On R&D Investment

Massoud Khazabi, Gamal Atallah
University of Ottawa - Canada

Abstract

The paper presents a theoretical model of R&D investment and extensively studies the capitalization policy of development-related costs. It is shown that a firm's R&D investment policy and capitalizing related costs are influenced by a set of variables such as stock market effects and corporate income tax rates. These results are sharper when spill-over effects are introduced. Interest rates, tax rates, production's marginal cost, stock market indices and speed of development benefits' revelation would alter the firm's disclosure and innovation policies conspicuously.

Keywords: R&D, Development, Innovation, Capitalization, Expensing, Corporate Income Tax, Disclosure

1. Introduction:

As we know R&D or research and development cost is the cost of discovering new knowledge about products, processes and services. This knowledge could be applied to create new and improved products, processes and services that fill market needs.
Firms can disclose their R&D approach and outcome to public or they can keep it secret. Obviously, disclosure of R&D information would cost firms their competitive advantage; however, doings could also result in more accurate and clear share prices. This type of trade-off is supported by a wide range of theoretical literature, such as Verrecchia (1983) and Entwistle (1999).
When it comes to bad news about R&D, however, firms are more in favour of revealing their results since it could increase market clarity, modify market expectations to bring them in line with the firm's anticipations, reduce any incentive for competitors to enter the market, as well as potential legal costs.
R&D investment may be considered an immediate expense. Alternatively it may be treated as capital, which will be depreciated over time.
Capitalization means paying for R&D costs out of future revenue (amortization) and getting back some capital gain in return. Through capitalization, a firm may stretch out her expenses into the future and smooth them out over a relatively long period of time. Contrarily, expensing means paying for development costs out of current revenue. In a preliminary economic review, these two alternatives could be compared using the cost of capital and an applicable discount rate. Assuming the competitive state of the world, these two are equal and there would be no gain in capitalizing over expensing. Obviously, the pure competition rejects any capital market imperfection as well.
A broader perspective, however suggests that a wide range of parameters effect the firm's decision to disclose or not. In fact there is extensive literature defending and rejecting one treatment over the other, all relying on some more comprehensive analyses. Opponents to the idea of deferring and amortizing development costs state that immediate expensing prevents the formation of negative sensitivity about the firm whereas not expensing R&D costs will immediately inflate the firm's profit, giving wrong and misleading signals to the stock market and investors. They point to the fact that most of international standards oppose the capitalization of R&D costs and argue that choosing an expensing policy firm may help them manage future write-downs more accurately, does not need to fulfil the value relevance precondition to warrant deferral and keep its competitiveness in stock exchange by avoiding cross listing problems. Some countries, such as

France allow capitalization of R&D costs on the condition that their projects and costs are clear and identifiable and that there is a positive chance of technical success and future profitability[1]. This condition is still too restrictive.
By contrast, some literature, such as E&Y (1994), Brennan (1992) and Solomons (1986), defend the idea of capitalization by explaining that there is a historically positive trend which favours deferring development costs. This literature considers this type of investment as long term assets, depreciable over time. In fact, capitalization provides an opportunity for managers to capitalize on the cost of projects that have a low probability of success or to delay write-down of impaired R&D assets.[2] Furthermore, capitalization allows the firm to have some control over its reported financial results[3].
Some recent research papers, such as Healy et al. (2002), Lev and Sougiannis (1996 and 1999), Aboody and Lev (1998) and Zhao (2002), discuss the value relevance of capitalization of R&D costs. Cazavan-Jeny and Jean-Jean (2003) use a sample of 95 French firms on a three year period and show that capitalized R&D is positively associated with stock prices and stock returns, whereas expensed R&D is negatively related with these factors. They conclude that the accounting treatment of R&D carries a signal to investors. Briefly, the expensing method is more objective and clear, whereas capitalization expresses a firm's information more accurately and is more informative. This trade-off has to be taken into account when a firm decides on a method for disclosure.
As already mentioned, most international standards ask firms to either expense their development costs immediately or capitalize them if they meet certain criteria (IAS 38). US standards require all R&D costs to be expensed (SFAS N°2). The only exception to this mandate is the R&D cost for computer software, where capitalization and depreciation are allowed as long as the project's technical achievability is proven. Canadian standards require TSE listed firms to expense their development costs. As an exception, firms that would like to defer their R&D expenditure have to meet five provisional norms, including clarity of market definition, resource capability for completing their R&D project, technical achievability of R&D outcome and specified amortization period. France is the only exception that allows both disclosure treatments openly. Canada is revealing its plan to allow for capitalization of the development costs starting in 2008.
We start with a basic model of R&D investment in part 2. Part 3 deals with the solution of the model. An analytical discussion is provided in sections 4 and 5. Part 6 concludes the paper.

2. The Basic Model:

We consider a monopolist, which performs in two periods. This monopolist has the following sequence of decision-making:

- ***Stage one***: The firm decides on a level of R&D investment and disclosure in this period.
- ***Stage two***: The decision about the production level in both periods is made, knowing that levels of R&D investment and expensing have already been revealed.

Starting from stage one, we think of a monopolist that makes a decision on the intensity of her R&D activity and her disclosure policy. The monopolist knows that all benefits from this investment will not be revealed in the first period so she defines λ as the portion of cost reduction benefits of R&D investment divulged in the period one. Presumably, all these benefits will be available to the firm in the second period.
In terms of expensing decision, we assume the monopolist expenses α percent of its R&D investment ($\gamma(x)$) and capitalizes the remainder $(1-\alpha)$ in the first period. Obviously, the capitalized portion of investment will be amortized over the firm's lifetime but since we have already assumed that the monopolist only operates in two consecutive periods, this $(1-\alpha)$ percent

[1] PGG99- Plan Comptable general, 1999
[2] Jean Jean
[3] Entwistle 1999

will be expensed in the second period anyway. Also, to discount future values, we define δ as the discount factor.

