SOCIAL VALUE OF THE FIRM: ANALYSES AND PRACTICAL APPLICATIONS*

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This paper analyses the social value of a firm considering different objective functions in a real options perspective. Our results show that the socially optimal investment policy is not Pareto optimal, but significant gains in the value (generated by a firm) can be obtained by departing from a strict shareholder maximizing objective. Taking into account the role of supporting businesses, this paper develops a simple cost benefit framework that serves as a tool for assessing public investment incentive policies.

Key words: real options, public investment incentives.

JEL Classification: G31, H25, H32, G18.

Consider the simple question what is the value of a firm? Since the value of a firm has different sources and 'belongs' to many different claimholders the question of firm value is really not a simple one and it needs to be properly addressed: the value of the firm to whom? Considering that the firm value is not only a function of its assets-in-place, but also its growth possibilities we face a second question that it is equally important: what measure of firm value should be maximized when exploiting its growth possibilities?

There are two approaches generally adopted regarding the value of a firm. The first approach considers the value of a firm from the perspective of its investors. From this perspective, firm value represents the value accruing to its providers of investment capital (its investors) and in terms of the objective function followed there is an overwhelming adoption of Friedman's shareholder value maximization objectives [Friedman (1970)][1]. This is the perspective classically followed in finance, which adopts a micro perspective to firm valuation, taking into account the individual char-

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(1) Management science proposes a notable exception to the shareholder maximization paradigm through the emergence of Corporate Social Responsibility [Bowen (1953)] and Stakeholder Theory [Freeman (1984)]. Contrary to the shareholder maximization paradigm, Corporate Social Responsibility and Stakeholder Theory claim that, additionally to the value being created to shareholders, it also matters the value being created to other stakeholders of the firm.

acteristics of the firm (the value of its assets-in-place and its growth possibilities)[2] the risk exposure of its investors (e.g. diversified or undiversified) and the nature of the relations between the different investors (e.g. the existence of potential agency conflicts between them). The second approach considers the broader value of the firm from the perspective of a social planer and defines it as the social value of the firm. From the perspective of a public planner, the concept of firm value is broader and includes positive externalities affecting other agents apart from the investors of the firm [González *et al*. (2005), Inci (2009), Toole (2009)]. Traditionally, aspects of social value and welfare are treated at the macroeconomic level and the evaluation of specific public policies, for instance, usually relies on ex-post analyses of the impact of policy instruments on macroeconomic variables [e.g. Feltenstein and Shah (1995), Gagnepain and Ivaldi (2002)].

From the point of view of private investors aspects of social value tend to be ignored[3], and from the point of view of a social planner there is little attention being paid to the assessment of public policies on the micro level. However, several public policy instruments aim at incentivizing private investment in specific firms or sectors in a context of high uncertainty, in which there are many different and diverse claims involved and the role of the public planner is in most situations case specific [see Tassey (2005)]. These aspects show the need to adopt a micro level approach to the field of public policy that is not currently being adopted. Tassey (2005) and Inci (2009) highlight this gap and point out the need to develop methodologies that properly address the idiosyncrasies of the relations between the public entity, the firm and other agents involved.

In terms of the objectives of a private investor and of a social planer there is an important conflict between social welfare maximization and private wealth maximization. This conflict usually results in social underinvestment by private firms and this phenomenon was initially reported in Griliches (1958) for the agricultural sector and similar evidence was later reported in other sectors in Mansfield *et al.* (1977). This concept of social underinvestment is directly linked with the existence of positive externalities that affect other firms and individuals and the existence of these positive externalities is usually recognized as providing a valid rational for public intervention [Inci (2009) and Toole (2009)].

This paper develops a structural model of a firm before it realizes its initial investment. It considers alternative measures of firm value including, not only the value accruing to its providers of investment capital, but also for the government and for supporting firms (the positive externalities). It analyses and contrasts different objective functions in terms of maximizing the different measures of firm value considered. The results reveal the existence of the classical social underinvestment problem of private firms, show that the objective of social value maximization is not Pareto optimal and highlight the positive externalities generated and the significant

(2) See Trigeorgis (1993) for a thorough detail of the growth possibilities or real options commonly available for firms to exploit.

(3) Goldstein, Ju and Leland (2001) and Mauer and Sarkar (2005) represent exceptions that consider measures of social value by taking into account the value generated in corporate taxes.

wealth transfers that occur when following a social value maximization objective. In the second part of the analysis, the framework developed is used to assess the impact of public intervention to address the underinvestment problem. Amongst the different types of public intervention[4] we have adopted direct investment subsidies. The choice of subsidies derives from the fact that they represent a valid mechanism to address the social underinvestment problem (see Tassey (2005) and Toole (2009)] and they represent a mechanism that allows the achievement of Pareto optimality [Inci (2009)]. The results show that spot subsidies represent a more cost efficient solution but rely on the existence of symmetries of information between the private firm and the public planner. In a context of asymmetries of information pre-committed subsidies represent a more appropriate solution.

This paper contributes to the literature that looks to develop better tools to assess the impact of public intervention [e.g. David and Hall (2000), Tassey (2005), Inci (2009), Toole (2009)]. It contributes to this field by developing a framework that links the private and social value perspectives of a firm. It allows measuring the level of social underinvestment, the positive externalities generated by public intervention and also the costs for a public planner by taking into account the direct costs of the subsidy and the resulting changes in the tax revenues. In this sense it addresses a weakness pointed out by Hymel (2006) by clarifying and properly measuring the costs and benefits of a social planer associated with a specific policy choice.

The remainder of the paper is as follows: section 1 presents the main model, section 2 presents the numerical analysis and finally section 3 concludes.

1. The model

The EBITDA generated by a firm once is producing is defined as x_t. This stream of earnings x_t is uncertain and follows *gBm*[5],

$$dx = \mu x dt + \sigma x \, dz \quad [1]$$

in which μ is a drift term, σ measures the volatility of the earnings flow x and dz is the increment of a standard Wiener process.

The value of all contingent claims to this earnings flow are solutions to following general partial differential equation (PDE), in which A represents the claim being valued, the subscripts indicate partial derivatives and r represents the return on a riskless asset,

$$0.5\,\sigma^2 x^2 A_{xx} + \mu x A_x - r\,A + x = 0. \quad [2]$$

(4) Please see Wohlgemuth and Madlener (2000) for a comprehensive list of public mechanisms aimed at fostering private investment.

(5) In terms of the modeling choices, this paper follows a very similar approach to Goldstein, Ju and Leland (2001), however this paper considers EBITDA as the value driver of the firm instead of EBIT as assumed in Goldstein, Ju and Leland (2001). By considering EBITDA we are able to take into account an additional stakeholder, it allows clarifying how governments participate in the costs of investment and to explain why, even with a symmetrical tax system, there is no tax neutrality regarding investment decisions.

