Basic research utilization and the R&D employment contract

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Abstract

Basic research results reduce a firm's R&D costs or interact with the R&D output in the market. Utilization of basic research carries its uncertainty over to the firm's revenue. We analyse the contract between the firm's owner and R&D manager. For a given R&D project, strong basic research influence to the firm's expected revenue implies low-powered incentives. When the owner can choose the R&D project, it is more aligned with basic research than when the manager chooses it and the incentive is lower powered. Contrary to the standard result, the power of the incentive is increasing in the uncertainty of basic research and in the manager's risk aversion.

**JEL Classification**: D23, L11, L15

**Keywords**: basic research, R&D, contract, moral hazard

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1 Introduction

Firms’ R&D projects are affected by the results of basic research. A firm utilizes the results to reduce R&D project costs or the results may interact with the firm’s R&D output in the market, either complementing or substituting it. A prominent example of the latter is the burgeoning Open Source movement that has properties of basic research. We raise the question, how does the existence of a basic research project affect firm behaviour and the R&D manager’s incentives to exert unobservable effort?

We present a model where the directions and objectives of basic research projects are known by firms. A firm’s R&D project may either be fixed or the owner or manager can choose its direction in relation to a relevant basic research project. Firms do take into account basic research projects in their R&D decisions. For example, Ward and Dranove (1995) provided evidence that firms in the pharmaceutical industry increase their R&D in those therapeutic categories that exhibit investments in basic research. For our purposes, the phenomenon we call a basic research project has to have the following properties that are widely accepted in the literature\(^1\). First, its properties and eventual output are public and freely usable. Thus the output carries a zero price. Second, the applicability of a basic research project’s output in the firm’s R&D, even if the firm knows the general outline of the research project, is uncertain. Third, the scientists have no strategic considerations when they create a basic research project. Open Source programming is an interesting example of activity reminiscent of basic research in that it fulfils the above requirements\(^2\). Basic research is usually considered to substitute firms’ R&D effort and accordingly reduce costs. However, Steinmueller (1994, p.59) pointed out that basic research may affect R&D by “reducing the expected returns from some lines of applied research…or increasing the real returns in other areas”. Open Source programs enhance or compete with firms’ programs in the market. A pharmaceutical basic research project tries to create a molecule that a


\(^2\) For descriptions of Open Source see Lerner and Tirole (2002), Schiff (2002), Heintzman (2003), Mustonen (2003, 2005) and The GNU project (2004a,b).
firm’s R&D also seeks. If the basic research project succeeds, its free output substitutes the firm’s product in the (licensing) market and thus it is possible that the existence of basic research reduces a firm’s expected revenue. Our analysis allows for both positive and negative revenue effects.

We analyze the employment contract of the R&D manager of a firm. The effort of the risk-averse manager is unobservable to the owner, who can only observe the market revenue. In our analysis, we extend the contracting model of Holmström and Milgrom (1987) and Holmström (1979). It features uncertain revenue, a linear incentive, unobservable continuous agent effort and convex costs. The presence of basic research influences the contract design in two ways. First, basic research results reduce the firm’s R&D costs or they complement or substitute the firm’s R&D in the market and this has a direct effect to the observable revenue of the firm. Second, basic research projects are inherently uncertain and a stronger influence of basic research also increases the volatility of the firm’s revenue. As a first step, we analyse the employment contract assuming that the position of the basic research project relative to the firm’s R&D project is given. It is also natural to analyse the contract in the case where the owner can choose the position of the R&D project in relation to basic research. As a third case, we analyse the contract assuming that the firm’s key R&D decisions are under the discretion of the manager. After accepting the contract, he chooses both effort and the relative position of the R&D project. Both choices are unobservable.

