 2003; Fosfuri, 2006). Therefore, to actually generate benefits from licensing, companies should license their technology if the *Revenue Effect* is greater than the *Rent Dissipation Effect*.

2.2 *Myopic Management Theory*

Effective management requires a long-term focus, prioritizing those projects that generate the greatest net present value for the firm (Mizik, 2010). However, managers' compensation and evaluations are based usually on the company's current stock price (Mizik, 2010), which, in turn, depends on whether the firm accomplishes three earnings benchmarks: zero earnings, prior comparable period's earnings and analysts' forecasts (Degeorge et al., 1999), managers are forced to adopt strategies that will provide immediate pay-offs (Dechow, 1994; Degeorge et al., 1999). In particular, the pressure to meet these thresholds provides managers with incentives to manipulate the company's results by inflating current earnings. For instance, in a survey conducted by Graham et al. (2005), financial executives declared that to avoid negative surprises and their dismissal, they were willing to undertake activities that inflate current earnings at the expense of long-term firm value. This pressure has been so severe that it even has changed the distribution of earnings reported: nowadays, few firms report losses, and the majority cite small profits (Dechow et al., 2003).

The literature on myopic management has studied all of the activities that have even a positive short-term effect, have a negative long term one. Among these activities, researchers had mainly

concentrated on the reduction in R&D (Baber et al., 1991; Dechow et al., 1991; Bushee, 1998; Bens et al., 2002, 2003; Cheng, 2004). But other activities to increase short-term earnings at the expense of long-term results were also found. Specifically, the literature found that managers reduce firms' marketing expenditures (Aaker, 1991) or advertising spending (Cohen et al., 2010); sell fixed assets strategically to benefit from acquisition cost principles (Bartov, 1993 and Herrmann et al., 2003); provide sale price reductions in fourth quarters (Jackson et al., 2000); repurchase stock (Hribar et al., 2006); use price discounts and zero financing strategies, overproduce and reduce their discretionary expenses (Roychowdhury, 2006); delay the introduction of innovations (Moorman et al. 2008) and/or record securitizations as collateralized borrowings at the end of the month (Dechow et al., 2009).

Despite such established evidence of these practices, only a few studies quantify their financial impacts. Pauwels (2004) finds that sales promotions imply negative long-term effects for firm value, and Gunny (2005) links myopic practices to lower returns on assets in the subsequent year. In Mizik and Jacobson's (2007) study, companies suffered negative earnings two years after reducing their marketing expenditures, such that by the fifth year, their market value had fallen by 25%. Mizik (2010) similarly reports that those companies that have reduced their marketing expenditures are more likely to suffer greater negative abnormal returns in the future than other companies. Chapman et al. (2009) also show that companies can use marketing to increase quarterly net income by up to 5%, but that this strategy will experience a 7.5% reduction in the next period's quarterly net income. All of this evidence emphasizes the trade-off associated with myopic management: the use of these activities increases short-term earnings and helps managers beat analysts' forecasts, but it also has negative long-term consequences for firm performance.

2.3 Propositions

In this section, we present our main propositions. As financial analysts become more influential and the consequences of missing forecasts grow more severe for companies (Skinner et al., 2002), managers are willing to engage in inefficient projects that threaten long-term firm performance. Yet these misleading decisions for the firm allow managers to avoid a decrease in the firm's stock prices, to keep their job leading the firm and to enhance their reputation (Degeorge et al., 1999).

Stein (1989) argues that the easiest method for managers to manipulate short-term earnings is to decrease intangible asset expenditures, as these are not separately recorded on the balance sheet and are not directly related to production. These two features also apply to licensing agreements. Usually, contracts are private and confidential, and accounting rules do not require companies to recognize licensing revenues as a separate item in corporate reports. When a company receives licensing revenues, external observers perceive only an increase in earnings; they are not able to discern if the reported earnings provide a valid proxy of future performance or if the earnings are actually achieved at the expense of future profits. Likewise, licensing out intellectual property does not affect short-term production. Even if companies license out their core technology to

competitors, it takes time before managers can observe any decrease in the firm's market share. This inability to immediately identify the consequences of licensing out practices provides managers with an opportunity to inflate current earnings and benefit from them for some time. Thus, we can assert that managers under pressure to beat analysts' forecasts likely overestimate the revenue effect and fail to make an efficient licensing decision. In other words, at the margin, we expect that licensing decisions that would not be made under normal conditions become more appealing to managers under pressure, because they discount the future more. We state this issue in the following hypothesis.

H1. *Companies are more likely to license out their intellectual property when they are under the pressure to meet analysts' forecasts, ceteris paribus.*

In addition, companies that make more licensing agreements in response to pressures to meet analysts' forecasts are more likely to suffer a greater market share reduction than companies that do not. This is stated in the following additional hypothesis.

H2. *Companies that increase the number of licensing contracts under a pressure situation experience a stronger reduction in their market share in subsequent years than companies that increase the number of licensing contracts, but not because of the pressure to meet analysts' forecasts, ceteris paribus.*

Finally, licensing contracts are characterized by a double-sided moral hazard problem. Evidence has shown that, in uncertain contexts, royalties are better than fixed fees because they reduce this problem (Arora, 1996) and represent the price of the licensed technology better (Sakakibara, 2010). However, as managers are so focused on beating the analysts' forecasts we expect that they prefer to "borrow" as much earnings as they can from the future rather than minimize the moral hazard problem or represent way the licensing price in a better. Therefore, we expect managers under a pressure situation to establish the maximum quantity that they can as fixed fee and the minimum quantity as royalties. This issue is stated in a third hypotheses.

H3. *Licensing contracts established under a pressure situation will present a distortion in the fixed fee (that will be greater than optimal) and in the royalties (that will be lower than optimal), as compared to those that are established under no such pressure, ceteris paribus.*

These three hypotheses are the core of this paper along with the summary of the literature on licensing and myopic management. In the following section, we present a theoretical framework that rationalizes these arguments.

3 A SIMPLE MODEL OF MYOPIC MANAGEMENT

In this section, we outline our model. All technical issues are gathered in the appendices.

Consider a firm operating in two periods: the *short term* and the *long term*, denoted by $t = 0$ and $t = 1$, respectively. The firm ownership and management are separate. The firm's owners are interested in the firm's intertemporal profits

$$\pi_0 + \frac{1}{R}\pi_1,$$

where π_t represents the profits at period $t = 0, 1$; and, R is the (exogenous) gross interest rate.

The firm is headed by a manager, who receives two types of compensation: a fixed salary and a bonus. We assume that the fixed salary equals her market opportunity cost, and, for simplicity, sets equals to zero. The variable salary –the bonus– at period t consists of a fraction $\phi \in (0, 1)$ of the firm's profits at period t ; thus, she will receive (for certain) a positive bonus compensation $\phi\pi_0$ at period $t = 0$. Yet, depending on whether the manager achieves some particular goals in the short run –i.e., meets the analysts' forecasts–, she keeps running the firm at period $t = 1$. If so, the manager will receive a bonus as compensation $\phi\pi_1$ at period $t = 1$. We consider that the manager gives a probability $\psi \geq 0$ that she will be able to accomplish those goals in the short run. The manager is risk-neutral with payoff function equal to the money received, and both the manager and the owner discount the future at the same rate R . Then, the manager's (expected) objective function becomes

$$\phi \left[\pi_0 + \psi \frac{1}{R} \pi_1 \right]. \quad (1)$$

The firm's profits at any period t (π_t) comprise the firm's revenue (net of costs). The firm's revenue depends on its market demand share. At period $t = 0$, the firm's market share is $\alpha_0 \in (0, 1)$, so that competitors accrue for $\beta_0 (= 1 - \alpha_0)$ of the market demand. That is, the firm's revenue is $\alpha_0 D_0$, D_0 being the total market demand revenue (net of costs) at period $t = 0$. We assume that the market demand grows at a rate $\rho \geq 1$ at period $t = 1$, so $D_1 = \rho D_0$.