This PDE was derived using contingent claims analysis and assuming all agents are risk neutral. The general solution for this type of PDE is of the type,

$$A(x) = A_C + C_1 x^{\beta_1} + C_2 x^{\beta_2} \qquad [3]$$

in which the particular solutions for A_C result from the non-bubble condition [7], C_1 and C_2 are constants to be determined, and β_1 and β_2 are solutions to the following quadratic equation,

$$0.5\sigma^2\beta^2 + \left(\mu - \frac{\sigma^2}{2}\right)\beta - r = 0 \qquad [4]$$

and therefore,

$$\beta_1 = 0.5 - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{\mu}{\sigma^2} - 0.5\right)^2 + \frac{2r}{\sigma^2}} > 1, \qquad [5]$$

$$\beta_2 = 0.5 - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{\mu}{\sigma^2} - 0.5\right)^2 + \frac{2r}{\sigma^2}} < 0. \qquad [6]$$

The non-bubble condition that applies to the present value accruing to all agents is,

$$lim_{x\to\infty} A(x) = \frac{x}{r-\mu} \;, \qquad [7]$$

Given that the constants C_1 and C_2 are both zero, since $\beta_1 > 1$ and there is no conceivable optimal abandonment since x follows gBm, the present value of this earnings flow for all risk neutral investors ($A(x)$) is simply,

$$A(x) = \frac{x}{r-\mu} \;. \qquad [8]$$

This represents the well known Gordon and Shapiro (1956) formula; however, it does not represent a realistic estimate of the social value of the firm. Although it considers the present value of the earnings generated by the firm to all agents considered, it ignores that fixed costs imply that investors may be required to make cash injections to keep the firm afloat and may therefore be unwilling to operate the firm for low enough values of x. In terms of investments it also ignores that not all agents contribute to the costs of investment, although all benefit from them. Therefore the timing of investment also requires a more thorough analysis that is detailed next.

1.1. The operating firm

Following an initially investment H the firm develops its production facility and starts generating the earnings flow x. The value of all the claims to the earnings flow x are solutions to following PDE, in which π_i represents the cash-flows accruing to each claim,

$$0.5\,\sigma^2 x^2 A_{xx} + \mu x A_x - rA + \pi_i = 0. \quad [9]$$

This production facility has an average life of *T* years, which means that it continuously depreciates (*H/T*)*dt* and requires continuous capital expenditures (*capex*) to maintain its production capacity.

The cash-flows accruing to shareholders (π_E), at any small period *dt*, are then given by,

$$\pi_E = \left(x - \frac{H}{T}\right)(1-\tau)dt - \left(capex - \frac{H}{T}\right)dt, \quad [10]$$

In order to maintain its production capacity and keep generating *x*, the firm needs to make capital expenditures that restore the economical value of its assets, so that at any moment the economical value of its assets equals *H*. If *cape*x = *H/T* and the accounting depreciation equals the economic depreciation of the assets (*d* = *H/T*), the continuous stream of earnings flows accruing to shareholders simplifies to equation [11][6],

$$\pi_E = (x-d)(1-\tau)dt. \quad [11]$$

The continuous flow of capital replacement investments *d*, necessary to maintain the production capacity, represents a fixed cost that operationally leverages the firm. Operational leverage is associated with fixed operating costs of which the most significant are usually salaries that remunerate the workers of the firm and equipment expenses that remunerate supporting firms that supply capital assets. In this paper, we focus our analysis on the supporting firms, which supply the equipments and services required to maintain the production capacity of the firm, although the workers of the firm may represent a more intuitive claimholder. Firstly, by considering the supporting firms instead of the workers our paper may loose some intuitiveness, but it gains in thoroughness by providing a strong link between the fixed operating costs, the initial costs of investment (e.g. the book value of the assets) and the expected life of these productive assets. Such a link would be absent if we considered the wages and salaries of the workers of the firm instead and any relation between *H* and *d* would be purely arbitrary. To consider the workers additionally to the supporting firms would be theoretically redundant and would only increase the number of parameters used in the model. Secondly, it has been shown that that machinery and equipment investment has a strong association with growth in terms of GDP[7] and therefore to consider this cost component provides a strong and intuitive link between micro variables at the level of the firm and macro variables at the level of the economy. Finally, recent evidence shows the importance of supporting firms as a driver for public intervention as reflected in the inclusion of the automotive industry in the US Troubled Asset Relief Program [see Hill, Menk and Cooper (2010) for a

(6) Henceforth we omit the *dt* parameter so that the cash-flows are represented as they are plugged into the PDEs.

(7) Bradford, De Long and Summers (1990) show that each percent of GDP invested in equipment is associated with an increase in GDP growth of 1/3 a percentage point per year while the same association is considerably weaker for other types of investment.

detailed analysis of the systemic importance of the automotive industry]. We consider then three different stakeholders as beneficiaries of x, Shareholders (E), the Government (G) and Supporting Firms in the same economy (S).

Regarding the cost of investment, it is entirely financed by shareholders when the investments are realized. In our model we disregard the possibility of financing the costs of investment with debt due to the following reasons: (i) operational leverage allows the firm to benefit from operational tax shields, therefore providing it with few incentives to issue debt (ii) our focus on operational rather than financial leverage, relates to the concerns of the social planner, and supporting firms are in many occasions an important driver for public intervention, whereas similar concerns are rarely displayed regarding the providers of investment capital (iii) the introduction of debt financing would not change the qualitative nature of our arguments, as long as the debt contract used did not induce a divergence of objectives between shareholders and debtholders. Regarding this last point, by assuming all equity financing we are disregarding potential agency conflicts between shareholders and debtholders. However, our framework may still be seen through the lenses of agency theory. In our case, we analyze an agency conflict between shareholders and society (represented also by the government and the supporting firms) that translates into an underinvestment problem as it is later explained[8].

In terms of the corporate tax system, we assume a symmetrical tax system in which the government equally and proportionally participates in both the losses and profits of the firm. In practice, the government also contributes to the investment costs H, although it does not do it at the moment the investment is realized, but throughout its economical life.

Table I summarizes how the earnings are distributed among the three claimants and how each participates or benefits from the initial cost of investment.

