Investment Decisions in Granted Monopolies Under the Threat of a Random Demonopolization

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Abstract

This paper studies the demonopolization process of granted monopolies. A demonopolization process may have different origins such as changes in the policy of a government or a regulator, or new invention or innovation competing with existing patented ones. The demonopolization of the market represents a threat for the granted monopolist and is a relevant source of risk. In the existing real options literature, the market structure is assumed to be steady state, not allowed to change. In the current paper, this assumption is relaxed. Here a monopolistic firm faces the threat of demonopolization, that changes the market structure to a duopoly market. This threat is treated as a random source of uncertainty and represents an additional risk both for a granted monopolistic operating firm, and for a company having a granted monopolistic option to invest.

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1 Introduction

In the literature on market structure, contestable markets (proposed by Baumol, Panzar and Willig (1982), a formal definition appears in Baumol (1982)) are characterized by a single or small number of operating firms, whose actions are largely influenced by the fear of new entrants in the market. In pure or perfect contestable markets there are no sunk costs, no barriers to enter, no costs to exit, and a full information context, making that installed companies tend to limit their profits in order to discourage potential entrants to effectively enter the market. In terms of policy implications, a pure contestable market may need no regulation because the (hidden or revealed) potential entrants compel the incumbent(s) to behave in an efficient manner.

In practice, however, markets are not pure contestable and its degree of contestability will depend, among other things, on barriers to entry (or exit): the higher the barriers the lower the degree of contestability (see Png and Lehman (2007), Lal (2005)). In the limit, under the presence of significant barriers that totally block the entrance of new firms, markets can be considered as pure non-contestable.

A particular type of non-contestable markets are granted monopolies where some entity (e.g., the government) gives a firm the exclusive right to exploit a business. This exclusive right allows the firm to avoid, at least during some period of time[2], any type of competition in the market.

Three types of granted monopolies can occur:

i) **Government-granted monopolies:** where the grant issuer is the government or a public entity. Varying accross countries, some examples of government-granted monopolies are: energy (oil, electricity, or gas), telecommunications and postal services, infrastructures (tollroads, airports, or railways), transportation (bus, train, metro, or airline), among others.

ii) **Granted monopolies through special rights:** typical examples of granted monopolies that could ensure no competition in the market are patents and copyrights.

iii) **Other types of granted monopolies:** granted monopolies can also be issued by private entities. Some examples include: a license to exclusively exploit a franchise (in some region, for example) granted by the franchisor, or a license to produce and sell a drug (in some region or county) granted by a pharmaceutical.

[2]Some empirical evidence of finite granted monopolies appears in Viani (2007), Purkayastha (1996).

Some granted monopolies could last forever (as it happens with some of those granted by the government), and some other only last for a predetermined period of time (e.g., patents give the inventor the right to exploit the innovation for a finite – and known – period of time).

However, as a result of a significant modification of the government policy (or some other public entity, like the regulator), and in order to introduce efficiency through competition, for example, the granted monopoly can arrive to an end by a process called *demonopolization*.

Sometimes in literature (e.g. Dewatripont and Roland (1992)) the demonopolization corresponds to the process where a state-owned company goes private, as happened in the ex-communist countries. However, in our approach, demonopolization is far more general: it simply means the end of a monopoly as a consequence of an event that the monopolist doesn't control.

Other examples of demonopolization occurred in several countries where industries and public utilities were privatized in the second half of the past century, namely in the US, Canada and Europe.

Also, in the private granted monopolies the demonopolization of the market can occur. Suppose a franchisor intending to concede a second license within the same region, a new drug for a same disease just being introduced by a pharmaceutical, or a new technology alternative to a patented one just arriving to the market. In all this cases, the incumbent firm faces a demonopolization process, possibly with a major impact on its own value.

In foreign investment decisions, demonopolization can be considered as a particular type of political risk.

An important feature of the demonopolization process is that it probably can not be anticipated by the granted monopolist, occurring, from his point of view, as a catastrophic exogenous random event. This represents the major motivation for this paper, which studies the impact of a random demonopolization of the market on the value of the incumbent, and also on his optimal investment decision.