The firm's market share (α_0) can be thought of as depending –proportionally– on the input factor “*knowledge*” (e.g., patents), as knowledge allows the firm to produce goods with higher quality or lower costs, thus increasing the firm's revenue. The input factor *knowledge* is a firm's intangible asset that can be sold to other firms at a price q . We can assume that the firm's market share (α_0) is the stock of the firm's knowledge at period $t = 0$. We will denote by $k \leq \alpha_0$ the amount of the firm's knowledge (i.e., patents) sold at period $t = 0$. Typically, licensing agreements comprise two types of revenues for the firm: in the short run (at $t = 0$), the firm receives a *fixed fee*, a monetary compensation qk ; and, in the long run (at $t = 1$), the firm receives *royalties*, a monetary income consisting of a rate r on the per unit revenue obtained using the firm's technology licensing k . Accordingly, a licensing agreement is fully represented by a pairwise (q, r) . If the manager sells a fraction of the firm's knowledge in the short run (at period $t = 0$), then this knowledge becomes publicly known in the long run (at period $t = 1$). Thus, other firms' interest in buying intellectual property is that each can get greater market share at period $t = 1$ through creating more knowledge –more patents– from R&D activities.

Undertaking an R&D activity at $t = 0$ requires a monetary expenditure i by the firm. This research process is an increasing function of the research expenditure $N(i)$, and generates gross knowledge production; that is, $N'(i) > 0$, $N(i) \geq 1$ and $N(0) = 1$. An example of this R&D activity is the linear technology $N(i) = 1 + Ai$, with $A > 0$. Competitors also perform R&D activities upon their own knowledge (β_0), as well as on that purchased –and, thus, publicly known– (k) at period $t = 0$. We assume that competitors create knowledge at an exogenous rate $\eta \geq 1$. Accordingly, the firm’s market share changes along time, from α_0 in the short run (at period $t = 0$) to

$$\alpha_1 \equiv \frac{N(i)\alpha_0}{N(i)\alpha_0 + \eta(\beta_0 + k)}$$

in the long run (at period $t = 1$). It is easy to show that the firm will decrease its market share (i.e., $\alpha_1 < \alpha_0$) provided that

$$k > \beta_0 \left[\frac{N(i)}{\eta} - 1 \right], \quad (2)$$

that is, in the case in the case the firm licenses so much intellectual property that its R&D investment is unable to offset the competitor’s (exogenous) production of knowledge.

To summarize, the firm’s profit in the short run (at period $t = 0$) comprises the firm’s revenues at $t = 0$ net of the R&D expenditure, plus the fixed fee received as the income for the knowledge sales:

$$\pi_0(i, k) = \frac{\alpha_0}{\alpha_0 + \beta_0} D_0 - i + qk,$$

with $\alpha_0 + \beta_0 = 1$. The firm’s profit in the long run (at period $t = 1$) comprises the firm’s revenues at $t = 1$ net of the R&D expenditure, plus the royalties received from the competitor’s sales using the firm’s knowledge k :

$$\pi_1(i, k) = \frac{N(i)\alpha_0}{N(i)\alpha_0 + [\beta_0 + k]\eta} \rho D_0 + r \frac{k\eta}{N(i)\alpha_0 + [\beta_0 + k]\eta} \rho D_0 = m(i, k) \rho D_0,$$

with $m(i, k) = \frac{N(i)\alpha_0 + r k \eta}{N(i)\alpha_0 + [\beta_0 + k]\eta} < 1$ being the firm’s market power at period $t = 1$.

3.1 The manager problem

The manager chooses the R&D investments $i \geq 0$ and the number of licensing agreements $k \in [0, \alpha_0]$ at period $t = 0$ that maximize her objective function (1), given her subjective probability (ψ) of accomplishing the objective goals at period $t = 1$, the interest rate (R), the price of the licensing agreement (q, r), the initial market size (D_0), the market demand expansion (ρ), the initial market demand shares –or, equivalently, the initial firm’s and competitor’s stock of knowledge (i.e., patents)– (α_0 and β_0), and the competitors patent’s growth (η). The first-order conditions becomes

$$i \left\{ -1 + \frac{\psi \pi_1}{R} \frac{\alpha_0 N'(i)}{N(i)\alpha_0 + r k \eta} [1 - m(i, k)] \right\} = 0 \quad (3)$$

$$k [k - \alpha_0] \left\{ q + \frac{\psi \pi_1}{R} \frac{\eta}{N(i)\alpha_0 + r k \eta} [r - m(i, k)] \right\} = 0 \quad (4)$$

with $[1 - m(i, k)] = \frac{\{[\beta_0+k]-rk\}\eta}{N(i)\alpha_0+[\beta_0+k]\eta}$ and $[r - m(i, k)] = \frac{N(i)\alpha_0[r-1]+\beta_0\eta r}{N(i)\alpha_0+[\beta_0+k]\eta}$.

The manager problem, however, is not a concave program (see Appendix A.1). The reason is that, in the model, licensing transforms private knowledge into public knowledge, and both the firm and its competitors are able to create more knowledge on the licensed knowledge.² Depending on the parameters, the firm can appropriate enough (or not) on this public good. This means that there might exist several potential R&D investment-licensing strategies as an optimal solution to the manager's problem. Specifically, for any set of strictly positive parameters, there can exist three candidates to optimal manager strategies (see Appendix A.2), any of them with positive R&D investment; namely,

1. an interior solution, with positive R&D investment and positive licensing –i.e., $i^1 > 0$ and $k^1 > 0$;
2. a corner solution with positive R&D investment ($i^2 > 0$) and licensing all the firm's knowledge $k^2 = \alpha_0$; and,
3. a corner solution with positive R&D investment ($i^3 > 0$) and no licensing $k^3 = 0$.

What investment-licensing strategy provides the highest welfare to the manager depends on the value of the parameters. The next result, proved in Appendix A.3, shows the optimal strategy when the R&D technology is linear.

Proposition 1 Optimal licensing strategies in the R&D linear case. *Assume that the R&D technology is linear –i.e., $N(i) = 1 + Ai$ with $A > 0$. For any given set of parameter values, let us denote*

$$\hat{q}(r) \equiv \frac{2}{\alpha_0} \left[\frac{\Psi}{\alpha_0 A / \eta} \right]^{\frac{1}{2}} \left[(1 - r\alpha_0)^{\frac{1}{2}} - (1 - \alpha_0)^{\frac{1}{2}} \right] - \frac{1}{\alpha_0 A / \eta},$$

with $\Psi = \psi\rho D_0/R$. Consider a particular licensing contract (\tilde{q}, \tilde{r}) . If $\tilde{q} > \hat{q}(\tilde{r})$ is satisfied, then full licensing ($k^* = \alpha_0$) is the optimal licensing strategy; otherwise, if $\tilde{q} < \hat{q}(\tilde{r})$, then the manager finds no licensing ($k^* = 0$) optimal.