Table I: CLAIMS TO THE EARNINGS FLOW X AND CONTRIBUTION TO THE COSTS OF INVESTMENT H

Stakeholder	π_i	Participation in investment
Shareholder (E)	$-d(1-\tau) \leq \pi_E = (x-d)(1-\tau) < \infty$	Contributes H when investment is realized, recovers τd during T
Government (G)	$-d\tau \leq \pi_G = (x-d)\tau < \infty$	No contribution when investment is realized, 'contributes' τd during T
Supporting firms (S)	$\pi_S = d$	Benefits from H when investment is realized

Notes: This table presents the division of the flow x between the different claimholders and how each contributes / benefits from the cost of investment H.

Source: Own elaboration.

(8) We are grateful to an anonymous referee for a clear discussion on the potential agency implications of our work and for frameworking our problem within the theory of agency conflicts.

The value of the different stakeholders claims are solutions to the PDE [9] with a general solution given by equation [3], in which the particular solutions for A_C result from the non-bubble conditions [12], [13] and [14] when $x >> x_A$, C_1 and C_2 are constants to be determined given appropriate boundary conditions and β_1 and β_2 are given in expressions [5] and [6].

The non-bubble conditions are as follows,

$$lim_{x\to\infty} E(x) = \left(\frac{x}{r-\mu} - \frac{d}{r}\right)(1-\tau), \qquad [12]$$

$$lim_{x\to\infty} G(x) = \left(\frac{x}{r-\mu} - \frac{d}{r}\right)\tau, \qquad [13]$$

$$lim_{x\to\infty} S(x) = \frac{d}{r}\,. \qquad [14]$$

When the abandonment probability is negligible, the value of $E(x)$, $G(x)$ and $S(x)$ is given by [12], [13] and [14] and since $\beta_1 > 1$, C_1 must be equal to 0. Although the flow x cannot be negative, it is possible that the cash-flows accruing to shareholders (π_E) are negative and, in order to cover the shortfall for the replacement investment d, shareholders may have to inject cash in the firm. In this case, there is an earnings level x_A for which it will not be optimal for shareholders to keep on injecting funds in the firm to maintain the replacement investment d and it is optimal simply to abandon. This is the main reason why the value $A(x)$ given by equation [7] is not realistically obtainable[9]. The value of the different claims after abandonment allows determining C_2. The value-matching abandonment boundary conditions are as follows,

$$E(x_A) = 0, \qquad [15]$$

$$G(x_A) = 0, \qquad [16]$$

$$S(x_A) = 0. \qquad [17]$$

Once shareholders decide to abandon operations, they are unable to recuperate the investments made and the firms' assets have a salvage value of 0 (boundary 15). Similarly, the government stops 'receiving' its flow of corporate taxes (boundary 16) and the supporting firms stop 'receiving' the replacement investment d (boundary 17).

Replacing the solutions for A_C and C_2 in the general solution [3] generates the value expressions for $E(x)$, $G(x)$ and $S(x)$,

$$E(x) = \left(\frac{x}{r-\mu} - \frac{d}{r}\right)(1-\tau) - \left(\frac{x_A}{r-\mu} - \frac{d}{r}\right)(1-\tau)\left(\frac{x}{x_A}\right)^{\beta_2}, \qquad [18]$$

(9) The value A could only be obtained if the firm could be operated under fully variable operating costs, which is not the case when a firm needs to make the replacement investment d.

$$G(x) = \left(\frac{x}{r-\mu} - \frac{d}{r}\right)\tau - \left(\frac{x_A}{r-\mu} - \frac{d}{r}\right)\tau\left(\frac{x}{x_A}\right)^{\beta_2}, \quad [19]$$

$$S(x) = \frac{d}{r} - \frac{d}{r}\left(\frac{x}{x_A}\right)^{\beta_2}. \quad [20]$$

The abandonment trigger is unique, because the decision to abandon operations is entirely on the hands of shareholders, when they stop injecting funds in a loss making firm to finance the replacement investments d, as so, x_A is determined to maximize the value of $E(x)$ as determined by the following smooth-pasting boundary condition,

$$\left.\frac{\partial E}{\partial x}\right|_{x=x_A} = 0. \quad [21]$$

Replacing [21] in equation [18] and solving for x_A, gives us the expression of the abandonment trigger that maximizes the value of $E(x)$,

$$x_A = \frac{\beta_2}{\beta_2-1}\frac{(r-\mu)d}{r}. \quad [22]$$

1.2. The investment stage

Before realizing the investment, the firm generates no income (the earnings flow is 0) and the value of the firm is simply the value of its future growth possibilities (its option to invest in the future). Investment is realized when the earnings flow x reaches a level x_I (the investment trigger), for which the expected present value of future earnings is greater than the total costs of investment (the total cost of investment includes H and the opportunity costs of investing at a higher value of x).

The value of the different claims to the value of the firm before investment ($E_0(x)$, $G_0(x)$ and $S_0(x)$) are also solutions to the general PDE [9] but in which the forcing term of the PDE, π_i, is equal to 0 (a firm with no assets does not generate earnings). The general solution for the value of the different claims is also given by [3] but with A_C = 0 and in which the absorbing barrier $A_0(0) = 0$ requires that $C_2 = 0$. In order to obtain the value of the different claims before investment is realized we need to determine C_1 from the following value-matching investment boundary conditions,

$$E_0(x_I) = E(x_I) - H, \quad [23]$$

$$G_0(x_I) = G(x_I), \quad [24]$$

$$S_0(x_I) = S(x_I) + H. \quad [25]$$

Equation [23] states that shareholders bear the total cost of investment H, which benefits other supporting businesses in the economy [equation 25]. The government does not bear any of the costs of investment H when investment is realized [equation 24], its participation in the costs of investment is done over time, through operational tax shields τd.

Replacing the solutions for C_1 in the general solution [3] generates the expressions for $E_0(x)$, $G_0(x)$ and $S_0(x)$,

$$E_0(x) = \left[\left(\frac{x_I}{r-\mu} - \frac{d}{r}\right)(1-\tau) - \left(\frac{x_A}{r-\mu} - \frac{d}{r}\right)(1-\tau)\left(\frac{x_I}{x_A}\right)^{\beta_2} - H\right]\left(\frac{x}{x_I}\right)^{\beta_1}, \qquad [26]$$

$$G_0(x) = \left[\left(\frac{x_I}{r-\mu} - \frac{d}{r}\right)\tau - \left(\frac{x_A}{r-\mu} - \frac{d}{r}\right)\tau\left(\frac{x_I}{x_A}\right)^{\beta_2}\right]\left(\frac{x}{x_I}\right)^{\beta_1}, \qquad [27]$$

$$S_0(x) = \left[\frac{d}{r} - \frac{d}{r}\left(\frac{x_I}{x_A}\right)^{\beta_2} + H\right]\left(\frac{x}{x_I}\right)^{\beta_1}. \qquad [28]$$

We have now three different measures for the value of a firm,

$$V_1(x) = E_0(x), \qquad [29]$$

in which V_1 represents the value accruing to investors, in our case shareholders,

$$V_2(x) = E_0(x) + G_0(x) \qquad [30]$$

in which V_2 represents the combined value accruing to investors and government and it is the social value of the firm as defined by Mauer and Sarkar (2005) and modeled by Goldstein, Ju and Leland (2001),

$$V_3(x) = E_0(x) + G_0(x) + S_0(x) \qquad [31]$$

in which V_3 represents the combined value accruing to investors, government and the supporting businesses in the same economy. The third measure of firm value represents its social value and takes into account the positive externalities of the firm in terms of the value it creates for its supporting businesses.