As concerns the R&D cost function; γ(x) is an increasing convex function of x. It is increasing in x because we assume the firm produces in an optimal manner and then faces an increasing cost function. The R&D cost function is a convex function of x if our production set is concave, closed and satisfies the free disposal property. Having all these assumptions, we can insure that we have a concave profit function and feasible production activity.

In our model, the negative market effect is shown by $\theta(\alpha)$, knowing that $\theta(\alpha)$ is an increasing and convex function of α. In a two-period world, we visualize η percent of these costs incurred in the period one and remaining $(1-\eta)$ percent in the second period.

The second market effect is the positive effect of R&D capitalization on the stock prices and stock returns insisting that R&D outputs generate some of the most prized economic assets in the economy.[4] In the following model, this positive effect is shown by the function $\psi(\alpha)$, which is a decreasing concave function of α. By assumption, μ percent of these benefits is revealed in the first period and $(1-\mu)$ percent in the second period.

Finally, the inverse demand function for the firm's product has a form of $P_t = P(y_t)$ where we take it to be continuous and strictly decreasing at all y such that $P(y_t)$>0 and $P(y_t)$=0 at an existing $\bar{y}<\infty$. In what follows, we assume that this demand function is known for the monopolist and output level y_t is producible at a cost $C(y_t)$.

To discuss effects of a specified tax on the firm's optimal trajectory we also think of a given corporate income tax at the rate t in this economy. We could also assume some other type of taxes, such as regulatory tax on quantity, quality and price. For the sake of simplicity, we will only discuss the corporate income tax case. Obviously the assumption will change the monopolist's disclosure and R&D investment decision, since α will be shown to be a function of t. We assert that there is a relation between the tax rate and the disclosure decision and also between the tax rate and the firm's R&D investment but accuracy and direction of this relation will be investigated in the section five of this paper.

3. Solution of the Model:

Using the backward induction method, we first solve the monopolist's problem when she decides on the level of production in each period. In fact her problem is to choose its profit maximizing price, but we are going to use the alternative approach, which is having the monopolist decide about her level of output and letting price be given by the inverse demand function. It is also logical to assume that R&D benefits reveal gradually, so presumably only λ percent of these cost reduction benefits reveal in the first period. In the second period, however, all development benefits will be accessible by the firm. This exposure sequence leads us to have the first period production cost in presence of R&D benefits as $C(y_1)-\lambda x y_1$ and the second period's cost as $C(y_2)-xy_2$. Hence we can conclude that:

$$\begin{aligned}\underset{y_1,y_2}{Max}\,\pi = &\{(1-t)[P(y_1)y_1 - C(y_1) + \lambda x y_1 - \alpha\gamma(x)] - \eta\theta(\alpha) + \mu\psi(\alpha)\} + \\ &\{\delta(1-t)[P(y_2)y_2 - C(y_2) + xy_2 - (1-\alpha)\gamma(x)] - \delta(1-\eta)\theta(\alpha) + \delta(1-\mu)\psi(\alpha)\}.\end{aligned} \tag{1}$$

The monopolist's optimal quantities must satisfy the following first order conditions:

$$\partial\pi/\partial y_1 = P'(y_1)y_1 + P(y_1) - C'(y_1) + \lambda x \le 0 \quad \textit{with equality if } y_1>0, \tag{2}$$

[4] Same

$$\partial\pi/\partial y_2 = P'(y_2)y_2 + P(y_2) - C'(y_2) + x \le 0 \ \ \textit{with equality if} \ \ y_2 > 0. \qquad (3)$$

These two conditions are well known conditions of a profit maximizing monopolist. The first two terms in equation 2 and 3 refer to the marginal revenue from a differential increase in y. These two terms are equal to the derivative of the firm's total revenue. The third term in these two equations is the corresponding marginal cost. We know that $P(0) > C'(0)$ then conditions 2 and 3 could be satisfied only at $y > 0$. Consequently marginal cost has to be equal to marginal revenue at the monopolist's optimal output levels:

$$P'(y_1)y_1 + P(y_1) = C'(y_1) - \lambda x, \qquad (4)$$
$$P'(y_2)y_2 + P(y_2) = C'(y_2) - x. \qquad (5)$$

From (4) and (5) we can calculate $y_1^*(x)$ and $y_2^*(x)$. Now in the first period the monopolist decides about her R&D activity and R&D disclosure then:

$$\begin{aligned}\underset{x,\alpha}{Max}\ (\pi_1^* + \delta\pi_2^*) = &\{(1-t)[P(y_1^*(x))y_1^*(x) - C(y_1^*(x)) + \lambda x y_1^*(x) - \alpha\gamma(x)] - \eta\theta(\alpha) + \mu\psi(\alpha)\} + \\ &\{\delta(1-t)[P(y_2^*(x))y_2^*(x) - C(y_2^*(x)) + x y_2^*(x) - (1-\alpha)\gamma(x)] - \delta(1-\eta)\theta(\alpha) + \delta(1-\mu)\psi(\alpha)\}\end{aligned} \qquad (6)$$