Figure 1 illustrates Proposition 1. The slope of the threshold condition –i.e., $1/d \frac{\partial \hat{q}(r)}{\partial r}$ – is negative, since

$$\frac{\partial \hat{q}(r)}{\partial r} = - \left[\frac{\Psi}{(1 - r\alpha_0)\alpha_0 \frac{A}{\eta}} \right]^{\frac{1}{2}} < 0,$$

and the intercept with the q -axis is $\hat{q}(r = 0)$, while the intercept with the r -axis is found at $\hat{q}(r_{q=0}) = 0$. Observe that with licensing agreement contracts (q, r) exhibiting high fixed fees and/or high royalties, the full licensing strategy becomes more likely; and vice versa: with licensing agreement contracts exhibiting low q and/or r , no licensing becomes the more likely optimal strategy.

²Observe that the non-concavity of the manager's payoff function does not depend on the returns-to-scale of the firm's or competitor's R&D technology, but on the public good feature. If licensing contracts preclude the firm from performing R&D activities with the licensing technology, then the market share at period $t = 1$ must be modified, and the productivity of the investment function $N(i)$ would play a role in the concavity of the manager's problem.

[Figure 1 about here.]

4 MAIN RESULTS AND DISCUSSION

In this section, we relate the manager's optimal decision to the hypotheses stated in Section 2.3.

4.1 Hypothesis 1

Hypothesis 1 states that a firm is more likely to license out its intellectual property when it fails to achieve market forecasts. In terms of our model, Hypothesis 1 can be interpreted as the consequence of the manager's inability to accomplish analysts' forecasts (and, thus, the likelihood of being fired), which can be formally presented in the following two results. First, in the case of (exogenous) full inability to meet the firm's goals in the short run, then the manager will license out all of the firm's intellectual property.

Proposition 2 Managerial myopia. *If the manager is unlikely to accomplish short-run goals –that is, if $\psi = 0$ –, then she will reduce R&D investment and license out all of the patents to increase profits at period $t = 0$ and then maximize her income –that is, $i^* = 0$ and $k^* = \alpha_0$.*

The proof is straightforward from the maximization of (1) for $\psi = 0$ (see the first-order conditions (3)-(4)). Note that this myopic strategy is rational for the manager, but it is a bad outcome for the owners of the firm.

Second, as the probability of meeting analysts' expectations increases –i.e., the more likely it is that a manager keeps her job–, the firm will be involved in less licensing.

Proposition 3 Managerial decision if the manager is likely to accomplish long-run goals. *If the manager is likely to accomplish the short-run goals –i.e., if $\psi > 0$ is high enough–, then the manager will optimally choose a non-zero R&D investment and will not sell all of the patents –that is, $i^* > 0$ and $k^* \leq \alpha_0$.*

4.2 Hypothesis 2

Hypothesis 2 states that a firm that increases licensing agreements is more likely to lose market share. We can present two results as formal statements of Hypothesis 2. Initially, observe that Proposition 3 entails that managers in less stressful situation (i.e., with higher ψ) will maximize the firm's intertemporal profit profile. But is this behavior optimal for the owners?

The first result shows that the more linked the manager's period $t = 1$'s income is with the firm's intertemporal results, the more aligned the manager's and the owner's incentives will be. Accordingly, the higher ψ –the more concerned the manager is with the intertemporal value of the firm–, the more likely the manager is to optimally choose a higher R&D investment at period $t = 0$ to obtain higher revenues –and compensation– in the long run.

Lemma 4 $\partial i^*(\psi)/\partial \psi > 0$.

In Appendix A.2, we present the proof for a linear R&D technology (i.e., $N(i) = 1 + Ai$ with $A > 0$). In this case, the firm's optimal investment is proportional to the probability of keeping the manager on the job.

The second results shows that the higher the licensing, the lower is the market share of the firm. The proof is easy after substituting optimal investment and licensing into (2).

Proposition 5 Licensing due to managerial myopia reduces market share.

$$\partial \alpha_1^*(\psi)/\partial \psi < 0.$$

It is important to realize that the firm's and the competitors' R&D technology play a key role in the trade-off between firm's revenue gains through licensing and the revenue losses through a decrease in market share, an issue that the literature seems to ignore.

4.3 Hypothesis 3

Hypothesis 3 states that the fixed fee and royalties involved in licensing agreements will be affected by myopic managerial behavior. In our model, however, fixed fee (q) and royalties (r) are exogenous variables. Yet we can address this hypothesis by undertaking a comparative statics analysis. In the set of licensing contracts –that is, in the set of parameters for fixed fee and royalties (i.e., the q - r -space)–, Figure 1 displays the combination of the value of parameters for royalties and fixed fees that results in an indifferent manager's strategy between full licensing and no licensing.

In the next result, we show that as the probability of the manager being fired increases, full licensing becomes a more likely optimal strategy.

Proposition 6 *The higher the probability that the manager will be fired –i.e., as ψ decreases–, the smaller is the set of parameters in the q - r -space that becomes no licensing optimal. And vice versa: the higher the probability the manager keeps in job –i.e., as ψ increases–, the greater are the values for fixed fee (q) and royalties (r) required in contract agreements for full licensing to be optimal.*

Figure 2 illustrates Proposition 6. As the parameter ψ increases, the (expected) benefits of no licensing –hence, independent of licensing agreements– increases, and the (expected) benefits of no licensing also increases but at a lower pace. This means that as the probability of being fired decreases, the manager will require a higher present compensation (higher fixed fee) to give up future flow of income because of a lower market share. Specifically, the slope of the threshold condition is increasing (it is less negative),³ so the changes in the slope (i.e., $1/[d\frac{\partial \hat{q}(r)}{\partial r}/d\psi]$) is

$$\frac{d\frac{\partial \hat{q}(r)}{\partial r}}{d\psi} = \frac{1}{2\Psi} \frac{\partial \hat{q}(r)}{\partial r} < 0,$$

³Recall that in Figure 2 the picture of the function $\hat{q}(r)$ is represented with the independent variable at the vertical axis, so the evolution of sign of the derivative is the inverse one.

and the intercept with the q - and the r -axis is increasing.⁴ This means that the greater the probability of accomplishing analysts' forecasts, the smaller is the set of licensing agreement contracts (q, r) that result in a full licensing optimal strategy.

[Figure 2 about here.]

Presenting a formal representation of Hypothesis 3 involves some difficulties since, as indicated, the licensing contracts (q, r) are exogenous in our setting. Thus, our model cannot identify the optimal licensing contract. Yet we could assume that there exists such an optimal contract for the firm (and, thus, for its owners). Observe that such a contract is also optimal for the manager provided that the owners' and manager's goals are aligned –i.e., $\psi = 1$ in our model. Also, if an optimal licensing contract exists, then our model specifies that there exists a continuum of contracts –i.e., combinations of fixed fee q and royalties r – that provides the firm's owners with the same return.

Assume, for instance, that the optimal licensing contract (q^*, r^*) is at the threshold $q = \hat{q}(r; \psi)$ defined for $\psi = 1$ (see Figure 3). In that case, as stated, any other contract (\tilde{q}, \tilde{r}) on the threshold frontier $q = \hat{q}(r; \psi = 1)$ is also optimal. However, not every licensing contract is optimal for the manager if she is (even slightly) myopic (i.e., for any $\psi < 1$). In this case, her licensing threshold becomes $q = \hat{q}(r; \psi < 1)$, and her indifferent map differs from the owners' indifferent map, presenting steeper indifferent curves (a straightforward consequence of Proposition 6 –see also Figure 2–). Thus, if the manager can choose among optimal licensing contracts, she will be biased towards contracts with higher fixed fees (q) and lower royalties (r). In our setting, the myopic manager's optimal licensing contract –the one that provides her with the maximum expected revenue– becomes the one with no royalties ($\tilde{r} = 0$) and the highest fixed fee (the allocation indicated by the red circle in Figure 3). This intuition allow us to present the following result, a formal statement of Hypothesis 3.