Having defined different measures for the value of the firm, we need now to define the investment policies that reflect the objective functions the decision maker pursues. We begin by defining the investment policy that maximizes the value of the investors of the firm (shareholders). The investment trigger that maximizes ($V_1 = E_0$) is defined as x_{I1} and is determined by solving the following smooth-pasting condition,

$$\left.\frac{\partial V_1}{\partial x}\right|_{x=x_{I1}} = \left.\frac{\partial E}{\partial x}\right|_{x=x_{I1}}, \qquad [32]$$

We can numerically solve equation [32] in order to determine the investment trigger x_{I1}, and this represents the classical shareholder maximization decision, famously defended by Milton Friedman [see Friedman (1970)],

$$x_{I1}\frac{(1-\tau)(\beta_1-1)}{r-\mu} + \beta_1\left(\frac{d(1-\tau)}{r} + H\right) + (\beta_2-\beta_1)\left(\frac{x_A}{r-\mu} - \frac{d}{r}\right)(1-\tau)\left(\frac{x_{I1}}{x_A}\right)^{\beta_2} = 0\,. \qquad [33]$$

Our second investment policy pursues the underlying objective of maximizing the combined value of the investors and the government ($V_2 = E_0 + G_0$). The investment trigger that maximizes (V_2) is defined as x_{I2} and is determined by solving the following smooth-pasting condition,

$$\left.\frac{\partial V_2}{\partial x}\right|_{x=x_{I2}} = \left.\frac{\partial (E+G)}{\partial x}\right|_{x=x_{I2}}, \quad [34]$$

and once again, we can numerically solve equation [34] to determine the investment trigger x_{I2},

$$x_{I2}\frac{(\beta_1-1)}{r-\mu} + \beta_1\left(\frac{d}{r}+H\right) + (\beta_2-\beta_1)\left(\frac{x_A}{r-\mu}-\frac{d}{r}\right)\left(\frac{x_{I2}}{x_A}\right)^{\beta_2} = 0\,. \quad [35]$$

Finally we define our third investment policy as pursuing the underlying objective of maximizing the combined value of all the stakeholders of the firm ($V_3 = E_0 + G_0 + S_0$) and this is the management objective as prescribed by different managerial theories. The investment trigger that maximizes (V_3) is defined as x_{I3} and is determined by solving the following smooth-pasting condition,

$$\left.\frac{\partial V_3}{\partial x}\right|_{x=x_{I3}} = \left.\frac{\partial (E+G+S)}{\partial x}\right|_{x=x_{I3}}, \quad [36]$$

once more, we need to numerically solve equation [36] in order to determine the investment trigger x_{I3},

$$x_{I3}\frac{(\beta_1-1)}{r-\mu} + (\beta_2-\beta_1)\frac{x_A}{r-\mu}\left(\frac{x_{I3}}{x_A}\right)^{\beta_2} = 0\,. \quad [37]$$

2. Numerical analysis

Consider a firm in a low competitive economic sector characterized by having an expected growth rate of 0 ($\mu = 0$) holding an investment opportunity with a cost of 100 ($H = 100$), an expected life of 10 years ($T = 10 \Rightarrow d = 10$) and a current estimated yearly EBITDA of 7.5 ($x_0 = 7.5$). This choice of parameter values generates an expected total payout at the expected time of investment for Policy 1 (x_{I1}) of 4.8% a figure in line with the estimates of Eom, Helwege and Huang (2004) and the total payout of 5% typical of an average S&P firm reported in François and Morellec (2004) and Hackbarth, Miao and Morellec (2006). The volatility of earnings is assumed to be 0.2 ($\sigma = 0.2$), although slightly lower, still in line with the estimates of Eom, Helwege and Huang (2004), Hackbarth, Miao and Morellec (2006) and Schaefer and Strebulaev (2008). The risk-free-rate is constant and represents 5% ($r = 5\%$), a figure similar to historical yields on US 10 year T-bonds and the tax system is fully symmetrical and firms have to pay corporate taxes at the rate of 25% ($\tau = 25\%$) a figure lower than the 40% statutory corporate tax rate of the US tax code, but closer to the average effective US tax rate taking into account the loopholes, tax credits, and legal tax deductions.

2.1. Impact of socially optimal investment policies

Table II presents firm and claim values and the investment and abandonment triggers considering the different investment policies.

Table II: INVESTMENT TRIGGERS AND STAKEHOLDER CLAIM VALUES FOR DIFFERENT INVESTMENT POLICIES

Investment policy	x_I	x_A	E_0	G_0	S_0	V_2	V_3
Policy 1 (max E_0)	29.2	5.4	10.5	5.3	14.5	15.8	30.3
Policy 2 (max E_0+ G_0)	25.8	5.4	10.3	5.8	18.6	16.1	34.7
Policy 3 (max E_0+ G_0+ S_0)	8.7	5.4	-57.1	4.9	134.0	-52.2	81.8

Notes: This table presents values of the firm and of the different claims (E_0 -Shareholders, G_0 Government and S_0 -Supporting firms, V_2 -Sum of value to shareholders and government and V_3 -Sum of value to all claims), investment and abandonment triggers (x_I -investment and x_A -abandonment) considering three different investment policies. Policy 1 aims at maximizing the value of the shareholders' claim, Policy 2 aims at maximizing the combined value of the shareholders and the government and Policy 3 aims at maximizing the value of the three claims considered. The base-case parameter values are as follows: x_0 is 7.5, $\mu = 0$, $\sigma = 0.2$, $H = 100$, $T = 10 \Rightarrow d = 10$, $r = 5\%$ and $\tau = 25\%$.

Source: Own calculations.