If the relative positions of basic research and R&D projects are given, the effect of basic research presence is quite natural. The stronger the expected revenue impact of the basic research, positive or negative, the more volatile is the revenue. The owner offers a lower-powered incentive because of this volatility and thus the optimal incentive coefficient is decreasing in the revenue impact. In accordance with the traditional result, now the incentive decreases also in the variance of the output of basic research and in risk aversion. Comparison of the cases where the owner or the manager endogenously chooses the relative position of the R&D project shows that the owner always chooses a closer proximity between the projects and the incentive is

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3 For a survey of incentives in organizations, see Gibbons (1998). Parallel to our research, Dasgupta and David (1994) and Lazear (1997) researched incentives to perform basic research.
lower-powered. In stark contrast to received literature, in both cases the optimal incentive coefficient is increasing in the basic research output uncertainty and in the manager’s risk aversion. Traditionally it has been considered that the utilization of basic research in firm R&D is hampered by friction in knowledge transfer. The ability to absorb research knowledge has been presented as the motivation for costly basic research in firms (e.g. Rosenberg 1990). Our analysis reveals another cost factor in basic research utilization: If the firm cannot align its R&D with basic research, the higher is the uncertainty over the basic research project’s outcome the lower is the R&D effort. With optimally aligned R&D, increased uncertainty of basic research surprisingly leads to higher R&D effort. So if owners or managers are able to adjust, high risk in basic research creates a positive externality to firm R&D and this could be taken into account if the government can influence the risk levels of basic research.

The analysis further shows that firm profits are higher when the owner determines the R&D strategy. This indicates that in research intensive industries, we should observe firm owners with scientific knowledge having an advantage to institutional owners. In all scenarios, the closeness between basic research and R&D projects and the R&D manager’s effort are inversely related, implying that basic research crowds out R&D due to moral hazard in R&D.

Baggs and Bettignies (2004) found within a duopoly model of horizontal differentiation that increased competition directly brings about stronger incentives. Raith (2003) reached the same conclusion, albeit indirectly, in an oligopoly model. Our result is reversed in the case where basic research substitutes the firm’s R&D in the market – a natural outcome in Open Source programming. The stronger substitute is the basic research outcome, – and thus the more ‘competitive’ the situation of the firm – the weaker is the optimal incentive. In the case of complement or cost-reducing basic research, stronger complementarity, which can be interpreted as reduced ‘competition’, brings about a weaker incentive. In the literature, the selection of riskiness has been recognized. Meth (1996) analysed a scenario where the agent can expend productive effort and effort to reduce outcome variance, both unobservable. Meth reported conditions under which the principal wants to motivate the agent to

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4 In Baggs and Bettignies (2004), a lower transport cost reduces the principals’ marginal cost of inducing effort. In equilibrium, they choose higher incentives.

5 In Raith (2003), competition induces firm exit, which in turn creates higher cost-reduction incentives for remaining firms.
work on reducing the variance. In Demski and Dye (1999), the manager can make mean-variance trade-offs in project selection. They presented and analyzed a special contract, linear in outcome sample mean and variance and including penalty terms from deviations between the announced mean and variance and their realized samples. Ghatak and Pandey (2000) analysed agricultural contracting and found that under limited liability, sharecropping is generated only when the tenant simultaneously and independently chooses effort and risk. In contrast to this literature, in our paper, we assume that the change in outcome variance is an externality of a decision involving the firm’s R&D project position and thus costless.

Our results provide an explanation to empirical findings that are contrary to the results of the Holmström-Milgrom model. In a survey of over twenty empirical studies, Prendergast (1999, 2002) reported that a majority of them found a neutral or positive relationship between measures of risk and pay-performance sensitivity. Prendergast (2000) offered reasons why the standard theory would not hold. In uncertain environments, i) input monitoring, ii) sorting, iii) investigations and iv) career concerns are less effective. Adding such assumptions to the standard model yields results where the incentive is increasing in risk. Raith (2003) in turn showed in a model of oligopoly with free entry how an increase in competition, for example in the substitutability of goods, increases both the incentive to cost reduction and output risk, resulting in a positive correlation between the two. In our model, the result follows causally from the manager’s or the owner’s optimal choice of the R&D project position while the market structure remains given.