Note that price and cost could be linear or nonlinear functions of y. The corner solutions for this maximization problem are:

$$\begin{aligned}&\frac{\partial(\pi_1^* + \delta\pi_2^*)}{\partial x} = \\ &(1-t)\left[y_1^{*'}(x)P'(y_1^*(x))y_1^*(x) + P(y_1^*(x))y_1^{*'}(x) - y_1^{*'}(x)C'(y_1^*(x)) + \lambda y_1^*(x) + \lambda x y_1^{*'}(x) - \alpha\gamma'(x)\right] + \\ &\delta(1-t)\left[y_2^{*'}(x)P'(y_2^*(x))y_2^*(x) + P(y_2^*(x))y_2^{*'}(x) - y_2^{*'}(x)C'(y_2^*(x)) + y_2^*(x) + x y_2^{*'}(x) - (1-\alpha)\gamma'(x)\right] = 0\end{aligned} \qquad (7)$$

$$\frac{\partial(\pi_1^* + \delta\pi_2^*)}{\partial\alpha} = (1-t)\gamma(x) - \eta\theta'(\alpha) + \mu\psi'(\alpha) + \delta(1-t)\gamma(x) - \delta(1-\eta)\theta'(\alpha) + \delta(1-\mu)\psi'(\alpha) = 0 \qquad (8)$$

Equation (7) explains that at optimum, the total marginal benefits of having one more unit of R&D activity outcome is equal to the total marginal costs of producing that extra unit. As expected, we have higher marginal profit of R&D outcome if all development benefits are revealed in the first period.

Equation (8) optimally equalizes the total marginal costs and total marginal benefits of disclosing one more unit of development expenditure. As we see, none of the first stage constraints have an effect on this optimality condition and this is due to the fact that optimal decision about the disclosure of any development cost is effected by the production decision of the firm. In other words, the monopolist chooses her optimal level of expensing autonomously regardless of the level of her optimal production.

Apparently having some explicit functional forms for demand and production cost would help us have a clearer interpretation of all the facts. In what follows we are going to narrow our discussion to some explicit forms of demand and production cost functions and also perform a comparative static analysis to study changes in the firm's environment.

4. Analytical Discussion:

Let's assume that demand for the monopolist's good is given by a liner function. More precisely, let's assume that the inverse demand function the firm is facing is given by $P(y_t) = A - y_t$. The production cost also has a linear form of $C(y_t) = cy_t$. Finally, since only λ percent of cost reduction benefits are revealed in the first period, we would have:

$$c_1 = R - \lambda x, \quad \& \qquad c_2 = R - x. \tag{9}$$

Using all above provisions our first stage results will be:

$$y_1 = \frac{A - R + \lambda x}{2}, \qquad \& \qquad y_2 = \frac{A - R + x}{2}. \tag{10}$$

And as for the second stage:

$$\partial\pi \;/\partial x \;= \frac{\lambda(A - R + \lambda x) + \delta(A - R + x)}{2} - \gamma'(x)(\alpha + \delta(1-\alpha)) = 0, \tag{11}$$

$$\partial\pi/\partial\alpha = (1-t)\gamma(x)(\delta - 1) - \theta'(\alpha)(\eta + \delta(1-\eta)) + \psi'(\alpha)(\mu + \delta(1-\mu)) = 0. \tag{12}$$

The first term in equation 11 represents total marginal benefits of development investment over the firm's lifetime, which contains two periods. The second term refers to the marginal cost of producing R&D outcome. As expected, these two would be equalized as a result of optimization. Equation 12 equates the marginal benefits of expensing with its marginal cost, again an expected outcome of the optimization process.

We continue our discussion by performing a comparative statics at this juncture. Our main intention is to discuss different changes in the firm's setting and effects of these changes on the firm's disclosure and innovation decisions. In other words, performing a comparative statics, we are going to show that change in every variable of interest would alter the monopolist development and disclosure decisions.
To begin, we have a partial change in λ, x and α, ceteris paribus. Totally differentiating equations 11 and 12 and summarizing results gives us:

$$\frac{dx}{d\lambda} = -\frac{0.5(A-R) + \lambda x}{0.5(\lambda^2 + \delta) - \gamma''(x)(\alpha + \delta(1-\alpha)) + \dfrac{(1-t)(\gamma'(x)(1-\delta))^2}{\theta''(\alpha)(\eta + \delta(1-\eta)) - \psi''(\alpha)(\mu + \delta(1-\mu))}} > 0 \cdot \tag{13}$$

It is straightforward to show that this expression has a positive sign. The numerator has a positive sign since we know that $P(0) > c$. In signing the denominator we need to use the following proposition.

Proposition:

Let f be a function of many variables with continuous partial derivatives of the first and second order on the convex open set *S* and denote the Hessian of f at the point *x* by *H*(*x*). Then:

- f is concave if and only if *H*(*x*) is negative semi definite for all $x \in S$
- If *H*(*x*) is negative definite for all $x \in S$ then f is strictly concave

- f is convex if and only if $H(x)$ is positive semi definite for all $x \in S$
- If $H(x)$ is positive definite for all $x \in S$ then f is strictly convex.

Now the profit function's Hessian would be:

$$H = \begin{bmatrix} \frac{\partial^2 \pi}{\partial x^2} & \frac{\partial^2 \pi}{\partial x \partial \alpha} \\ \frac{\partial^2 \pi}{\partial \alpha \partial x} & \frac{\partial^2 \pi}{\partial \alpha^2} \end{bmatrix} =$$

$$\begin{bmatrix} 0.5(\lambda^2 + \delta) - \gamma''(x)(\alpha + \delta(1-\alpha)) & -\gamma'(x)(1-\delta) \\ -(1-t)\gamma'(x)(1-\delta) & -\theta''(\alpha)(\eta + \delta(1-\eta)) + \psi''(\alpha)(\mu + \delta(1-\mu)) \end{bmatrix}.$$

We know that profit function is a concave function of x and α. This means that $f_{11} = \frac{\partial^2 \pi}{\partial x^2} < 0$, which is true. Based on the proposition we could also conclude that f_{22} has a positive sign. This in turn yields a negative sign for the denominator of 13 and a positive sign for the whole expression ultimately.