Table II shows that investment policy 3 is the one that clearly maximizes the social value of the firm; however, it also shows that the social optimum is clearly not Pareto optimal. Policy 3 maximizes the present value of the earnings flow (x) generated by the assets of the firm, but within the resulting distribution of wealth between all different claims (according to the characteristics of the different claims as presented in Table I) the shareholders and, to a lower degree, the government loose in favor of the supporting businesses. Shareholders have an incentive to delay investing beyond what would be socially optimum ($x_I = 8.7$), because they bear the full costs of investment upfront but share the benefits of investment with other stakeholders. Following Myers (1977), rational shareholders wait for higher earnings ($x_I = 29.2$) before realizing the investment in order to capture a higher proportion of the benefits generated and maximize their own wealth. If investment takes place at the socially optimum, shareholders suffer a significant wealth transfer of 65.6. Two different components contribute to this loss of value, firstly, the negative net present value (NPV) to shareholders of investing when $x = 8.7$ that represents -57.1, the second component is the opportunity cost of 'killing' the investment option too early that represents -10.5.

Regarding investment policy 2, the differences with investment policy 1 are not very significant and result merely from the fact that the tax system considered is not neutral to investment decisions. Shareholders bear the costs of investment when the investment is realized and the government makes its contribution over a period of T years. For clarification, consider the case of our base case parameter values. The cost of investment of 100 is amortizable during 10 years in an economy with a symmetrical corporate tax system with a tax rate of 20%. When the investment is realized, shareholders pay the total investment costs 100. Once the project starts generating earnings, the government will make its contribution through the yearly tax savings of 2 (τd), that over the 10 year period amount to a total contribution of 20, representing 20% of the investment costs. From the shareholders perspective, shareholders contribute 100% of the investment costs when the investment is realized, but they recover 20% of these costs during the following 10 years. The delay in the governmental contribution to the costs of investment induces the earlier investment reported in Table II for investment policy 2, relative to the shareholder maximization case (under investment policy 2 the firm invests at a cash flow level of 25.8, relatively lower than the shareholder optimum of investing when x reaches 29.2). Regarding the abandonment decision we consider a single policy throughout the paper, abandonment following the objective to maximize shareholder value. There is however a coincidence of interests between the government and shareholders regarding the abandonment decision, resulting from the symmetrical nature of the tax system (equation [22] is not a function of τ). Under an asymmetrical tax system or when pursuing the interests of the supporting firms, the optimal decision in policies 2 and 3 would be never to abandon, however, and as Leland (1998) points out, such abandonment policy would inevitably result in a violation of limited liability.

It is clear that the socially optimum policy is not Pareto optimal and this explains the underinvestment behavior of shareholders. If shareholders pursue an objective of social value maximization they will suffer a significant transfer of wealth towards the supporting firms. Both these aspects are not new and have been reported and discussed in previous research. The divergence between the socially and the privately optimum, resulting from positive externalities affecting other firms, has already been identified in González, Jaumandreu and Pazó (2005). The trade-offs between the different stakeholders associated with pursuing social objectives have already been discussed in Jensen (2001) and are at the basis of Jensen's statement that managers cannot serve many masters. These results may however help shed some light on the evidence suggesting a negative relation between Corporate Social Responsibility [e.g. see Gri n and Mahon (1997)] or Stakeholder Management [e.g. see Hillman and Keim (2001)] and financial performance.

Regarding the static analysis presented in Table III the results are mostly as anticipated.

Decreases in the growth rate (μ), increases in the investment costs (H), decreases in the average life of the assets (T) or increases in the interest rates (r), increase the investment triggers and reduce the value of all individual claims and the social value of the firm. In terms of increases in corporate tax rates (τ), they induce a delay in investments in policy 1 and they negatively affect shareholder value and positively affect governmental value across all investment policies. With investment policy 1 they also affect the value of the supporting businesses negatively, but when considering investment policies 2 and 3 there is no effect in terms of the timing of investment and the value of supporting businesses and the social value are both unaffected by changes in τ. Regarding increases in volatility (σ), the results show a decrease in the abandonment triggers and an increase in the investment triggers in policies 1 and 2. In policy 3, however, there is a decrease in the investment trigger. This counterintuitive result is explained by the fact that this investment policy maximizes the value of all claims; therefore there is a strong incentive to invest as early as possi-

Table III: COMPARATIVE STATICS FOR FIRM AND CLAIM VALUES, ABANDONMENT AND INVESTMENT TRIGGERS

	Effects of increases in the following parameter values					
	μ	σ	r	τ	H	T
x_A	↓	↓	↑	–	↑	↓
Panel A: Investment Policy 1 (Maximize firm value)						
x_{I1}	↓	↑	↑	↑	↑	↓
V_0	↑	↑	↓	↓	↓	↑
G_0	↑	↑	↓	↑	↓	↑
S_0	↑	↑	↓	↑	↓	↑
V_2	↑	↑	↓	↓	↓	↑
V_3	↑	↑	↓	↓	↓	↑
Panel B: Investment Policy 2 (Maximize firm and government values)						
x_{I2}	↓	↑	↑	–	↑	↓
V_0	↑	↑	↓	↓	↓	↑
G_0	↑	↑	↓	↑	↓	↑
S_0	↑	↑	↓	–	↓	↑
V_2	↑	↑	↓	–	↓	↑
V_3	↑	↑	↓	–	↓	↑
Panel C: Investment Policy 3 (Maximize value of all stakeholders)						
x_{I3}	↓	↓	↑	–	↑	↓
V_0	↑	↓	↓	↓	↓	↑
G_0	↑	↑	↓	↑	↓	↑
S_0	↑	↑	↓	–	↓	↑
V_2	↑	↑	↓	–	↓	↑
V_3	↑	↑	↓	–	↓	↑

Notes: This table presents directional changes in claim and firm values (E_0 -Shareholders, G_0 Government and S_0 -Supporting firms, V_2 -Sum of value to shareholders and government and V_3 -Sum of value to all claims), investment and abandonment triggers (x_I -investment and x_A -abandonment) resulting from increases in a parameter value holding all remaining parameters constant. The base-case parameter values are as follows: x_0 is 7.5, $\mu = 0$, $\sigma = 0.2$, $H = 100$, $T = 10 \Rightarrow d = 10$, $r = 5\%$ and $\tau = 25\%$.

Source: Own calculations.

ble. However, this acceleration of investments was limited by the abandonment decision of shareholders, and by entering too early, the expected time of actual operations would be reduced. However, with increased volatility, shareholders delay the decision to abandon significantly, therefore allowing the firm to invest much earlier when looking to maximize the social value.

2.2. *Implications for social planners*

Our results show that for the social planner, the social value of the firm is quite important due to the positive externalities associated, in our case, with the value accruing to the supporting businesses. The second measure of social value considered and traditionally used in previous research [e.g. Mauer and Sarkar (2005) or Goldstein, Ju and Leland (2001)] is quite limited in the sense that ignores the role of these important externalities. The results also show that, although challenging, there is scope for a public planner to intervene with an objective to improve social welfare. He must necessarily take into account and balance the shareholder value maximizing objectives with its own objectives of achieving welfare maximization and maintaining a balanced public budget.