Proposition 7 *If the manager is myopic –that is, if $\psi < 1$ –, then licensing contracts established by myopic managers will be biased towards optimal contracts (q, r) with high fixed fees and low royalties, as compared to those that are not myopic –that is, with those determined if $\psi = 1$.*

[Figure 3 about here.]

4.4 Comparative Statics: Different relative R&D productivity between the firm and competitors.

We conclude our analysis by performing a comparative statics of changes in the firm vs. competitors relative R&D productivity A/η . The firm can be relatively more or less productive in creating patents than the competitors. This will have consequences for the type of licensing agreements, for any given probability of accomplishing the analysts' forecasts (ψ). The next result depicts two cases:

⁴Concretely, $\frac{d\hat{q}(r=0)}{d\psi} = \frac{1-\beta_0^{1/2}}{\alpha_0\Psi} \left[\Psi / (\alpha_0 \frac{A}{\eta}) \right]^{1/2} > 0$, and $d\hat{q}(r=0)/d\psi > 0$.

Proposition 8 Denote the threshold $\chi = [1 + \beta_0^{1/2}]^2 / [\Psi\alpha_0]$.

(i) If the relative productivity is higher than the threshold $A/\eta > \chi$, then the more productive is the firm's R&D technology, and a licensing agreement must comprise a higher fixed fee (q) and a lower royalties (r) (see Figure 4(a)).

(ii) If the relative productivity is higher than the threshold $A/\eta < \chi$, then the less productive is the firm's R&D technology, and a licensing agreement must comprise a higher fixed fee (q) and a lower royalties (r) (see Figure 4(b)).

Figure 4 illustrates Proposition 6. As the relative productivity A/η increases, the slope of the threshold condition is increasing (it is less negative),⁵ so the change in the slope is

$$\frac{d\frac{\partial\hat{q}(r)}{\partial r}}{dA/\eta} = -\frac{1}{2A/\eta} \frac{\partial\hat{q}(r)}{\partial r} > 0,$$

the change in the intercept with the r -axis is increasing ($d\hat{q}(r=0)/dA/\eta > 0$). The change in the intercept with the q -axis,

$$\frac{d\hat{q}(r=0)}{dA/\eta} = \frac{1 - \beta^{1/2}}{\alpha_0^2} [\Psi\alpha_0]^{1/2} \left[\chi^{1/2} - \left[\frac{A}{\eta} \right]^{1/2} \right],$$

depends on the value of χ . For high levels of the relative productive R&D technology, $A/\eta > \chi$, after an increase in the productivity the subsequent licensing agreements (q, r) exhibit higher royalties -i.e., $d\hat{q}(r_{q=0})/\partial(A/\eta) > 0$ - and present lower fixed fees ($d\hat{q}(r=0)/\partial(A/\eta) < 0$). Inversely, for low levels of the relative productive R&D technology, $A/\eta < \chi$, an increase in the productivity will show up as licensing agreements (q, r) exhibiting higher royalties -i.3., $d\hat{q}(r_{q=0})/\partial(A/\eta) > 0$ - and higher fixed fees ($d\hat{q}(r=0)/\partial(A/\eta) > 0$).

[Figure 4 about here.]

5 SUMMARY AND CONCLUSIONS

In this paper, we propose three hypotheses that links companies' licensing strategy with their financial situation. As a recent trend, financial analysts have influenced the way that managers run their businesses; thus, our work asserts that licensing out technology could be one of the creative activities in which managers engage. We present a simple microeconomic model to address this relationship.

Our paper highlights the following results: 1) The more linked the manager's income is with the firm's intertemporal results, the more aligned the manager's and owners' incentives will be; 2) The more likely a manager is able to meet analysts' forecasts (and, then, to keep her job), the less the firm will be involved in licensing; 3) The higher licensing, the lower is the market share of the firm; 4) As the probability that the manager will be unable to meet analysts' forecasts increases,

⁵Recall, again, that the picture of the function axis are $\hat{q}(r)$ is represented by the independent variable on the vertical axis, so the sign of the derivative is the inverse, and the slope in the picture is less steep.

full licensing becomes the most likely optimal strategy; and, 5) If the manager is myopic, she will choose licensing contracts with greater fixed fees.

This article also offers practical insights for companies. First, managers need to learn about the potential long-term consequences of licensing so that they can analyze their licensing decisions carefully, considering the net costs and benefits. Second, managerial compensation plans should encourage managers to undertake projects that maximize discounted future profits rather than short-run results. Our results suggest the careful design of managerial compensation contracts. Third, a centralized licensing structure might be helpful to seek long-term value for the firm; companies with an independent licensing department, with incentives that differ from those motivating managers, can prevent managers from simply licensing out technology to receive the benefits of inflated current earnings. Fourth, for society in general, it would be beneficial to mitigate the negative consequences of imposing earnings pressures on managers. This pressures prevent managers from focusing on long-term strategies, such that it puts firms' survival at risk and, thus, may limit the level of productivity in society as a whole.

Further research requires empirical analysis. There are a number of difficulties related to the data that preclude straightforward studies. First of all, licensing data are not publicly and easily available. Licensing agreements are confidential, and it is not compulsory for companies to report licensing revenues as a separate item in the income statement. Therefore, the license agreements available to researchers are those that companies announce publicly. Such announcements could be selective and subject to strategic consideration by the firm, and they usually do not disclose the specificities of the contract (such as the economic conditions, whether the licensed technology is core for the company, etc.). Second, even if collected information from public sources were available, it would be difficult to show the existence of the *rent profit dissipation effect*. Usually, companies that license out and publish their agreements are large and diversified, and even though we could identify the main sector in which each company operates (for instance, with the three-digit SIC code), it would be complex to identify the exact subsector in which the technology is applied. Also, to show the existence of the *rent profit dissipation effect*, one would need to get the information about the stage of the licensed technology in order to know if the *rent profit dissipation effect* might arise in the next two years or if a longer period of analysis might be required.

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APPENDICES

A.1 The manager problem: Sufficient conditions

To find whether the solution of the manager problem is interior or not, it will be useful to characterize the second-order conditions. If the Hessian matrix is negative semidefinite, the manager problem $f(i, k) = \phi[\pi_0(i, k) + \psi\pi_1(i, k)/R]$ is a concave program, so the interior solution –i.e., i^1 , k^1 – are strictly positive– will be the optimal solution.

Derivation of the first-order conditions for the manager problem (3)-(4), we find that the Hessian matrix

$$H = \begin{pmatrix} \frac{\partial^2 f}{\partial^2 i} & \frac{\partial^2 f}{\partial i \partial k} \\ \frac{\partial^2 f}{\partial i \partial k} & \frac{\partial^2 f}{\partial^2 k} \end{pmatrix},$$

with

$$\begin{aligned} \frac{\partial^2 f}{\partial^2 i} &= \frac{N''(i)}{N(i)} - 2 \frac{\alpha_0 N'(i)}{\alpha_0 N(i) + (\beta_0 + k)\eta} & (A.1) \\ \frac{\partial^2 f}{\partial i \partial k} &= \frac{\eta}{\alpha_0 N(i) + (\beta_0 + k)\eta} \left[-2 + \frac{\alpha_0 N(i) + (\beta_0 + k)\eta}{(\beta_0 + k)\eta - r\eta} (1 - r) \right] \\ \frac{\partial^2 f}{\partial k^2} &= \frac{2q\eta}{\alpha_0 N(i) + (\beta_0 + k)\eta} \end{aligned}$$

For this Hessian matrix to be negative definite, the principal minors must alternate (see Mass-Colell et al. 1995, Th.M.D.2). Yet, as Mass-Collel et al. (1995, Example M.D.1) illustrates, both $\partial^2 f / \partial^2 i$ and $\partial^2 f / \partial^2 k$ must be non-positive, which it is not the case as $\eta > 0$. Thus, the manager problem is not a concave program, so depending on the value of the parameters we might find a optimum.