The model we present is developed taking into account the point of view of the granted monopolistic firm, being useful for the firm's stakeholders. However, the model is also relevant for other types of entities, namely governments and regulators. Some of the important questions that the model may help to answer are the following:

Q1) What is the value of an active firm exploiting a granted monopoly which can randomly end with the demonopolization of the market?

Q2) What is the value and the optimal timing of the option to invest in a granted monopoly project that lasts for a random period of time and ends with a sudden demonopolization process?

Q3) What is the (negative) impact on the incumbent firm (or project) value of a non-anticipated modification of the policy of the grant issuer about the market structure?

Q4) How can the grant issuer (mainly the regulator or the government) mitigate monopolistic abuses invoking the possibility of demonopolization?

Q5) How can the grant issuer induce early investment in a granted monopolistic project (in order to occur in a moment when it is not yet optimal to invest if under a steady state market structure) by the threat of a demonopolization?

Q6) What is the appropriate compensation that must be paid by the grant issuer for a changing in the market structure not pre-established contractually? This would be more relevant for the situations where the grant issuer is a private entity (e.g., a franchisor), since a public entity may have the power to enforce the changes in market structure without paying any type compensation.

Optimal investment under uncertainty have been studied mainly in monopolistic market structures (McDonald and Siegel 1986, Dixit and Pindyck 1994, Trigeorgis 1996) and in some cases in duopoly markets as in Smets (1991) and Grenadier (1996)[3]. In both cases the market structure is a steady state, not allowed to change. In the current paper, this assumption is relaxed. Here a monopolistic firm faces the threat of demonopolization, that changes the market structure to a duopoly market. This threat is treated as a random source of uncertainty and represents an additional risk both for a granted monopolistic operating firm, and for a company having a granted monopolistic option to invest.

This paper unfolds as follows. Section 2 derives the model to value the option top invest in a monopoly threaten by a demonopolization process. Section 3 discusses the results and performs a comparative statics. Finally, section 4 concludes.

2 The Model

In this section we derive the model to determine the value of an active granted monopolistic firm facing the threat of demonopolization, and also the value of the option to invest and optimal investment timing of an idle granted monopolist facing the same threat.

2.1 The value functions for the incumbent and for the new entrant after demonopolization

The valuation follows the standard backwards procedure, starting by the decision process for a follower assuming both that an incumbent is already in place, and the random event that demonopolizes the market has already occurred. Let x be the total cash flow for

[3] A simplified version of Smets (1991) appears in Dixit and Pindyck (1994, section 9.3).

the whole market evolving randomly according to a standard geometric Brownian motion (gBm) as follows:

$$dx = \alpha x dt + \sigma x dz \tag{1}$$

where $x > 0$, α and σ correspond to the trend parameter (the drift) and to the instantaneous volatility, respectively. Additionally, $\alpha \in [0, r)$ is the drift in the equivalent risk-neutral measure and r is the risk-free rate; finally dz is an increment of the Wiener process.

The cash flow that a given firm receives depends on its market share, represented by $D(i)$, where i corresponds to the number of firms in place. Since our model admits both monopoly and duopoly periods, $i = \{1, 2\}$. For convenience we assume *ex post* symmetry implying that both the incumbent (hereafter also referred as the leader) and the new entrant (referred as the follower) share the market equally, receiving each of them a part of total market equal to $D(2) = 0.5$. For the monopoly period, $D(1) = 1$, $xD(1) = x$. To cover asymmetric situations, one can easily relax this assumption (Tsekrekos 2003, Armada, Kryzanowski and Pereira forthcoming).

The demonopolization process puts an end to the monopoly period by dropping a key barrier for entering, and so the leader firm will face competition from a new firm in a duopoly market. The optimal behavior of the firms results from a leader-follower setting as in Dixit and Pindyck (1994, section 9.3). Dropping the barrier doesn't mean necessarily the immediate entry of the follower. In fact, the second firm will behave optimally entering only at a given threshold level of x, denoted by x_f^*.