From the point of view of the public planner, when defining its policies, it will look for ways to accelerate investments. To achieve this goal, there are several options available such as fostering competition, or using subsidies or tax breaks. In terms of competition, we are implicitly assuming a sector with imperfect competition and that is why we value investment options. If there is perfect competition, the strategic investment triggers will converge to the zero NPV or Marshallian triggers [see Lambrecht and Perraudin (2003) amongst others] thereby increasing the social value of firms. When awarding subsidies or tax breaks, governments are compensating (in some cases even rewarding) the financial claimants (notably shareholders) for the wealth transfer they have suffered to other claimants by accelerating investment.

The following section models and analyses the results of a specific policy instrument aimed at accelerating private investments. It considers an investment subsidy, because as Inci (2009) points out, public subsidizing of private investments allows achieving Pareto optimality while increasing social welfare.

2.3. *Analysis of a public investment subsidy*

Let us consider our example within a direct public investment subsidy. Within our framework, the main question for the social planner when designing the subsidy simplifies to a cost-benefit analysis.

In terms of the value functions, the subsidy does not affect the value of the operating firm and the operating value accruing to the different agents since it is an investment subsidy and not an operating subsidy.

For the supporting businesses there is also no impact in terms of their value function before investment is realized; however there is a change for the values of the shareholders and the government that we now define as E_{S0} and G_{S0}.

The benefits of the subsidy are associated with an earlier investment and the present value of the social benefits, reflecting the increase in welfare and are defined as,

$$\textit{Social Benefits}\ (SB) = V_{S3}(x_0) - V_3(x_0). \tag{38}$$

The cost for the social planner represents the present value of the subsidy needed to induce shareholders to invest earlier and is defined as,

$$\textit{Social Planner Costs}\ (SPC) = G_{S0}(x_0) - G_0(x_0). \tag{39}$$

The social net position naturally represents the difference between the Social Benefits generated and the costs accrued by the social planner

$$\textit{Social Net Position (SNP)} = SB - SPC. \quad [40]$$

2.3.1. Pre-committed subsidy

This specific policy implies that the government determines the optimal subsidy it will award (K) rationally anticipating the investment behavior of the shareholders. Once the optimal subsidy K is defined, the government is not required to monitor the evolution of x. With the investment subsidy K, the following value matching conditions replace equations [23] and [24] and allow us to determine the appropriate C_1 coefficient in equation [11],

$$E_{S0}(x_1) = E(x_1) - (H - K), \quad [41]$$

$$G_{S0}(x_1) = G(x_1) - K. \quad [42]$$

Equation [41] states that shareholders now only bear part of the investment costs, since they benefit from a direct subsidy K at the time of investment. The subsidy K is taken into account in the investment value matching condition of the government [equation 42]. With the subsidy the government directly bears part of the costs of investment H when the investment is realized therefore approximating the shareholders' and the government claims.

Replacing the solutions for C_1 in the general solution [3] we determine the new value expressions for $E_{S0}(x)$ and $G_{S0}(x)$.

$$E_{S0}(x) = \left[\left(\frac{x_I}{r-\mu} - \frac{d}{r}\right)(1-\tau) - \left(\frac{x_A}{r-\mu} - \frac{d}{r}\right)(1-\tau)\left(\frac{x_I}{x_A}\right)^{\beta_2} - (H-K)\right]\left(\frac{x}{x_I}\right)^{\beta_1}, \quad [43]$$

$$G_{S0}(x) = \left[\left(\frac{x_I}{r-\mu} - \frac{d}{r}\right)\tau - \left(\frac{x_A}{r-\mu} - \frac{d}{r}\right)\tau\left(\frac{x_I}{x_A}\right)^{\beta_2} - K\right]\left(\frac{x}{x_I}\right)^{\beta_1}. \quad [44]$$

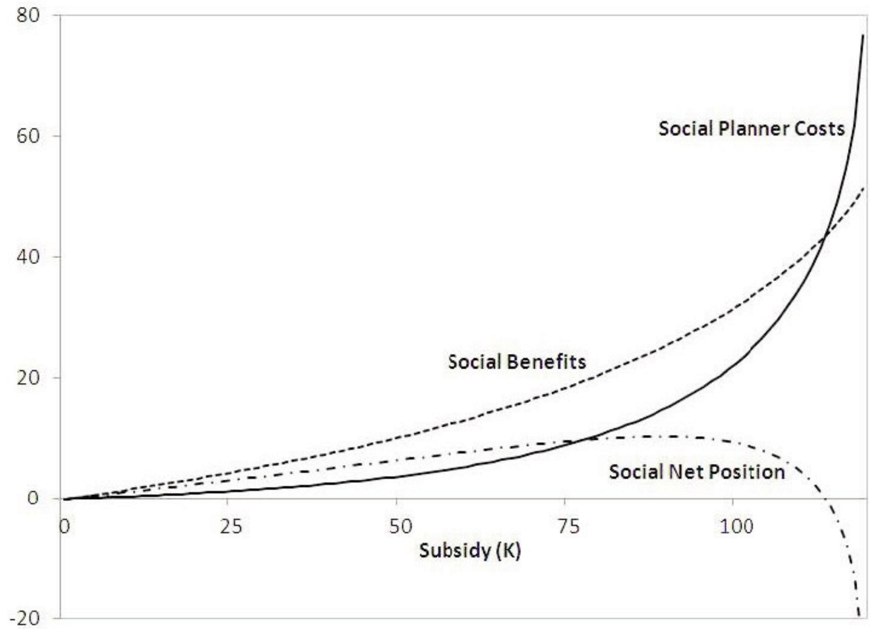
The subsidy affects the investment decision and the new investment trigger results from solving equation [32] with the new value function [43] for E_{S0} replacing [26] for E_0, yielding the following equation that can be numerically solved for the investment trigger x_{IS},

$$x_{IS}\frac{(1-\tau)(\beta_1-1)}{r-\mu} + \beta_1\left(\frac{d(1-\tau)}{r} + (H-K)\right) + (\beta_2-\beta_1)\left(\frac{x_A}{r-\mu} - \frac{d}{r}\right)(1-\tau)\left(\frac{x_{IS}}{x_A}\right)^{\beta_2} = 0\,. \quad [45]$$

For the base case parameter values, Figure I presents the benefits, costs and the net position for different subsidy values.

Figure I shows that direct investment subsidies have the potential to realize social firm value. Even low subsidies produce an increase in welfare higher than the cost the government incurs when implementing them.