The analysis proceeds as follows: in section 2 we develop first the optimal incentive for given basic research and R&D project directions. Then we solve for the optimal incentive and optimal R&D project direction when either the owner or the manager can choose the direction. In section 3 we analyse and compare the outcomes and section 4 concludes.

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6 In Raith (2003), an increase in substitutability causes firms to exit and the incentive for cost reduction is higher for the remaining firms. Simultaneously, the constant variance of cost reduction of each firm translates to higher output variation as the number of firms decreases.
2 The model

Consider a moral hazard scenario (Holmström and Milgrom 1987) with a continuous choice of the manager’s effort and a wage contract that is linear in revenue. The risk-neutral owner maximises his expected profit, which is the net of market revenue and wages paid, \( \max \pi = \mathbb{E} w \). The manager’s unobservable effort is \( e \). We assume that the manager’s effort is manifested as the value of the R&D project. A basic research project exists. It’s output is uncertain, \( y \sim N(1, v) \). Consider first that basic research results affect the costs of the R&D project. The direction of the R&D project relative to the basic research project, \( k \), \( 0 \leq k < k_{\text{max}} \), determines the cost of the R&D project, \( \alpha - ky \), where \( \alpha > 0 \) is the fixed cost. The firm’s revenue is \( e - (\alpha - ky) \). The basic research project output may alternatively affect the expected value of the R&D project in the market. A visible example of such is Open Source programming. If the basic research output is a substitute to the R&D project (as an OS program may well be to a commercial program), manifested by \( k < 0 \), the revenue impact of basic research can also be negative. Consider homogeneous buyers of mass 1 with utility functions \( U = V - p \), where \( V \) is the value of the R&D outcome and \( p \) the price. When basic research complements a monopoly firm’s R&D, its value is \( V = e + ky \). The optimal price is thus \( p = e + ky \). If basic research is a substitute, \( k < 0 \), there are two goods for buyers to choose from with values \( V = e \) and \( V_{br} = -ky \). The firm has to set the price in such a way that buyers prefer the commercial good i.e. \( V - p \geq V_{br} - 0 \). The optimal price is \( p = e + ky \), and the ex-ante revenue is \( e + ky \). Without loss of generality we can set \( \alpha = 0 \) and cover both cases with the expected revenue being \( e + ky \):

\[
\mathbb{E} = e + ky
\]

\( \text{(1)} \)

\[7\] We acknowledge the possibility of a negative draw of the OS effort, but abstract from it (as Holmström and Milgrom).
The total revenue is observable. The risk-averse \((r > 0)\) manager’s utility is 
\[ U = -e^{-r(u-c(e))} \], where the cost of effort is 
\[ c(e) = \frac{ce^2}{2}, \quad c > 0. \] In the basic analysis, we abstract from the (general) market uncertainty. Later on, in section 3, we discuss its effect to the results.

**2.1 Baseline case: A fixed R&D project**

Let us first assume that the relative position of the R&D project, \(k\), is given. The owner offers a contract to the manager, who accepts. The manager exerts effort \(e\). The outcome of the basic research project, \(y\), is resolved. These factors determine the firm’s revenue. Finally, wages \(w\) are paid. Consider the incentive pay contract \(w = a + bR\). The manager’s incentive compatibility constraint follows from expected utility maximization, \[ \max_e EU = a + b(e + k) - \frac{1}{2} rb^2 k^2 v - \frac{1}{2} ce^2, \] which yields the familiar IC-condition

\[ e = \frac{b}{c} \]  

**(IC1)**

The owner maximizes expected profit, \(\max_b E\pi = (1 - b)[e + k] - a\) conditional on the incentive compatibility condition (IC1) and the individual rationality condition

\[ U \geq \bar{u}. \]  