A.2 The manager problem: Candidates to optimum

The first-order conditions for the manager problem becomes

$$\begin{aligned} i \left\{ -1 + \frac{\psi\pi_1}{R} \frac{\alpha_0 N'(i)}{N(i)\alpha_0 + rk\eta} [1 - m(i, k)] \right\} &= 0 \\ k[k - \alpha_0] \left\{ q + \frac{\psi\pi_1}{R} \frac{\eta}{N(i)\alpha_0 + rk\eta} [r - m(i, k)] \right\} &= 0 \end{aligned}$$

with $[1 - m(i, k)] = \frac{[(\beta_0 + k) - rk]\eta}{N(i)\alpha_0 + [\beta_0 + k]\eta}$ and $[r - m(i, k)] = \frac{N(i)\alpha_0[r - 1] + \beta_0 r \eta}{N(i)\alpha_0 + [\beta_0 + k]\eta}$.

From the first-order conditions (3)-(4), the solution of the manager problem depends on the value of the parameters. Next, we present the three possibilities: an interior solution $-i^1 > 0$ and $k^1 > 0$ –, and two corner solutions licensing all the firm’s knowledge or none.

1. Interior solution (i^1 , k^1), verifying a positive investment ($i^1 > 0$) and a particular value for licensing, $k^1 \in (0, \alpha_0)$. In this case the first-order conditions become

$$1 = \frac{\psi\pi_1}{R} \frac{\alpha_0 N'(i)}{N(i)\alpha_0 + rk\eta} [1 - m(i, k)] \quad (A.2)$$

$$q = \frac{\psi\pi_1}{R} \frac{\eta}{N(i)\alpha_0 + rk\eta} [m(i, k) - r]. \quad (A.3)$$

The former condition states that the manager increases the firm’s involvement in R&D investment until it is able to offset the increase in competitors market-demand share due to their own R&D investments. The

latter condition states that the manager will sell part of the firm's knowledge until the monetary earnings of the last patent sold (q) equals the loss in the firm's market demand share net of the royalties received. Observe that, for an interior solution to exist, condition (A.3) implies that the firm's market power at period $t = 1$ must verify $m(i^1, k^1) > r$; this entails⁶ that $r < 1$ and also the relative increase in the firm's useful knowledge with respect that of the competitors must be high enough, i.e. $N(i^1)/\eta > \beta_0 r / [\alpha_0(1-r)]$.

Next, we identify the interior candidates. Initially, operating in (A.2) –that is, by substituting π_1 and $[1 - m(i, k)]$ –, we find that

$$[N(i)\alpha_0 + (\beta_0 + k)\eta]^2 = \Psi\alpha_0 N'(i)[\beta_0 + k(1-r)]\eta, \quad (\text{A.4})$$

with $\Psi = \psi\rho D_0/R$. Then, dividing both first-order conditions, i.e. (A.2)/(A.3), we find an optimal relationship between the R&D expenditure and the licensing agreements

$$N(i) = \frac{1}{\alpha_0(1-r)} \{q\alpha_0 [\beta_0 + k(1-r)] N'(i) + \beta_0\eta r\}. \quad (\text{A.5})$$

Finally, substitution of $N(i)$ in (A.4) into (A.4) we find the optimal licensing

$$k^1 = \alpha_0\Psi\eta(1-r) \frac{N'(i^1)}{[q\alpha_0 N'(i^1) + \eta]^2} - \frac{\beta_0}{1-r} \in (0, \alpha_0),$$

and we find the optimal investment by substituting k back into (A.5)

$$N(i^1) = \frac{1}{\alpha_0(1-r)} \left[q\alpha_0^2\Psi\eta(1-r)^2 \left(\frac{N'(i^1)}{q\alpha_0 N'(i^1) + \eta} \right)^2 + \beta_0\eta r \right].$$

In the case that the R&D function is linear, $N(i) = 1 + Ai$, with $A > 0$, then the optimal decision is

$$\begin{aligned} k^1 &= \frac{\alpha_0\Psi\eta(1-r)A}{[q\alpha_0 A + \eta]^2} - \frac{\beta_0}{1-r} \in (0, \alpha_0) \\ i^1 &= q \frac{\alpha_0\Psi\eta(1-r)A}{[q\alpha_0 A + \eta]^2} + \frac{\beta_0\eta r}{\alpha_0(1-r)A} - \frac{1}{A}. \end{aligned}$$

Observe that the higher the probability the manager remains at the firm, the higher the licensing and the R&D investment, i.e. $\partial k^1/\partial\psi > 0$ and $\partial i^1/\partial\psi > 0$. The manager's welfare for this interior case is

$$U(i^1, k^1) = \phi \left[\pi_0(i^1, k^1) + \psi \frac{1}{R} \pi_1(i^1, k^1) \right] = \phi \left[\frac{\alpha_0}{\alpha_0 + \beta_0} D_0 - i^1 + qk^1 + \Psi \frac{\alpha_0 N(i^1) + rk^1\eta}{\alpha_0 N(i^1) + [\beta_0 + k^1]\eta} \right].$$

2. No-licensing corner solution ($i^2, k^2 = 0$), verifying a positive investment ($i^2 > 0$) and no licensing, $k^1 = 0$. In this case the first-order conditions become (A.2) and $k^2 = 0$. Then, we find the optimal investment is the positive roots of (A.4) for $k = 0$, that is

$$N(i^2) = \frac{1}{\alpha_0} \left\{ -\beta_0\eta + [\Psi N'(i^2)\beta_0\eta\alpha_0]^{1/2} \right\}.$$

In the case that the R&D function is linear, $N(i) = 1 + Ai$, with $A > 0$, then the optimal decision is $k^2 = 0$ and

$$i^2 = \frac{1}{A\alpha_0} \left\{ -\beta_0\eta + [\Psi A\eta\alpha_0\beta_0]^{1/2} \right\} - \frac{1}{A}.$$

⁶Recall that with $[r - m(i, k)] = \frac{N(i)\alpha_0[r-1] + \beta_0\eta r}{N(i)\alpha_0 + [\beta_0 + k]\eta}$.

Observe that the higher the probability the manager remains at the firm, the higher the licensing and the R&D investment, i.e. $\partial k^2/\partial\psi > 0$ and $\partial i^2/\partial\psi > 0$. The manager's welfare for this interior case is

$$U(i^2, 0) = \phi \left[\frac{\alpha_0}{\alpha_0 + \beta_0} D_0 - i^2 + \Psi \frac{\alpha_0 N(i^2)}{\alpha_0 N(i^2) + \beta_0 \eta} \right],$$

which coincides with $\lim_{k \rightarrow 0} U(i^1(k), k)$.