Figure I: COST-BENEFIT ANALYSIS OF THE PRE-COMMITTED SUBSIDY



Notes: This figure presents the cost for a social planner (solid line), the social benefits (dashed line) and the net social position (dotted and dashed line) considering different subsidy levels. The base-case parameter values are as follows: x_0 is 7.5, $\mu = 0$, $\sigma = 0.2$, $H = 100$, $T = 10 \Rightarrow d = 10$, $r = 5\%$ and $\tau = 25\%$.
Source: Own calculations.

Figure I also shows that there may be 'too much of a good thing' when talking about subsidies, because the costs for a social planner of high subsidies may easily exceed the increase in welfare they generate. This result is heightened if we consider that the funds allocated to the subsidy by the public planner imply a reduction in other social services at the expense of having an ever increasing public budget. Translating into the timing of investments, it is not economically sound to accelerate the investment for a trigger level lower than 11.4 due to the costs this policy entails. This result already shows the limitations of the specific public policy analyzed that is unable to achieve the socially optimum of investing at a trigger level of 8.7.

Table IV presents the details of three different subsidy policies represented in Figure I.

Policy 1 represents the maximum subsidy the government may award without incurring a deficit. In this case, there is an increase in welfare of 7.7 that benefits the supporting firms and investment occurs at a lower trigger value of 21.0. Policy 2 represents the optimal subsidy in terms of generating the maximum social net gain. To award a subsidy of 89 increases social welfare in 24.9, with a social cost of 14.6 and

Table IV: Pre-committed subsidy results

Subsidy policy	K	x_I	E_{S0}	G_{S0}	S_{S0}	SB	SPC	SNP
Policy 1 ($G_0 = 0$)	59.2	21.0	15.0	0.0	28.1	12.9	5.2	7.7
Policy 2 (max SNP)	88.6	16.4	19.2	-9.3	45.2	24.8	14.5	10.3
Policy 3 ($SNP = 0$)	113.2	11.5	25.6	-38.2	86.3	43.5	43.5	0.0

Notes: This table presents values of the subsidy, of the investment and abandonment triggers (x_I - investment and x_A - abandonment), of the different claims (E_{S0} -Shareholders, G_{S0} -Government and S_{S0} -Supporting firms), and of the social benefits and costs considering three different subsidy policies. Policy 1 represents the maximum subsidy given budgetary constraints, Policy 2 represents the subsidy that maximizes the social net position and Policy 3 represents the maximum subsidy that can be awarded without incurring social costs higher than the social gains generated. The base-case parameter values are as follows: x_0 is 7.5, $\mu = 0$, $\sigma = 0.2$, $H = 100$, $T = 10 \Rightarrow d = 10$, $r = 5\%$ and $\tau = 25\%$.

Source: Own calculations.

in which investment takes place at a trigger value of 16.4. It is important to notice that such a high subsidy implies a public deficit and an important transfer of wealth from the government to shareholders. Shareholders in this case are not only being compensated for their losses, they are being generously rewarded for accelerating investments (the difference $E_{S0}(x_0) - E_0(x_0)$ is equal to 8.7). Budgetary, legal or even political constraints may invalidate this solution due to the deficit it imposes and due to the significant wealth transfers it implies. Policy 3 represents the maximum subsidy that should be awarded, since for higher subsidy levels the costs for the public planner outweigh the social benefits generated.

2.3.2. Spot subsidy

The pre-committed subsidy generates significant wealth transfers between the government and the shareholders of the firm. An alternative solution that minimizes these wealth transfers is to define a spot subsidy awarded at the moment investment takes place. This solution implies that the government must define an appropriate subsidy $K(x_I)$ for every possible x_I.

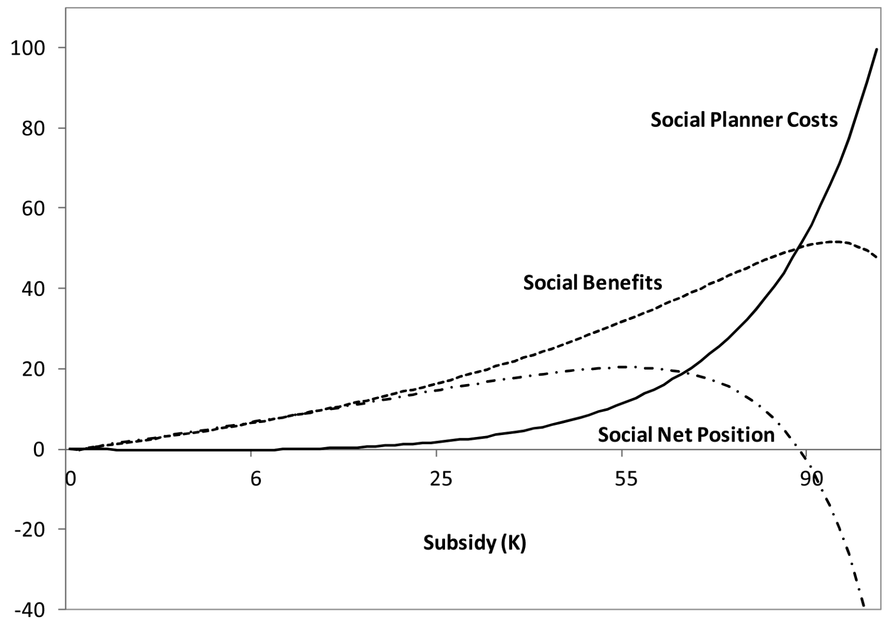
The spot subsidy is defined as the amount that shareholders receive from the social planner at the time of investment, which makes them indifferent between investing earlier and receiving the subsidy or disregarding the subsidy and investing at x_{I1}. Therefore, for each possible investment trigger x_I, the value of the corresponding subsidy $K(x_I)$ is numerically determined from the following equation,

$$E_{S0}(x_I) - E_0(x_{I1}) = 0. \quad [46]$$

In this case, the value accruing to shareholders is not affected by the subsidy and it will always be equal to the initial value $E_0(x_{I1})$. For any given combination of trigger level and subsidy (x_I, $K(x_I)$), the value accruing to the other claimants is determined from equations [44] for the government and [28] for the supporting businesses.

For the base case parameter values, Figure II presents the benefits, costs and the net position for different subsidy values.

Figure II: COST-BENEFIT ANALYSIS OF THE SPOT SUBSIDY



Notes: This figure presents the cost for a social planner (solid line), the social benefits (dashed line) and the net social position (dotted and dashed line) considering different subsidy levels. The base-case parameter values are as follows: x_0 is 7.5, $\mu = 0$, $\sigma = 0.2$, $H = 100$, $T = 10 \Rightarrow d = 10$, $r = 5\%$ and $\tau = 25\%$.