The value function is given by:

$$F(x) = \begin{cases} \dfrac{K}{\beta_1 - 1}\left(\dfrac{x}{x_f^*}\right)^{\beta_1} & \text{for } x < x_f^* \\[2ex] \dfrac{xD(2)}{r-\alpha} - K & \text{for } x \geq x_f^* \end{cases} \tag{2}$$

where $F(x)$ is the value function for the follower in the two regions (defer region and in the optimal investment region), and K represents the investment cost (assumed to be sunk).

The optimal threshold that breaks the two regions is given by:

$$x_f^* = \frac{\beta_1}{\beta_1 - 1}\frac{r-\alpha}{D(2)}K \tag{3}$$

and β_1 is the positive root of the quadratic equation:

$$\mathcal{Q}(\beta) = \frac{1}{2}\sigma^2\beta\left(\beta - 1\right) + \alpha\beta - r = 0 \tag{4}$$

Let us consider now the value function for the incumbent. After the event that demonopolizes the market, the incumbent is no more a monopolist. Instead, he assumes the leader position waiting for the entry of the follower. Until then, the leader firm continues to receive the whole market cash flow x, but after the follower entry, his cash flows drop to $xD(2)$. Accordingly, the value function for the leader (V_l) must satisfy the following non-homogeneous ordinary differential equation (o.d.e.):

$$\frac{1}{2}\sigma^2 x^2 \frac{\partial^2 V_l(x)}{\partial x^2} + \alpha x \frac{\partial V_l(x)}{\partial x} - rV_l(x) + x = 0 \tag{5}$$

subject to the following boundary conditions:

$$\lim_{x \to 0} V_l(x) = 0 \tag{6}$$

$$\lim_{x \to x_f^*} V_l(x) = \frac{x_f^* D(2)}{r - \alpha} \tag{7}$$

The second boundary (equation (7)) ensures that when the optimal trigger for the follower approaches ($x \to x_f^*$), the value of the active project for the leader drops, and tends to the value of the shared market. The first boundary simply means that when the market cash flow goes to zero, the active project value also goes to zero.

The solution for the non-homogeneous o.d.e. (5) has the form:

$$V_l(x) = c_1 x^{\beta_1} + c_2 x^{\beta_2} + \frac{x}{r - \alpha} \tag{8}$$

where $\beta_1 > 1$ and $\beta_2 < 0$ are the two roots of the quadratic equation (4). Considering the boundary conditions (6) and (7):

$$c_1 = \frac{x_f \left[D(2) - 1\right]}{r - \alpha} \frac{1}{x_f^{*\beta_1}} \tag{9}$$

$$c_2 = 0 \tag{10}$$

From equation (3) we know that $x_f^* = \frac{\beta_1}{\beta_1 - 1} \frac{r-\alpha}{D(2)} K$, so c_1 can be rearranged:

$$c_1 = \frac{\beta_1}{\beta_1 - 1} \frac{D(2) - 1}{D(2)} K \frac{1}{x_f^{*\beta_1}} \tag{11}$$

Accordingly, $V_l(x)$ is given by:

$$V_l(x) = \begin{cases} \dfrac{x}{r - \alpha} + \dfrac{\beta_1}{\beta_1 - 1} \dfrac{D(2) - 1}{D(2)} K \left(\dfrac{x}{x_f^*} \right)^{\beta_1} & \text{for } x < x_f^* \\[2ex] \dfrac{x D(2)}{r - \alpha} & \text{for } x \geq x_f^* \end{cases} \tag{12}$$

where β_1 is as follows,

$$\beta_1 = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt{\left(-\frac{1}{2} + \frac{\alpha}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}} > 1 \tag{13}$$

2.2 The value functions for the incumbent before demonopolization

Before the demonopolization process occurs, the incumbent is a firm that exploits the market as a monopolist, facing, however, the risk of demonopolization. This event, that profoundly modifies the market structure, is due to a third-party decision (e.g., government, regulator), which, from the firm perspective, occurs randomly, and about which he has no control. In other words, the demonopolization process is a random exogenous event. We assume that the demonopolization follows a Poisson process with intensity λ.