This positive sign indicates that an increase in λ will amplify innovation benefits in general. Putting it differently, if R&D benefits revealed in the first period are increased, or if the firm obtains a higher portion of development benefits in the first period, her overall R&D benefits increase. Knowing that the discount factor is always smaller than one, this is a predictable outcome of the model.

In terms of change effects of the revealed benefits on the disclosure decision of the monopolist, we have:

$$\frac{d\alpha}{d\lambda} = \frac{(1-t)(\delta - 1)\gamma'(x)\left(\frac{dx}{d\lambda}\right)}{\theta''(\alpha)(\eta + (1-\eta)) - \psi''(\alpha)(\mu + \delta(1-\mu))} < 0. \qquad (14)$$

As we see λ has a negative effect on the firm's expensing decision, meaning that if the portion of benefits available in the first period increases, the firm will be persuaded to expense a lower fraction of her R&D expenses in that period. We already know that an increase in λ amplifies the innovation benefits and it is easy to show that x and α move in opposite directions i.e. if innovation benefits increases, the proportion expensed by the firm decreases as a result. These two justify the sign of the above relation between revealed benefits and disclosed proportion of expenses.

In section 5 we will prove that there is a negative relationship between x and α. To understand this relation, let's assume that the rate of disclosure in the first period increases for some reason. This discourages the optimal development activity by increasing the total cost of innovation, which decreases the R&D outcome.

Next we discuss the effect of changes in marginal cost on innovation outcome and disclosure decision of the firm. Totally differentiating 11 and 12 results:

$$\frac{dx}{dR} = \frac{0.5(\lambda + \delta)}{0.5(\lambda^2 + \delta) - \gamma''(x)(\alpha + \delta(1-\alpha)) + \frac{(1-t)(\gamma'(x)(1-\delta))^2}{\theta''(\alpha)(\eta + \delta(1-\eta)) - \psi''(\alpha)(\mu + \delta(1-\mu))}} < 0 \cdot \qquad (15)$$

This negative sign shows the inverse relationship between R&D benefits and the marginal cost of production. In fact, a monopolist with a higher cost of production has a narrower (production or geographic) market, less demand and R&D outcome with a smaller extent of application. It is also shown in (10) that the lower production originated from the narrower market reduces the unit of innovation outcome consequently.
To discuss the effects of marginal cost changes on the firm's disclosure decision we have:

$$\frac{d\alpha}{dR}=\frac{(1-t)(\delta-1)\gamma'(x)\left(\dfrac{dx}{dR}\right)}{\theta''(\alpha)(\eta+(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu))}>0\,. \tag{16}$$

The marginal cost has a positive effect on the monopolist's disclosure decision. The negative effect of R on x on the one hand and the negative effect of x on α on the other explain this positive relationship.
To explain the consequences of a negative respond of market to expensing decision of the firm we can totally differentiate 11 and 12 with respect to x, α and η. Summarizing differentiation results:

$$\frac{d\alpha}{d\eta}= -\frac{\theta'(\alpha)(1-\delta)}{\dfrac{(1-t)[\gamma'(x)(1-\delta)]^2}{0.5(\lambda^2+\delta)-\gamma''(x)(\alpha+\delta(1-\alpha))}+\theta''(\alpha)(\eta+(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu))}<0. \tag{17}$$

The negative sign of this expression indicates that having the market responds in effect, the firm has a strong incentive to decrease expensing in order to avoid such negative consequences.

And for the R&D benefits we have:

$$\frac{dx}{d\eta}=-\frac{(\delta-1)\gamma'(x)}{0.5(\lambda^2+\delta)-\gamma''(x)(\alpha+\delta(1-\alpha))}\frac{d\alpha}{d\eta}>0. \tag{18}$$

Again, the positive relationship between x and η could be explained by considering two simultaneous reactions: the first is the negative effect of η on α; the second is the negative effect of α on x. A hypothetical increase in η decreases α and increases x through α.

Turning to positive effects of capitalization on the market value of the firm we have:

$$\frac{dx}{d\mu}=-\frac{(1-\delta)^2\psi'(\alpha)\gamma'(x)}{(1-t)((1-\delta)\gamma'(x))^2+(0.5(\delta+\lambda^2)-(\alpha+(1-\alpha)\delta)\gamma''(x))(\theta''(\alpha)(\eta+\delta(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu)))}<0\cdot \tag{19}$$

The fact that x and μ are both benefits attached to the R&D investment activity, one caused by the actual investment and the other by the disclosure treatment of the investment expenses, expresses the substitutability of these two benefits and justifies the negative sign of the above expression.
Using the same approach, we can study the effect of positive market effects on the monopolist's disclosure decision:

$$\frac{d\alpha}{d\mu}=\frac{\left(0.5\left(\delta+\lambda^2\right)-\left(\alpha+(1-\alpha)\delta\right)\gamma''(x)\right)}{(1-\delta)\gamma'(x)}\frac{dx}{d\mu}>0. \tag{20}$$