Source: Own calculations.

Similarly to the previous case, we observe that even a small spot subsidy generates a significant increase in social benefits. The spot subsidy represents a cheaper solution than the pre-committed subsidy by allowing investments to be accelerated with a cheaper cost for the public planner. The earlier investment benefits essentially the supporting firms at the expense of the government. The value accruing to the private investors is secured by the subsidy, but the governmental position is unsecured, and therefore the government bears the additional cost of the earlier investment. With this scheme there are no transfers of wealth from the government to the private investors, but there are still important transfers of wealth to the supporting businesses. This explains why with this particular scheme it is not rational to award a subsidy larger than 87.9 (with the pre-committed scheme this figure was 113.2), but it is important to notice that the maximum subsidy with the spot scheme allows an earlier investment relative to what the maximum subsidy with the pre-committed scheme achieved. The results of Table V clarify these aspects considering the same three policies represented in Table IV: Policy 1 in which the government aims to maintain a balanced public budget, Policy 2 in which the government aims to maximize the Social Net Position and Policy 3 that represents the maximum subsidy that should be awarded.

Table V: SPOT SUBSIDY RESULTS

Subsidy policy	K	x_I	E_{S0}	G_{S0}	S_{S0}	SB	SPC	SNP
Subsidy 1 ($G_0 = 0$)	39.9	16.7	10.5	0.0	43.6	23.9	5.3	18.9
Subsidy 2 (max SNP)	55.5	14.3	10.5	-6.6	58.5	32.2	11.8	20.3
Subsidy 3 ($SNP = 0$)	87.9	9.7	10.5	-44.8	114.6	50.1	50.1	0.0

Notes: This table presents values of the subsidy, of the investment and abandonment triggers (x_I -investment and x_A - abandonment), of the different claims (E_{S0} -Shareholders, G_{S0} -Government and S_{S0} -Supporting firms), and of the social benefits and costs considering three different subsidy policies. Policy 1 represents the maximum subsidy given budgetary constraints, Policy 2 represents the subsidy that maximizes the social net position and Policy 3 represents the maximum subsidy that can be awarded without incurring social costs higher than the social gains generated. The base-case parameter values are as follows: x_0 is 7.5, $\mu = 0$, $\sigma = 0.2$, $H = 100$, $T = 10 \Rightarrow d = 10$, $r = 5\%$ and $\tau = 25\%$.

Source: Own calculations.

For the three policies we observe that relative to the pre-committed scheme, the spot subsidy induces an earlier investment with a lower subsidy required. This translates into higher Social Net Gains and it is noticeable that with the spot subsidy it is even possible to obtain the maximum Social Net Gain of the pre-committed scheme and at the same time achieve a balanced public budget. Even if the social costs are lower with the spot subsidy, we observe that it is not rational to try and accelerate investments to the socially optimum of $x_I = 8.7$ due to the high costs it entails for the public planner.

2.3.3. Discussion and extensions

The framework developed in this paper allowed us to analyze two different subsidy schemes under a simple cost benefit analysis. Although the spot subsidy scheme appears to be more efficient, because it effectively eliminates the wealth transfers between the government and the shareholders, it is not applicable in every context and pre-committed subsidies are also appropriate solutions to incentivize investments in specific contexts.

Spot subsidies imply no asymmetries of information between the public planner and the private investors and, therefore, require that the public planner is able to assess the evolution of x. Spot subsides are therefore appropriate solutions when [1] the market value of the investment opportunity is already observable, as in the case of investments in already adopted technologies [2] the public planner is able to monitor the evolution of the market value of the investment opportunity, because it has the know-how to do so, as in the case of public policy supported by agencies dedicated to promote and assess entrepreneurial and innovative initiatives with the capacity to properly assess, forecast and monitor the value of specific investment opportunities[10].

(10) There are several examples of agencies that are able to advise public planners on the value of technology adoption such as governmental agencies (e.g. ICEX - Spanish Agency devoted to attract FDI and support the internationalization Spanish firms), regional agencies (e.g. IDEA, CIDEM Spanish regional innovation and investment agencies), supranational agencies (e.g. UNIDO - United Nations Industrial development Organization) or even academic research centers (e.g. SPRU - research centre of the university of Sussex).

In a context of asymmetries of information between private investors and the government, it is unrealistic to assume that such a scheme could be applied without incurring important monitoring costs. For these cases it would be more appropriate to implement the pre-commitment scheme developed in section 2.3.1.

In this paper we have considered the case of investment subsidies as means to accelerate investments, however there are numerous alternative policy solutions such as direct public provision, tax breaks, operational subsidies or public financing that may also be analyzed within the framework developed in this paper. As so, this framework provides an additional tool for assessing public policy instruments through a simple cost benefit analysis, mostly applicable for single firm or sector target policies.

3. Conclusions

This paper analyzed different measures of the value of a firm, and different objective functions considering three different claimholders. Our results clarify the wealth transfers that take place when we shift the objective function. Given the differences in the investment participation and earnings profiles of the different claimholders, the results show that the social optimal investment policy is not a Pareto optimal policy. However, the results also show that there is significant value that can be realized when departing from a classical shareholder maximization objective. Namely, the value generated to supporting businesses is quite significant and should therefore be included when measuring the social value of a firm.

Building on these findings, we develop a cost benefit analysis tool that allows a social planner to analyze different policy alternatives, define socially optimal investment incentives even when introducing constrains in the analysis such as the need to maintain a balanced public budget. Our results show that if the government has the ability to monitor the evolution of the market value of new businesses or their ability to generate cash flows, a spot subsidy solution is preferable due to the lower costs it generates for the public planner. However, in cases the in which the public planner is unable to track and monitor the evolution of the market value of new businesses governments should apply a pre-committed subsidy policy.

There are several aspects that could extend the framework developed in this paper such as considering alternative claimholders, different corporate decisions, different tax systems, different financing solutions or even introducing the effects of competition. These are all aspects to be developed in future research.

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RESUMEN

Este artículo analiza el valor social de una empresa considerando distintas funciones objetivo y utilizando un modelo de opciones reales. Los resultados muestran que el objetivo de maximizar el valor social no es Pareto óptimo, pero existe la posibilidad de incrementar el valor generado por una empresa si nos distanciamos del objetivo de maximizar el valor del accionista. Teniendo en cuenta el rol de las empresas de suporte, este articulo desarrolla un simple modelo de coste beneficio que puede servir como instrumento de análisis para distintas políticas publicas de incentivos a la inversión.

Palabras clave: opciones reales, incentivos públicos a la inversión.

Clasificación JEL: G31, H25, H32, G18.