This means the active monopolist value function (V_m) must satisfy the following non-homogeneous o.d.e.:

$$\frac{1}{2}\sigma^2 x^2 \frac{\partial^2 V_m(x)}{\partial x^2} + \alpha x \frac{\partial V_m}{\partial x} - rV_m(x) + x + \lambda\left[V_l(x) - V_m(x)\right] = 0 \tag{14}$$

where the last term of the left-hand side of the equation reflects the expected loss in value, for a infinitesimal period of time, due to the occurrence of a non-anticipated demonopolization process.

The solution to this o.d.e. corresponds to the sum of the homogeneous solution to its particular solution, for each region[4]:

$$V_m(x) = \begin{cases} b_1 x^{\eta_1} + b_2 x^{\eta_2} + V_l(x) & \text{for } x < x_f^* \\ \\ b_3 x^{\eta_1} + b_4 x^{\eta_2} + \dfrac{x}{r-\alpha+\lambda} + \dfrac{\lambda}{r-\alpha+\lambda}\dfrac{xD(2)}{r-\alpha} & \text{for } x > x_f^* \end{cases} \tag{15}$$

where b_1, b_2, b_3, and b_4 are arbitrary constants that remain to be determined, and

$$\eta_1 = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt{\left(-\frac{1}{2} + \frac{\alpha}{\sigma^2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}} > 1 \tag{16}$$

$$\eta_2 = \frac{1}{2} - \frac{\alpha}{\sigma^2} - \sqrt{\left(-\frac{1}{2} + \frac{\alpha}{\sigma^2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}} < 0 \tag{17}$$

[4]Note that the value function $V_l(x)$ has two regions depending on x in relation to x_f^*

Noting that:

$$\lim_{x\to 0} V_m(x) = 0 \tag{18}$$

$$\lim_{x\to +\infty} V_m(x) = \frac{x}{r-\alpha+\lambda} + \frac{\lambda}{r-\alpha+\lambda}\frac{xD(2)}{r-\alpha} \tag{19}$$

the constants b_2 and b_3 must be set equal to zero. Condition (18) ensures the active project is worthless if the cash flow is zero, and condition (19) reflects the expected value of V_l in a region where it is optimal for the follower to enter if the market turns to be demonopolized (which happens with intensity λ).

For the remaining arbitrary constants two additional conditions are necessary. The two regions must met at $x = x_f^*$, and so $V_m(x)$ must be continuous and differentiable along x. Accordingly:

$$b_1 x_f^{*\eta_1} + V_l(x_f^*) = b_4 x_f^{*\eta_2} + \frac{x_f^*}{r-\alpha+\lambda} + \frac{\lambda}{r-\alpha+\lambda}\frac{x_f^* D(2)}{r-\alpha}$$

$$\eta_1 b_1 x_f^{*\eta_1 - 1} + V_l'(x_f^*) = \eta_2 b_4 x_f^{*\eta_2 - 1} + \frac{1}{r-\alpha+\lambda} + \frac{\lambda}{r-\alpha+\lambda}\frac{D(2)}{r-\alpha}$$

where $V_l'(x_f^*) = \dfrac{\partial V_l(x)}{\partial x}|_{x=x_f^*}$. Solving in order to b_1 and b_4, we get:

$$b_1 = -\frac{\lambda}{r-\alpha+\lambda}\frac{D(2)-1}{r-\alpha}\frac{\eta_2-1}{\eta_1-\eta_2}x_f^{*1-\eta_1} - \frac{\beta_1}{\beta_1-1}\frac{D(2)-1}{D(2)}\frac{\beta_1-\eta_2}{\eta_1-\eta_2}Kx_f^{*-\eta_1} \tag{20}$$

$$b_4 = -\frac{\lambda}{r-\alpha+\lambda}\frac{D(2)-1}{r-\alpha}\frac{\eta_1-1}{\eta_1-\eta_2}x_f^{*1-\eta_2} + \frac{\beta_1}{\beta_1-1}\frac{D(2)-1}{D(2)}\frac{\beta_1-\eta_1}{\eta_1-\eta_2}Kx_f^{*-\eta_2} \tag{21}$$