**(IR1)**

Inserting the constraints (IC1) and (IR1) yields:

\[ \max_b E\pi = (1 - b)\left[ \frac{b}{c} + k \right] + b\left( \frac{b}{c} + k \right) - \frac{1}{2} rb^2 k^2 v - \frac{b^2}{2c} - \bar{u} \]
The first order condition is \( \frac{1}{c} - rvk^2b - \frac{b}{c} = 0 \). Note for reference that the manager’s risk premium is increasing in risk-aversion and variance. The FOC yields the optimal coefficient of the incentive in the contract,

\[
b^* = \frac{1}{1 + rvck^2}.
\]

**Proposition 1:** The closer the given basic research and R&D projects are to each other, or the stronger complement or substitute the basic research project is to the R&D project in the market, the lower-powered is the optimal incentive.

**Proof:** In (2), the larger is the absolute value of \( k \), the smaller is the optimal incentive. **QED.**

A high absolute value of \( k \) implies that the variance of the observable revenue is large. This in turn increases the risk premium of the manager. The owner takes this into account and in optimum sets a low incentive. In the case of market interaction of substitute basic research and R&D, the requirement of non-zero profits presents a lower bound to the substitutability between them. Being a substitute to the firm’s R&D, the presence of basic research output reduces the firm’s profit. Furthermore, it reduces the firm’s R&D because the manager’s effort is reduced, since by (IC1), the manager’s optimal effort and thus the R&D are proportional to the incentive coefficient.

### 2.2 The owner chooses the R&D project

Suppose the owner can set the relative position of the projects \( k_o \) by design decisions or by selecting an optimal project from the firm’s portfolio of R&D projects. We assume that the portfolio contains projects that differ in their closeness to the basic research project but that the productivity of the manager is equal in all of them. The cost of the owner’s (and later the manager’s) effort in selecting and implementing the position is fixed by assumption and we set it to zero. The owner offers a contract to
the manager. The manager accepts and exerts effort \( e_o \) in R&D taking the R&D project position as given. Again, after the uncertainty is resolved, wages are paid. The owner will position the projects in a way that will maximise his profit anticipating the behaviour of the manager. The choice of position has a direct effect to the owner’s profit via a revenue or cost change and an indirect effect because it changes the optimal incentive coefficient and thus the agent’s effort. As in the baseline case, the manager’s optimal effort conditional on the revenue share is \( e_o = \frac{b_o}{c} \) from (IC1). The owner chooses the optimal incentive and project direction taking the manager’s choice and individual rationality (IR1) into account

\[
\max_{b_o, k_o} E\pi_o = (1-b_o) \left[ \frac{b_o}{c} + k_o \right] + b_o \left( \frac{b_o}{c} + k_o \right) - \frac{1}{2} rb_o^2 k_o^2 v - \frac{b_o^2}{2c} - \Pi
\]

The first-order conditions read

\[
\frac{\partial \pi_o}{\partial b_o} = \frac{1}{c} - r vk_o^2 b_o - \frac{b_o}{c} = 0, \quad (3a)
\]

\[
\frac{\partial \pi_o}{\partial k_o} = 1 - r v b_o^2 k_o = 0. \quad (3b)
\]

Condition (3a) is equivalent to the first order condition in the baseline case and (3b) yields the owner’s choice of the project position for a given incentive, \( k_o = \frac{1}{r v b_o} \). In (3b), the owner equals the marginal revenue from proximity to basic research to its marginal cost in the form of the manager’s risk premium. Being closer to basic research increases the firm’s revenue and thus wages. But it also increases uncertainty related to output, for which the manager must be compensated through the individual rationality condition (IR1). Thus a bounded optimum is found. We observe that it is the owner’s voluntary choice that introduces uncertainty to the problem.