3. All-licensing corner solution ($i^3, k^3 = \alpha_0$), verifying a positive investment ($i^3 > 0$) and no licensing, $k^3 = \alpha_0$. In this case the first-order conditions become (A.2) and $k^3 = \alpha_0$. Then, we find the optimal investment is the positive roots of (A.4) for $k = \alpha_0$, that is

$$N(i^3) = \frac{1}{\alpha_0} \left\{ \left[\Psi N'(i^3) \eta \alpha_0 (1 - r \alpha_0) \right]^{1/2} - \eta \right\}.$$

In the case that the R&D function is linear, $N(i) = 1 + Ai$, with $A > 0$, then the optimal decision is $k^3 = \alpha_0$ and

$$i^3 = \frac{1}{A \alpha_0} \left\{ \left[\Psi N'(i^3) \eta \alpha_0 (1 - r \alpha_0) \right]^{1/2} - \eta \right\} - \frac{1}{A}.$$

Observe that the higher the probability the manager remains at the firm, the higher the licensing and the R&D investment, i.e. $\partial k^3/\partial\psi > 0$ and $\partial i^3/\partial\psi > 0$. The manager's welfare for this interior case is

$$U(i^3, \alpha_0) = \phi \left[\frac{\alpha_0}{\alpha_0 + \beta_0} D_0 - i^3 + q \alpha_0 + \Psi \frac{\alpha_0 N(i^3) + r \alpha_0 \eta}{\alpha_0 N(i^3) + [\beta_0 + \alpha_0] \eta} \right],$$

which coincides with $\lim_{k \rightarrow \alpha_0} U(i^1(k), k)$.

4. No investment decision ($i^4 = 0, k^4$). Here we can find three candidates: no investment and no licensing $i^4 = k^4 = 0$, no investment and full licensing, $i^4 = 0$ and $k^4 = \alpha_0$; and no investment and an interior licensing $i^4 = 0$ and $k^4 \in (0, \alpha_0)$.

We begin with the latter. If there is no investment ($i^4 = 0$), we can find the optimal licensing in the first-order condition become (A.3) for $i = 0$. However, in this case there is real root for $i = 0$. So there is no such a candidate.

Also, for any given licensing level k , the function $f(i, \bar{k})$ is concave in the first argument i provided (A.1) is negative. This means that, for a given level of licensing \bar{k} , the no-investment is a strategy worse than implementing a positive investment. Indeed, this is the case for the linear R&D technology, since $N''(i) = 0$. Thus, we strategies ($i^4 = 0, k^4 = 0$), and ($i^4 = 0, k^4 = \alpha_0$) will be never optimal.

A.3 Proof of Proposition 1

Since the manager problem is not a concave program, the optimal solution will display the highest welfare for a given set of parameters. To study the optimal licensing, we must study the welfare regions for any value in the set of parameters. Yet, to provide useful intuitions, we will find useful to characterize the optimal solution for different regions of the fixed fee-royalty space, i.e. at the q - r -space.

We initially present intuitions by addressing the welfare regions at the q - r -space of parameters; then, we prove Proposition 1. Observe that given any value of the fixed fee (q) and royalty (r) parameters, the welfare at the no licensing strategy $U(i^2, 0)$ is constant. Recall also that, for any fixed level of royalties \bar{r} , the welfare of the interior strategy converges to the corner strategies, i.e. $\lim_{k \rightarrow 0} U(i^1(k), k; \bar{r}) = U(i^2, 0)$

and $\lim_{k \rightarrow \alpha_0} U(i^1(k), k; \bar{r}) = U(i^3, \alpha_0)$. Thus, fixed fixed level of royalties \bar{r} , we can draw the welfare values for different values of the fixed fee parameter q (see Figure 5). The picture shows that, for a given fixed level of royalties \bar{r} , there exists a threshold in the royalties \hat{q} that separates two optimal licensing strategies for the manager: full licensing ($k^* = \alpha_0$) and no licensing ($k^* = 0$).⁷

[Figure 5 about here.]

Proof of Proposition 1. Next, we present the proof by showing these intuitions algebraically. We initially compare the welfare regions for different licensing strategies, and find a threshold condition of the parameters in the q - r -space where the manager is indifferent between licensing strategies. Then, we show that for any value of the parameters, full licensing and no licensing can be the only optimal strategies.

First, we show the conditions that full licensing (**case 3.**) is a Pareto dominant strategy with respects to no licensing (**case 2.**):

$$\begin{aligned} U(i^3, \alpha_0) &\geq U(i^2, 0) \\ -i^3 + q\alpha_0 + \Psi \frac{\alpha_0 N(i^3) + r\alpha_0 \eta}{\alpha_0 N(i^3) + [\beta_0 + \alpha_0]\eta} &\geq -i^2 + \Psi \frac{\alpha_0 N(i^2)}{\alpha_0 N(i^2) + \beta_0 \eta}, \end{aligned}$$

with $\frac{\alpha_0 N(i^3) + r\alpha_0 \eta}{\alpha_0 N(i^3) + [\beta_0 + \alpha_0]\eta} = 1 - \frac{[\Psi A \eta \alpha_0 (1 - r \alpha_0)]^{1/2}}{\Psi A \alpha_0}$ and $\frac{\alpha_0 N(i^2)}{\alpha_0 N(i^2) + \beta_0 \eta} = 1 - \frac{[\Psi A \eta \alpha_0 \beta_0]^{1/2}}{\Psi A \alpha_0}$. Full licensing provides a higher welfare to the manager with respects to the welfare if no licensing provided the parameters verify

$$q \geq \frac{2}{A\alpha_0^2} [\Psi A \eta \alpha_0]^{1/2} \left[(1 - r\alpha_0)^{1/2} - \beta_0^{1/2} \right] - \frac{\eta}{A\alpha_0^2} (1 - \beta_0). \quad (\text{A.6})$$

If the inequality is opposite, then no licensing would be a Pareto dominant strategy with respects to full licensing. Thus, from condition (A.6), there exists a threshold set of values for the fixed fee and royalty parameters, $q = \hat{q}(r)$, such the manager is indifferent between full licensing and no licensing.

Second, we show the conditions that no licensing (**case 2.**) is a Pareto dominant strategy with respects to the interior solution (**case 1.**):

$$\begin{aligned} U(i^1, k^1) &\leq U(i^2, 0) \\ -i^1 + qk^1 + \Psi \frac{\alpha_0 N(i^1) + rk^1 \eta}{\alpha_0 N(i^1) + [\beta_0 + k^1]\eta} &\leq -i^2 + \Psi \frac{\alpha_0 N(i^2)}{\alpha_0 N(i^2) + \beta_0 \eta}, \end{aligned}$$

with $\frac{\alpha_0 N(i^1) + rk^1 \eta}{\alpha_0 N(i^1) + [\beta_0 + k^1]\eta} = 1 - \frac{\eta(1-r)}{q\alpha_0 A + \eta}$ and $-i^1 + qk^1 = -\frac{\beta_0}{1-r} \left[q + \frac{\eta r}{\alpha_0 A} \right] + \frac{1}{A}$. No licensing is a Pareto dominant strategy with respects to the interior solution provided the parameters verify $k^1 \geq 0$, that is

$$q \leq \frac{1}{A\alpha_0} \left[\left(\frac{\Psi A \eta \alpha_0 (1-r)}{\beta_0 / \alpha_0} \right)^{1/2} - \eta \right]. \quad (\text{A.7})$$

That is, since $\lim_{k \rightarrow 0} U(i^1(k), k) = U(i^2, 0)$, the set of parameters such that $k^1 \in (0, \alpha_0)$ results in no licensing as the strategy that provides the higher welfare to the manager. We find, from condition (A.7), a threshold combination of values for the fixed fee and royalty parameters, $q = q_{k=\alpha_0}(r)$, such the manager is indifferent between an interior licensing and no licensing.

⁷The reason of this result might stem from the assumed linearity of the R&D technology. Observe from Figure 5 that if the welfare function $U(i^1(k), k; \bar{r})$ could be enough concave, then there would exist a region of parameter such that an interior licensing strategy is optimal.