As expected, the existence of positive market reactions will encourage the firm to prefer expensing. To discuss the effect of a change in the discount factor on the disclosure decision and R&D output, we totally differentiate (11) and (12) with respect to x, α and δ. Summarizing those results we see:

$$\frac{dx}{d\delta}=-\frac{\left(\theta''(\alpha)(\eta+\delta(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu))\right)\left(0.5(A-R+x)-\gamma'(x)(1-\alpha)\right)+\gamma'(x)(\delta-1)\left[(1-t)\gamma(x)-\theta'(\alpha)(1-\eta)+\psi'(\alpha)(1-\mu)\right]}{\left(0.5\left(\lambda^2+\delta\right)-\gamma''(x)(\alpha+\delta(1-\alpha))\right)\left(\theta''(\alpha)(\eta+\delta(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu))\right)+(1-t)\left[\gamma'(x)(1-\delta)\right]^2}. \tag{21}$$

We can simplify this expression to:

$$\frac{dx}{d\delta}=-\frac{\left(\theta''(\alpha)(\eta+\delta(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu))\right)\left(0.5(A-R+x)-\gamma'(x)(1-\alpha)\right)+\gamma'(x)\left(\theta'(\alpha)-\psi'(\alpha)\right)}{\left(0.5\left(\lambda^2+\delta\right)-\gamma''(x)(\alpha+\delta(1-\alpha))\right)\left(\theta''(\alpha)(\eta+\delta(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu))\right)+(1-t)\left[\gamma'(x)(1-\delta)\right]^2}. \tag{22}$$

We would expect to see a positive relation between the discount factor and the innovation benefits, but we can not prove such a connection using expression (22) and without imposing more constraint on the model.

As for the effect of a change in the discount factor on the disclosure decision, we have:

$$\frac{d\alpha}{d\delta}=\frac{\left(0.5\left(\lambda^2+\delta\right)-\gamma''(x)(\alpha+\delta(1-\alpha))\right)\left((1-t)\gamma(x)-\theta'(\alpha)(1-\eta)+\psi'(\alpha(1-\mu))\right)-(1-t)(\delta-1)\gamma'(x)\left(0.5(A-R+x)-\gamma'(x)(1-\alpha)\right)}{\left(0.5\left(\lambda^2+\delta\right)-\gamma''(x)(\alpha+\delta(1-\alpha))\right)\left(\theta''(\alpha)(\eta+\delta(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu))\right)+(1-t)\left[\gamma'(x)(1-\delta)\right]^2}. \tag{23}$$

We expect to explore a negative relation between the discount factor and the disclosure decision, but the above equation only states an ambiguous connection between the variables of interests.

Finally, to examine the tax effects on two variables of interest means the disclosure decision and the R&D outcome, we use the same procedure. As already explained, we expect to see a negative link between the tax rate and disclosure decision, ceteris paribus, thus:

$$\frac{dx}{dt}=\frac{\gamma(x)\gamma'(x)(1-\delta)^2}{(1-t)\left(\gamma'(x)(1-\delta)\right)^2+\left(\theta''(\alpha)(\eta+\delta(1-\eta))-\psi''(\alpha)(\mu+\delta(1-\mu))\right)\left(0.5\left(\lambda^2+\delta\right)-\gamma''(x)(\alpha+\delta(1-\alpha))\right)}<0. \tag{24}$$

The expression states that an increase in the tax rate goes along with a decrease in R&D output, which is in line with a priory expectation.

We can also show that:

$$\frac{d\alpha}{dt}=\frac{\left(0.5\left(\lambda^2+\delta\right)-\gamma''(x)(\alpha+\delta(1-\alpha))\right)\frac{dx}{dt}}{(1-\delta)\gamma'(x)}>0, \tag{25}$$

The positive sign explains that when corporate income tax rate increases, the firm increase her R&D expenses in the present period to reduce her tax burden. An increase in α reduces the

present value of the total profit, which in turn decreases the firm's tax load in turn. This is in line with the main objective of the profit maximizing monopolist.
It is worth nothing that having a ceteris paribus assumption does not utterly satisfy the objective of a comprehensive discussion, but at least gives us a tangible way of having a naïve assessment of the tax effects.

5. Optimal Choice of α :

One of our basic assumptions in developing the model was that the decision about α is being made by the monopolist. Alternatively, we can assume that the regulator defines the optimal level of disclosure and dictate it to the monopolist. This framework could be developed in a three stage game as following:

- ***Stage one***: The regulator chooses about the optimum level of α **.**
- ***Stage two:*** The monopolist enters the market and chooses about her level of R&D investment.
- ***Stage three***: The monopolist chooses her level of production, knowing that levels of R&D investment and expensing have been already revealed.

Using the backward induction method, we start from the stage three means, giving the firm the option of choosing her optimal level of output. Then at the second stage she has the choice of taking her previous information into account to choose her R&D investment. Finally at stage one, the government takes all of the information revealed by the firm as given and announces α as the optimal expensing rate.
The third stage results stay the same as before. Proceeding to the second stage we have:

$$\max_{x} \quad (\pi_1 + \delta\pi_2) = (1-t)\left[\left(\frac{A-R+\lambda x}{2}\right)^2 - \alpha\gamma(x)\right] - \eta\theta(\alpha) + \mu\psi(\alpha) + \delta(1-t)\left[\left(\frac{A-R+x}{2}\right)^2 - (1-\alpha)\gamma(x)\right] - \delta(1-\eta)\theta(\alpha) + \delta(1-\mu)\psi(\alpha) \tag{26}$$

The first order condition is:

$$\partial\pi/\partial x = \frac{\lambda(A-R+\lambda x) + \delta(A-R+x)}{2} - \gamma'(x)(\alpha + \delta(1-\alpha)) = 0\,. \tag{27}$$