\[\text{8 We note that the second order conditions are satisfied. We assume that } k_{\max} \text{ is sufficiently small to ensure that the owner’s profit is higher in an interior solution than for } b = e \text{ and a very strong OS complement.}\]
Solving for the optimal incentive yields
\[ \frac{1}{c} - \frac{1}{rvb_o^3} - \frac{b_o}{c} = 0 , \]
which develops to
\[ b_o^4 - b_o^3 + \frac{c}{rv} = 0 . \]  
(4)

The optimal incentive coefficient \( b_o^* \) balances the marginal revenue from the firm’s R&D to the marginal cost from the risk premium and from effort. Given the owner’s choice of \( k_o \), the risk premium is decreasing in \( b_o \).

### 2.3 The manager chooses the R&D project

Consider an (institutional) owner who cannot choose an R&D project. The choice of the relative position between the R&D project and basic research, \( k_M \), is left to the manager. Having accepted the contract, the manager exerts effort \( e_M \) and chooses the position, \( k_M \). The manager’s problem is reminiscent of the multitask problem. He chooses optimal effort by trading off wage against disutility of effort. The manager also chooses the optimal position by trading off wage against the risk premium. The manager’s problem is

\[
\max_{e_M, k_M} EU = a + b_M (e + k_M) - \frac{1}{2} rb_M k_M^2 v - \frac{1}{2} ce^2
\]

yielding the familiar IC-condition, \( e_M = \frac{b_M}{c} \). The first order condition for the optimal \( k_M \) is

\[
\frac{\partial EU}{\partial k_M} = b_M - k_M rvb_M^2 = 0 ,
\]  
(5)

---

\(^9\) The second order condition is satisfied for \( b_o > \frac{4}{\sqrt{rv}} \).
which yields the IC-condition concerning the project position,

\[ k_M = \frac{1}{r v b_M} \text{ for } b_M > 0^{10} . \]  

(IC 2)

In (5), the manager equals the marginal wage from proximity to basic research to the marginal cost of the risk premium.

**Lemma 1:** For a given incentive coefficient, the owner chooses closer proximity between R&D and basic research than does the manager, \( k_O > k_M \).

The owner wants the projects to be closer because the marginal revenue from basic research is 1 but for the manager it is dulled by the revenue share \( b_M < 1 \). In their decisions, both face the same marginal cost from the risk premium, which is increasing in \( k \). Comparison of the first order conditions (3b) and (5) shows this. From the owner’s point of view, information has value since the manager’s unobservable choice of project direction \( k_M \) differs from his profit-maximising choice. The owner anticipates the manager’s choices and sets the incentive pay to maximise profit. Inserting the conditions IC1 and IC2 and IR1 to the firm’s profit function yields

\[
\max_{b_M} E \pi_M = \left(1 - b_M \right) \left[ b_M + \frac{1}{r b_M v} \right] + b_M \left( \frac{b_M}{c} + \frac{1}{r b_M v} \right) - \frac{1}{2} r \left( \frac{1}{r b_M v} \right)^2 b_M^2 v - b_M^2 - \bar{u}
\]

The first order condition for maximum reads:

\[
\frac{d \pi_M}{d b_M} = \frac{1}{c} - \frac{1}{r v b_M^2} - \frac{b_M}{c} = 0^{11} .
\]

\[ (6) \]

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\(^{10}\) We note that the second order conditions are satisfied trivially.

\(^{11}\) The second order condition is satisfied for \( b_M > \sqrt{\frac{2c}{r v}} \).
Comparing (6) to the first order condition of the baseline case (1) shows that the manager’s decision rule (IC2) for the project direction $k_M$ renders the risk premium independent of the incentive in the owner’s optimization. The marginal revenue from basic research (second term in (6)), is in turn increasing in the incentive coefficient, risk-aversion and variance. The optimal incentive $b_M^*$ balances marginal revenue from R&D and basic research against the manager’s marginal cost of effort. The condition (6) develops to

$$b_M^3 - b_M^2 + \frac{c}{rv} = 0. \quad (7)$$

### 3 Analysis and comparison of regimes

We start with

**Proposition 2:** If the owner can position the R&D project, he chooses a closer proximity to basic research than the manager and the optimal incentive of the manager is lower-powered.