Finally, we show the conditions that the interior solution (**case 1.**) is a Pareto dominant strategy with respects to full licensing (**case 3.**):

$$\begin{aligned} U(i^1, k^1) &\leq U(i^3, \alpha_0) \\ -i^1 + qk^1 + \Psi \frac{\alpha_0 N(i^1) + rk^1 \eta}{\alpha_0 N(i^1) + [\beta_0 + k^1] \eta} &\leq -i^1 + qk^1 + \Psi \frac{\alpha_0 N(i^1) + rk^1 \eta}{\alpha_0 N(i^1) + [\beta_0 + k^1] \eta}. \end{aligned}$$

Full licensing is a Pareto dominant strategy with respects to the interior solution provided the parameters verify $k^1 \leq \alpha_0$, that is

$$q \leq \frac{1}{A\alpha_0} \left[\left(\frac{\Psi A \eta \alpha_0 (1-r)}{\alpha_0 + \frac{\beta_0}{\alpha_0}} \right)^{1/2} - \eta \right]. \quad (\text{A.8})$$

That is, since $\lim_{k \rightarrow \alpha_0} U(i^1(k), k) = U(i^3, \alpha_0)$, the set of parameters such that $k^1 \in (0, \alpha_0)$ results in full licensing as the strategy that provides the higher welfare to the manager. We find, from condition (A.8), a threshold combination of values for the fixed fee and royalty parameters, $q = q_{k=\alpha_0}(r)$, such the manager is indifferent between an interior licensing and full licensing.

[Figure 6 about here.]

In Figure 5 we show the pattern of the welfare functions for different values of the fixed fee q . This analysis means that there can only be two optimal solutions for the manager: full licensing ($k^1 = \alpha$) provided (A.6), and no licensing ($k^1 = \alpha$) provided this condition is verified with opposite sign. Thus, we can find the optimal licensing strategy in Figure 6. This completes the proof of Proposition 1. ■

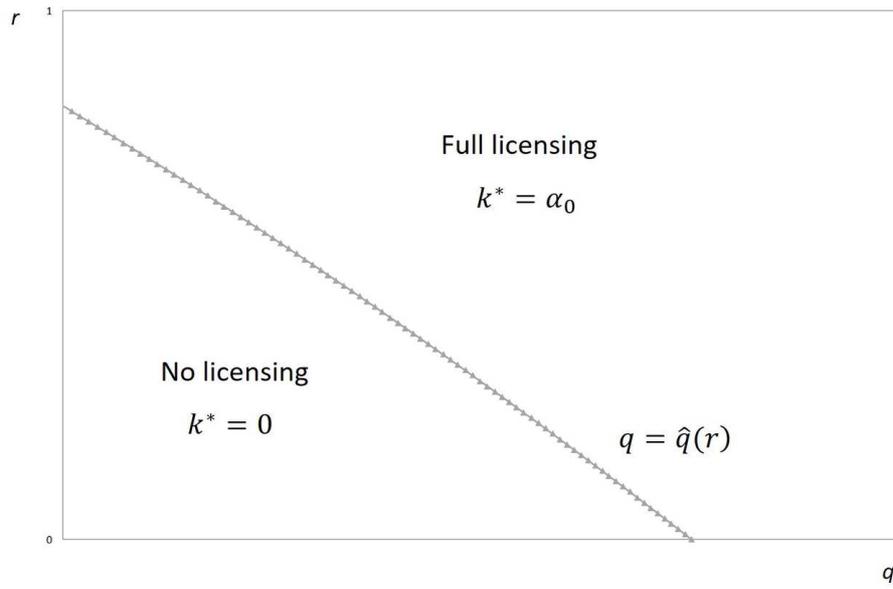


Figure 1: **Optimal licensing strategy at the parameter values in the q - r -space.** Parameter values: $\psi = 0.5$, $\rho = 1.5$, $D_0 = 100$, $R = 1.5$, $\alpha_0 = 0.5$, $\eta = 1.5$, $A = 0.5$.

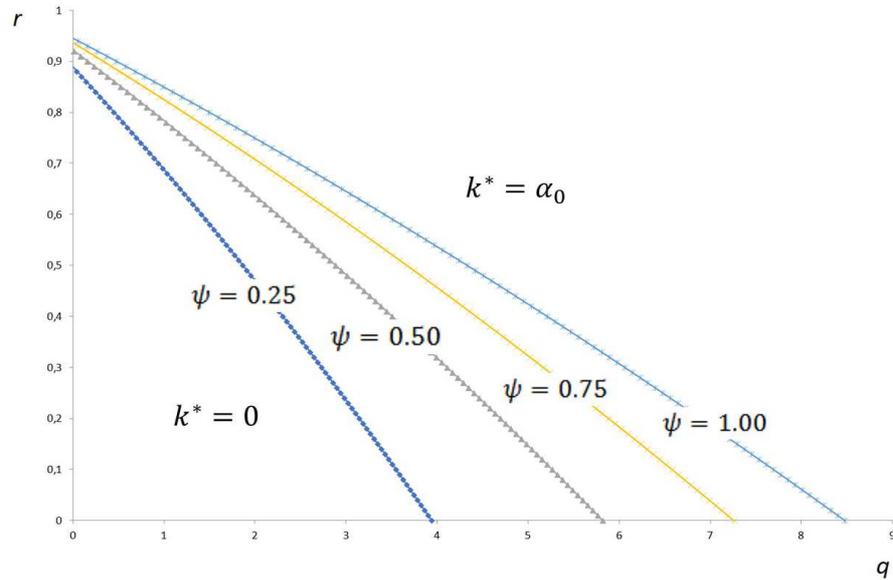


Figure 2: **Licensing agreement strategy for different probability of accomplish analysts' forecast ψ .** Parameter values: $\psi = 0.5$, $\rho = 1.5$, $D_0 = 100$, $R = 1.5$, $\alpha_0 = 0.5$, $\eta = 1.5$, $A = 0.5$.