This gives us $x^*(\alpha)$ as the solution to our maximization problem. Now at the first stage the government takes all of the previously revealed information and rules about the socially optimum level of α :

$$\max_{\alpha} W = \frac{1}{8}\{3\left(A^2(1+\delta) + R^2(1+\delta) - 2Rx^*(\alpha)(\delta+\lambda) + (x^*(\alpha))^2(\delta+\lambda^2) - 2A(R(1+\delta)) - x^*(\alpha)(\delta+\lambda)\right) + 8(\alpha(\delta-1)-\delta)\gamma(x^*(\alpha)) + 8(\delta(\eta-1)-\eta)\theta(\alpha) + 8(\delta(1-\mu)+\mu)\psi(\alpha)\} \tag{28}$$

The corner solution to this optimization problem is:

$$\frac{\partial W}{\partial \alpha} = \frac{1}{8}\{3\left(-2Rx^{*'}(\alpha)(\delta+\lambda) + 2x^{*'}(\alpha)(\delta+\lambda^2) - x^{*'}(\alpha)(\delta+\lambda)\right) + 8((\delta-1))\gamma(x^*(\alpha)) + 8(\alpha(\delta-1)-\delta)x^{*'}(\alpha)\gamma'(x^*(\alpha)) + 8(\delta(\eta-1)-\eta)\theta'(\alpha) + 8(\delta(1-\mu)+\mu)\psi'(\alpha)\} = 0$$

(29)

Equation (29) provides us with the optimal value for α , which satisfies the regulator's objective.
To study the effect of changes in the firm's environment on the socially optimum value of the parameter of interest, the rate of disclosure, we perform a comparative statics as before. The effect of a change in λ on the socially optimum value of disclosure rate is:

$$\frac{d\alpha}{d\lambda} = -\frac{(3(1+2R-4\lambda)x'(\alpha))}{-72(\delta-1)x'(\alpha)\gamma'(x(\alpha)) + (3((2R-1)\delta+\lambda+2(R-\lambda)\lambda) + 64(\alpha+\delta(1-\alpha))\gamma'(x(\alpha)))x''(\alpha) - 64(\alpha+\delta(1-\alpha))(x'(\alpha))^2\gamma''(x(\alpha)) - 64(\delta(\eta-1)-\eta)\theta''(\alpha) + 64(\delta(\mu-1)-\mu)\psi''(\alpha)}. \quad (30)$$

Referring to the second order conditions of welfare maximization process we can conclude that the denominator of the above expression is always positive. Thus, the sign of this expression depends on the sign of $(1+2R-4\lambda)$ knowing that $x'(\alpha)<0$. We must first show that $x'(\alpha)$ is negative. To do so, we must remember that our second stage profit function is a concave function of α , thus:

$$\frac{dx}{d\alpha} = \left(\frac{d\alpha}{dx}\right)^{-1} = -\frac{0.5(\delta+\lambda^2)+(\alpha+\delta(1-\alpha))\gamma''(x)}{(\delta-1)\gamma'(x)} < 0 \quad (31)$$

Now (31) is negative if $(1+2R-4\lambda)<0$ or $\lambda > \frac{1+2R}{4}$ and is positive otherwise (being equal to zero is not an acceptable answer). As we see λ has a negative effect on the socially optimum value of α only if it is large enough to overcome the positive effect of the marginal cost of production.

To study the effect of change in the marginal cost of production on the socially optimum rate of disclosure we have:

$$\frac{d\alpha}{dR} = -\frac{6(\delta+\lambda)x'(\alpha)}{-72(\delta-1)x'(\alpha)\gamma'(x(\alpha)) + (3((2R-1)\delta+\lambda+2(R-\lambda)\lambda) + 64(\alpha+\delta(1-\alpha))\gamma'(x(\alpha)))x''(\alpha) - 64(\alpha+\delta(1-\alpha))(x'(\alpha))^2\gamma''(x(\alpha)) - 64(\delta(\eta-1)-\eta)\theta''(\alpha) + 64(\delta(\mu-1)-\mu)\psi''(\alpha)} > 0 \quad (32)$$

This expression indicates that an increase in the marginal cost of production will increase the socially optimum rate of disclosure. In fact an increase in R lessens the innovation outcome. Consequently, a reduction in innovation benefits increases the rate of disclosure defined by the regulator.
The effect of a change in the negative response of the market to the capitalization of the firm is:

$$\frac{d\alpha}{d\eta} = \frac{64(\delta-1)\theta'(\alpha)}{-72(\delta-1)x'(\alpha)\gamma'(x(\alpha)) + (3((2R-1)\delta+\lambda+2(R-\lambda)\lambda) + 64(\alpha+\delta(1-\alpha))\gamma'(x(\alpha)))x''(\alpha) - 64(\alpha+\delta(1-\alpha))(x'(\alpha))^2\gamma''(x(\alpha)) - 64(\delta(\eta-1)-\eta)\theta''(\alpha) + 64(\delta(\mu-1)-\mu)\psi''(\alpha)} < 0 \quad (33)$$

An increase in the negative response of the market will optimally decrease the rate of disclosure dictated by the regulator. As the negative market response influences the total welfare negatively, any increase in it will trigger the optimum level of expensing defined by the regulator.