**Proof:** Under the owner’s rule, the optimal incentive from (4) is $b_o^3 - b_o^4 = \frac{c}{rv}$. Rearranging equation (7) for the optimal incentive under the manager’s rule yields $b_M^2 - b_M^3 = \frac{c}{rv}$. We note that the first and second order conditions are satisfied simultaneously for $b_M > \frac{2}{3}$ and $b_o > \frac{3}{4}$. Graphical illustration in figure 1 shows that when the owner can choose the project direction, the optimal incentive turns out to be
lower than when the manager chooses the project, $b_o^* < b_M^*$. (See figure 1). From Lemma 1 we can infer that since also $(b_o^*)^2 < b_M^*$, this implies $k_o^* > k_M^*$. QED.

![Figure 1. Optimal incentive under manager’s and owner’s rule](image)

Our earlier result in Lemma 1 was that for a given incentive coefficient, the owner chooses closer proximity to basic research than the manager. The fact that the owner chooses always a lower incentive coefficient further increases the difference. Under the owner’s rule, the manager’s R&D effort is low and the firm utilizes much basic research.

If the manager makes the (unobservable) choice of the project position $k_M^*$, the decision rule is not optimal from the owner’s point of view. In the margin, the

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12 From the graph we can also note that the incentive problem has an interior solution under manager’s rule when $\frac{c}{rv} < \text{sup} (b^2 - b^4)$ translating to $0 < \frac{c}{rv} < 0.148$ and under owner’s rule when $\frac{c}{rv} < \text{sup} (b^3 - b^4)$, in turn yielding $0 < \frac{c}{rv} < 0.105$. 

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manager receives only the portion $b_m^*$ of increased revenue (5) whereas the owner receives all of it (3b). Yet both have to take into account same marginal costs of uncertainty and effort. To maximize utility, the manager chooses lesser proximity to basic research, $k_m^* < k_o^*$. The owner compensates this choice by inducing higher effort by choosing a higher-powered incentive, $b_m^* > b_o^*$. The optimal choices of the owner and the manager imply that profits are equal or higher in the case where the owner chooses the R&D project, $\pi_o(b_o^*, k_o^*) \geq \pi_m(b_m^*, k_m^*)$ than when the manager does that. This is obvious since under the owner’s rule, he maximises profits by simultaneously determining $b_o^*$ and $k_o^*$ whereas under the manager’s rule, he determines $k_m^*$ to maximise utility. Anticipating this, the owner chooses $b_m^*$ and these choices are suboptimal for profit maximization. An interesting implication arises: In an industry with entry barriers and basic research presence, we should see more firms with knowledgeable owners that are able to direct firm R&D. Furthermore, the importance of the owner’s expertise in R&D and basic research provides a motivation for Venture Capital presence in such industries. Institutional owners share ownership with VCs to be able to utilize their industry skills also in R&D strategy and contract design.

Analysis of the optimal incentive coefficients yields a surprising result:

**Proposition 3:** If the manager or the owner can choose the position of the R&D project relative to basic research, the optimal incentive coefficient is decreasing in the cost of effort, but increasing in the manager’s risk-aversion and the variance of the basic research outcome.