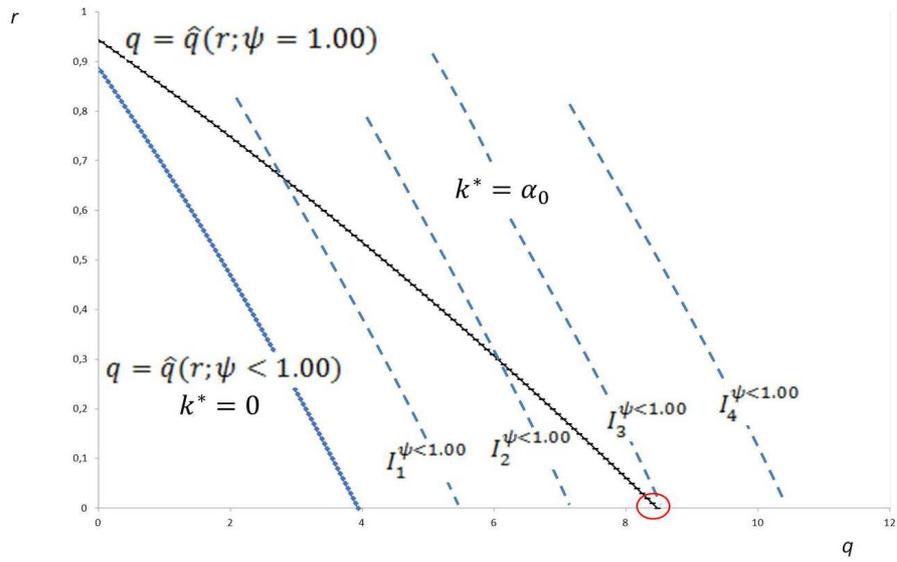
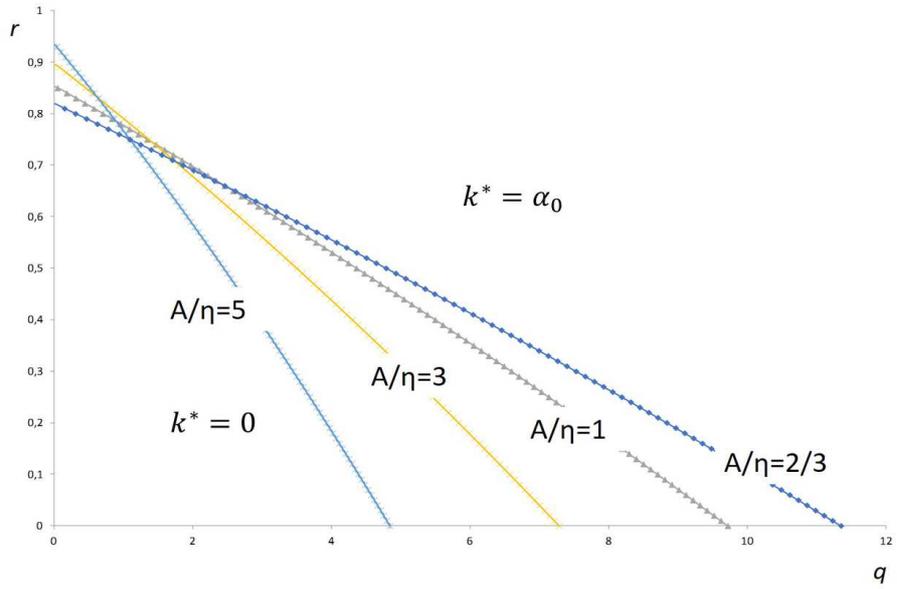
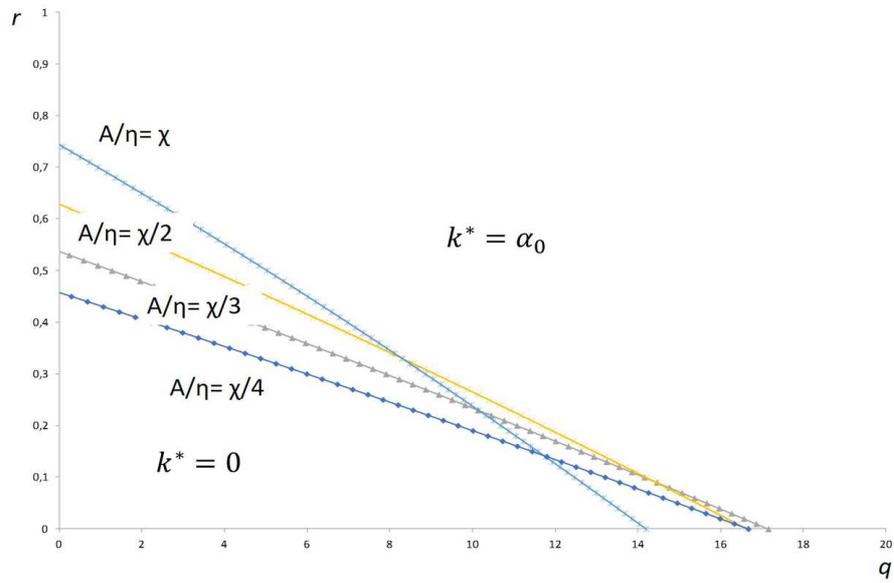


Figure 3: **The owners' optimal licensing contract** (assumed to be those contracts (\tilde{q}, \tilde{r}) at the threshold $q = \hat{q}(r; \psi = 1)$) and the **myopic manager' optimal licensing contract**. The latter is identified with the contract $(\tilde{q}, 0)$ circled in red. The dash lines $I_n^{\psi < 1}$, together with the threshold $q = \hat{q}(r; \psi < 1)$ comprises the myopic manager indifferent map.



(a) Case of relatively high R&D productivity, $A/\eta > \chi$



(b) Case of relatively high R&D productivity, $A/\eta > \chi$.

Figure 4: **Licensing agreement strategy for different relative R&D productivity A/η .** Parameter values: $\psi = 0.5$, $\rho = 1.5$, $D_0 = 100$, $R = 1.5$, $\alpha_0 = 0.5$. Thus, $\chi = 2/3$.

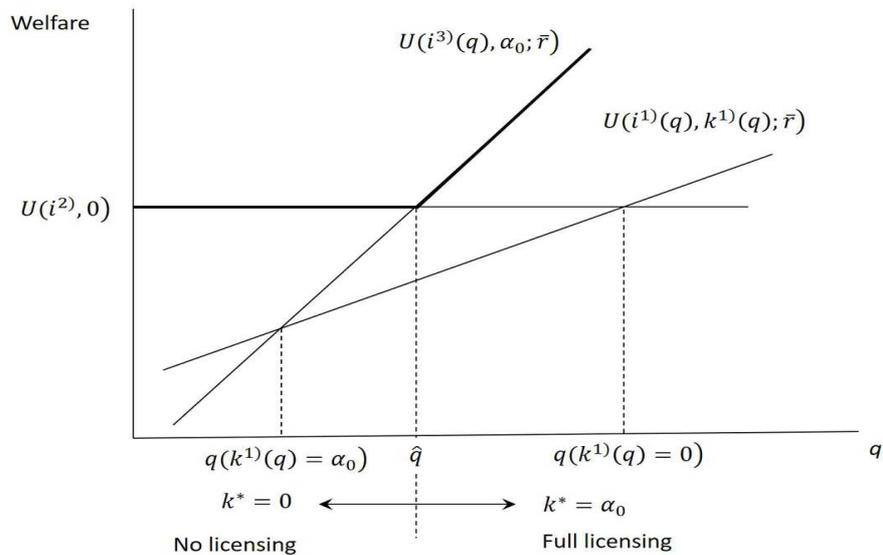


Figure 5: Welfare patterns for different values of the fixed fee q at the linear R&D technology for any given level of royalties r .

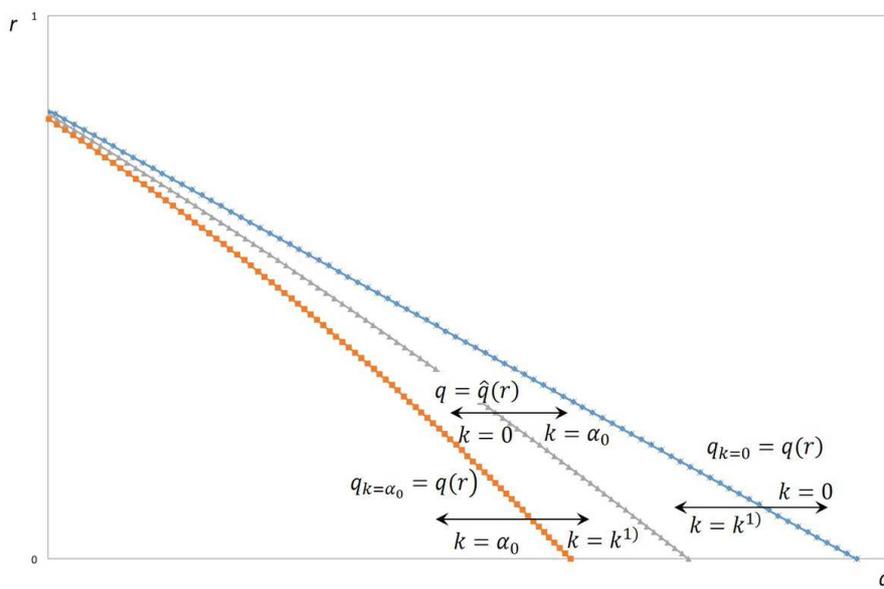


Figure 6: Welfare regions.