To see the positive market effects on socially optimal level of disclosure:

$$\frac{d\alpha}{d\mu}=\frac{64(\delta-1)\psi'(\alpha)}{-72(\delta-1)x'(\alpha)\gamma'(x(\alpha))+(3((2R-1)\delta+\lambda+2(R-\lambda)\lambda)+64(\alpha+\delta(1-\alpha))\gamma'(x(\alpha)))x''(\alpha) -64(\alpha+\delta(1-\alpha))(x'(\alpha))^2\gamma''(x(\alpha))-64(\delta(\eta-1)-\eta)\theta''(\alpha)+64(\delta(\mu-1)-\mu)\psi''(\alpha)}>0 \tag{34}$$

Expression (34) states that any increase in the positive reaction of the market to expensing has to be accompanied by an increase in the optimal rate of disclosure as its magnifier.
And finally to see the effect of change in the discount factor on the optimal value of disclosure, we have:

$$\frac{d\alpha}{d\delta}=-\frac{-8\gamma(x(\alpha)+x'(\alpha)(-3+6R-64(\alpha-1)\gamma'(x(\alpha))))-64(\eta-1)\theta'(\alpha)+64(\mu-1)\psi'(\alpha)}{-72(\delta-1)x'(\alpha)\gamma'(x(\alpha))+(3((2R-1)\delta+\lambda+2(R-\lambda)\lambda)+64(\alpha+\delta(1-\alpha))\gamma'(x(\alpha)))x''(\alpha) -64(\alpha+\delta(1-\alpha))(x'(\alpha))^2\gamma''(x(\alpha))-64(\delta(\eta-1)-\eta)\theta''(\alpha)+64(\delta(\mu-1)-\mu)\psi''(\alpha)}. \tag{35}$$

This expression is ambiguous in sign. Lack of information about the market components is responsible for this ambiguity.
It is worth noting that, since corporate income tax has no effect on social welfare, we do not expect it to have any influence on the optimal rate of disclosure either.

6. Concluding Remarks:

Developing an R&D model, we showed how different market elements could alter the monopolist's R&D decision-making process and its outcomes. We introduced positive and negative market reactions to the capitalization of the R&D costs. The tax effect was taken into account to enrich the economic insights of the model.
Using this well developed model, a comparative statics was performed and equations were calculated and signed. Not surprisingly, all existing connections between variables of interest were reasonable and acceptable.
Future works should include a more dynamic revision of this model. For example, we studied the effect of a corporate income tax on the innovation outcome and the disclosure decision, ceteris paribus. As an attempt to obtain more accurate results, one can study the same effect when other factors, such as the discount factor, are taken into account. Although this may be a difficult goal to achieve, taking other variables' effects into account would provide us with more reliable and efficient results.
We also studied the case of a monopolist that performs in only two periods. Obviously this is a very limiting condition imposed on the model. A future attempt for improving the model could contain a discussion of an infinite horizon decision-making firm.
Discussing some other tax types, such as regulatory taxes, could enrich the interest model and enlighten some other policy making instruments' effect.
Other types of market structures could be the center of future research activities. Oligopoly markets in which spill-over effects are tractable are presented in the Appendix A of this paper.

Appendix A - Oligopoly Market and Interaction Effects:

So far we have assumed that there is a single monopolist operating in the market. This monopolist has a two period decision-making horizon in which she tries to achieve optimum levels of production and innovation and her production decision in period one is independent from that in the second period. However, if there is more than one firm operating in the market, this simple framework is no longer valid. The simplest example is a two firms $i \; and \; j$ oligopoly, in which the demand function both firms are facing with is $P(y_t) = A - y_t$ and the firm i's marginal cost in each period is as follows:

$$c_{i1} = R - \lambda x_i, \qquad \text{A(1)}$$

$$c_{i2} = R - x_i - \beta x_j. \qquad \text{A(2)}$$

This implies that the firm i's marginal cost is affected only by her own R&D activity in the first period and by both firms in the second period, which is an acceptable assumption. In the first period, each firm chooses about her own R&D activity and gets only a share of its own developments' benefit, but in the second period she receives not only all benefits of her own development activity but also a part of her rival's as the spill-over.

Having the same set of assumptions, the firm i's problem will be as following:

$$\begin{aligned} &\underset{y_{i1}, y_{i2}}{Max} \; (1-t)[(P(y_1) - c_{i1})y_{i1} - \alpha_i \gamma(x_i)] - \eta_i \theta(\alpha_i) + \mu_i \psi(\alpha_i) + \\ &\delta(1-t)[(P(y_2) - c_{i2})y_{i2} - (1-\alpha_i)\gamma(x_i)] - \delta(1-\eta_i)\theta(\alpha_i) + \delta(1-\mu_i)\psi(\alpha_i). \end{aligned} \qquad \text{A(3)}$$

Our first order conditions are:

$$\begin{aligned} \partial\pi / \partial y_{i1} &= (A - 2y_{i1} - y_{j1} - c_{i1}) = 0 \Rightarrow y_{i1} = \frac{A - c_{i1}}{2} - \frac{y_{j1}}{2}, \\ \partial\pi / \partial y_{i2} &= (A - 2y_{i2} - y_{j2} - c_{i2}) = 0 \Rightarrow y_{i2} = \frac{A - c_{i2}}{2} - \frac{y_{j2}}{2}, \end{aligned} \qquad \text{A(4)}$$

by substitution:

$$y_{i1} = \frac{A - 2c_{i1} + c_{j1}}{3}, \qquad \text{A(5)}$$

$$y_{i2} = \frac{A - 2c_{i2} + c_{j2}}{3}. \qquad \text{A(6)}$$

Substituting for $c_{i1}, c_{i2}, c_{j1} \; and \; c_{j2}$ we have:

$$\begin{aligned} y_{i1} &= \frac{A - R + 2\lambda x_i - \lambda x_j}{3}, \\ y_{i2} &= \frac{A - R + x_i(2-\beta) + x_j(2\beta - 1)}{3}. \end{aligned} \qquad \text{A(7)}$$