**Proof:** Graphic illustration shows that $\frac{db_m^*}{dc/(rv)} < 0$ and $\frac{db_o^*}{dc/(rv)} < 0$. Thus the optimal contract incentive is decreasing in the cost of effort and increasing in risk aversion and variance. QED.
The result is in stark contrast to current literature and provides one explanation to Prendergast’s (2002) finding that more than half of some twenty empirical studies on incentives cannot confirm the negative relationship between risk and the level of incentive. If the project positions are given, the incentive coefficient decreases in risk-aversion and revenue variance as in the standard model (Proposition 1). Now the incentive coefficient increases in risk-aversion and variance. Why is this? In the standard case, the risk premium is increasing in the incentive coefficient. Under the owner’s rule, his optimal choices $b^*_o, k^*_o$ imply that the risk premium is decreasing in the incentive coefficient and the revenue from basic research is independent of the incentive. Under the manager’s rule, the higher an incentive coefficient the owner chooses, the more distant an R&D project position the manager selects, because the risk premium increases faster than wage in $k^*_M$. The owner takes this into account in his optimal choice of the incentive coefficient. From his point of view, the risk premium turns out constant but the expected revenue from basic research decreases in the incentive $b^*_M$ (and in the basic research outcome variance and in the manager’s risk aversion) via its effect on $k^*_M$ chosen by the manager. Since the manager’s effort increases in the incentive coefficient, this implies the following:

**Result:** R&D effort is increasing in the risk level of the basic research project provided that the either the owner or manager can align the R&D project with it. If not, R&D effort decreases in basic research risk level.

Let us analyse the decision rules (2, 3b, IC2) that bind the utilization of basic research, $k$, to the incentive coefficient $b$. In all of them, there is an inverse relation between the variables. The R&D effort is determined by $b$ and thus we can say that

**Result:** For $k > 0$, the utilization of basic research and R&D effort crowd each other out due to moral hazard in R&D.

So far, we have abstracted from market uncertainty. We can incorporate it to the analysis by replacing the revenue equation (1) by $R = e + kY + \varepsilon$ where $\varepsilon \sim N(0, \sigma)$. Let us analyse the effect of market risk to the results. We note that market risk does
not affect the manager’s incentive compatibility conditions or the owner’s condition for optimal $k_o$. However, it enters into the owner’s profit maximization problem via the individual rationality condition. Under owner’s rule, the equation for optimal incentive (4) is transformed to $(rz + 1)b^3 - b^2 + \frac{c}{rv} = 0$ and under the manager’s rule, (7) turns into $(rz + 1)b^3 - b^2 + \frac{c}{rv} = 0$. The larger is the term $rcz$, the smaller are the terms $b^2 - (rz + 1)b^3$ and $b^3 - (rz + 1)b^4$. From the graph in figure 1 we can deduce that that the optimal incentive is thus decreasing in the term $rcz$. Combining this with the result of proposition 3, we note that an increase in the market variance, $z$, and in effort cost, $c$, lower the optimal incentive as predicted by Holmström and Milgrom. The result of proposition 3 regarding the variance of the effort of the OS community, $v$, holds. The effect of risk aversion, $r$, to the incentive is now ambiguous and depends on variances of the market and OS effort uncertainty.

4 Conclusion

We analysed the optimal employment contract under moral hazard when basic research exists and its output either lowers the costs of R&D or interacts with the firm’s R&D in the market. The trade-off between increased revenue and increased uncertainty results in a bounded optimum for the closeness between the basic research and R&D. The owner chooses a closer proximity than does the manager and this leads to a lower powered incentive. Optimal incentive coefficients in both cases are increasing in risk aversion and variance contrary to the traditional result. Our work has policy implications. If the position of basic research is given (Proposition 1), the firm is a monopoly, but constrained by two effects: The substitute basic research is an invisible (in revenue terms) competitor to the firm and reduces its profits. In addition to that, the uncertainty related to the basic research outcome worsens the moral hazard problem and lowers the manager’s effort, which results in further reduction of profits. A firm may be a monopoly if one looks at the market research data, but at the same time it may also face competition in the market and severe moral hazard problems in employment due to basic research, especially Open Source, presence. This may be
something that, for example, competition authorities should take into account when assessing market power of firms in the IT-industry.

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