Back to the first stage of the game:

$$\underset{x_i,\alpha_i}{Max} \quad (1-t)\left[\left(\frac{A-R+2\lambda x_i-\lambda x_j}{3}\right)^2-\alpha_i\gamma(x_i)\right]-\eta_i\theta(\alpha_i)+\mu_i\psi(\alpha_i)+$$
$$\delta(1-t)\left[\left(\frac{A-R+x_i(2-\beta)+x_j(2\beta-1)}{3}\right)^2-(1-\alpha_i)\gamma(x_i)\right]-\delta(1-\eta_i)\theta(\alpha_i)+\delta(1-\mu_i)\psi(\alpha_i).$$

A(8)

Again our first order conditions imply:

$$\partial\pi_i \big/ \partial x_i = \frac{4\lambda}{3}\left(\frac{A-R+2\lambda x_i-\lambda x_j}{3}\right)+\delta\left[\frac{2(2-\beta)}{3}\left(\frac{A-R+x_i(2-\beta)+x_j(2\beta-1)}{3}\right)\right]-$$
$$\gamma'(x_i)(\alpha_i+\delta(1-\alpha_i))=0,$$

A(9)

$$\partial\pi_i/\partial\alpha_i=(1-t)\gamma(x_i)(\delta-1)-\theta'(\alpha_i)(\eta_i+\delta(1-\eta_i))+\psi'(\alpha_i)(\mu_i+\delta(1-\mu_i))=0\,.$$

A(10)

Equation A(9) equates all marginal benefits of R&D activities for firm i; undertaken by firms i and j; with the marginal cost of the development activity undertaken only by firm i. The first two terms of this expression give us marginal benefits of R&D activities over the lifetime of the firm. As we see, spill-over effects tend to increase this total benefit. The third term in A(9) refers to the marginal cost of the R&D activity undertaken by the firm i. As expected, marginal benefits and marginal cost of the development activity are equal at optimum.
Equation A(10) optimally equates the marginal benefit of expensing firm i's R&D spending with total marginal costs attributable to her disclosure decision. The first and third terms in this equation refer to the marginal benefits of expensing when the second term refers to the marginal cost of it. As expected, spill-over effects do not have any influence on the firm's expensing decision.

References:

Atallah, Gamal; Khazabi, Massoud (2005), "A Model of R&D Capitalization," *International Journal of Business and Economics*, 4(2), 107-121.

Baber, W. R.; Fairfield, P. M. and Haggard, J. A. (1991), "The effect of Concern about Reported Income on Discretionary Spending Decisions: The Case of Research and Development," *The Accounting Review*, 66(4), 818-829.

Cazavan-Jeny, A. and JeanJean, T. (2003), "*Value* Relevance of R&D Reporting: A Signaling Interpretation," DR03021, ESSEC Research Center.

Chiang, C. Catherine; Mensah, Yaw M. (2004), "The Determinants of Investor Valuation of R&D Expenditure in the Software Industry," *Review of Quantitative Finance and Accounting*, 22(4), 293-313.

Entwistle, G. M. (1999), "Exploring the R&D Disclosure Environment," *Accounting Horizons*, 13(4), 323-341.

Elliott, John; et al (1984), "The Impact of SFAS No. 2 on Firm Expenditures on Research and Development: Replications and Extensions," *Journal of Accounting Research*, 22(1), 85- 102.

Gigler, Frank (1994), "Self-Enforcing Voluntary Disclosures ," *Journal of Accounting Research*, 32(2), 224-40.

Horwitz, Bertrand N; Kolodny, Richard (1980), "The Economic Effects of Involuntary Uniformity in the Financial Reporting of R&D Expenditures: A Reply," *Journal of Accounting Research,* 18, 96-107.

Horwitz, Bertrand N; Kolodny, Richard (1980), "The Economic Effects of Involuntary Uniformity in the Financing Reporting of R&D Expenditures," *Journal of Accounting Research,* 18, 38-74.

Healy, Paul M; Myers, Stewart C; Howe, Christopher D (2002), "R&D Accounting and the Trade-off between Relevance and Objectivity," *Journal of Accounting Research*, 40(3), 677-710.

Kothari, S.P.; Laguerre, Ted E.; Leone, Andrew J. (2002), "Capitalization versus Expensing: Evidence on the Uncertainty of Future Earnings from Capital Expenditures versus R&D Outlays," *Review of Accounting Studies*, 7(4), 355-82.

Linhart, P. B.; Lebowitz, J. L. and Sinden, F. W. (1974), "The Choice between Capitalizing and Expensing under Rate Regulation," *The Bell Journal of Economics and Management Science*, 5(2), 406-419.

Lev, Baruch; Sougiannis, Theodore (1996), "The Capitalization, Amortization, and Value-Relevance of R&D," *Journal of Accounting and Economics*, 21(1), 107-38.

Landry, S.; Callimaci, A. (2002), "The characteristics of Canadian Firms that capitalize R&D," Working Paper 07-2002.

Marshall, William (1980), "Discussion of the Economic Effects of Involuntary Uniformity in the Financial *Reporting* of *R&D* Expenditures and Accounting for Research and Development Costs: The Impact of Research and Development Expenditures," *Journal of Accounting Research,* 18, 84-90.

Schankerman, M. (1981), "The Effects of Double-Counting and Expensing on the Measured Returns to R&D," *Review of Economics and Statistics*, 63(3), 454-458.

Wolfson, Mark A (1980), "Discussion of The Economic Effects of Involuntary Uniformity in the Financial Reporting of R&D Expenditures," *Journal of Accounting Research,* 18, 75-83.

Yuan Ding, Gary Entwistle, and Herve Stolowy, Sevilla (2003), "International differences in R&D disclosure practices: Evidence in a French and Canadian context," Presented in the 26th Annual Congress of European Accounting Association.