2.3 The value and the optimal trigger for the granted monopolist

Let $G(x)$ be the value of the option to invest for the granted monopolist. In absence of demonopolization risk (captured by a $\lambda = 0$) the granted monopolist holds a perpetual investment opportunity, with the well known solutions:

$$G(x)_{\lambda=0} = M(x) = \begin{cases} \dfrac{K}{\beta_1-1}\left(\dfrac{x}{x^*}\right)^{\beta_1} & \text{for } x < x^* \\[2ex] \dfrac{x}{r-\alpha} - K & \text{for } x \geq x^* \end{cases} \tag{22}$$

where $M(x)$ is the value function for the perpetual monopolist, and

$$x^* = \frac{\beta_1}{\beta_1-1}(r-\alpha)K \tag{23}$$

represents the optimal trigger to invest.

For an intensity rate $\lambda > 0$, $G(x)$ defers from $M(x)$. During the continuation period (when it is not optimal to invest, $x < x_m^*$), $G(x)$ must satisfy the following o.d.e.:

$$\frac{1}{2}\sigma^2 x^2 \frac{\partial^2 G(x)}{\partial x^2} + \alpha x \frac{\partial G(x)}{\partial x} - rG(x) + \lambda[\gamma(x) - G(x)] = 0 \tag{24}$$

where:

$$\gamma(x) = \begin{cases} F(x) & \text{for } x < x_l^* \\ \\ p\left[V_l(x) - K\right] + (1-p)F(x) & \text{for } x_l^* \leq x < x_m^* \end{cases} \tag{25}$$

The rationale for $\gamma(x)$ is the following. Remember the granted monopolist is idle, waiting for the optimal moment to invest. If the demonopolization occurs during this period, a second company is allowed to enter the market, and the monopolistic investment opportunity becomes a leader/follower investment problem. Assuming both firms are *ex ante* symmetric, for $x < x_l^*$, i.e., for an x lower that the optimal trigger for the first company to enter the market (the leader), they both prefer to be a follower. In this region the follower value function dominates the leader value function net of the investment cost, and after x_l^* the leader position is more valuable. Formally:

$$F(x) > V_l(x) - K \quad \text{for } x < x_l^* \tag{26}$$

$$F(x) < V_l(x) - K \quad \text{for } x \geq x_l^* \tag{27}$$

and both positions have the same value at $x = x_l^*$:

$$F(x_l^*) = V_l(x_l^*) - K \tag{28}$$

The trigger for the leader, x_l^*, is determine by solving equation (28). After that point, both firms prefer to be the leader, so they both decide to invest. However, only one of them effectively enters the market, achieving the leader position. The other firm acts optimally deferring the investment until x hits x_f^*, where x_f^* the optimal trigger for the follower, given by equation (3).

Accordingly, if the demonopolization process occurs in the interval where $x_l^* \leq x < x_m^*$ the, until then, granted monopolist has the probability p to enter the market as the leader, and $(1-p)$ to become a follower. Even under *ex ante* symmetry (where usually both firms have the same odds to become the leader, $p = 0.5$), we can have $p > 0.5$ for the *ex*-granted monopolist, because managing the option to invest during some period of time can give him some moving advantage.

Taking into account that $G(0) = 0$, and that at the trigger x_m^* the firm immediately invests by paying the investment cost K and receiving V_l, given by equation (12), the solution for $G(x)$ becomes:

$$G(x) = \begin{cases} a_1 x^{\eta_1} + F(x) & \text{for } x < x_l^* \\ a_3 x^{\eta_1} + a_4 x^{\eta_2} + p\left[V_l(x) - K\right] + (1-p)F(x) & \\ \qquad -\dfrac{px}{r-\alpha+\lambda} + \dfrac{prK}{r+\lambda} & \text{for } x_l^* \le x < x_m^* \\ V_m(x) - K & \text{for } x \ge x_m^* \end{cases} \tag{29}$$

The four unknowns (the constants a_1, a_3, a_4, and the trigger x_m^*) are determined by solving numerically and simultaneously the four non-linear equations, that ensure $G(x)$ continuous and differentiable along x:

$$a_1 x_l^{*\eta_1} + F(x_l^*) = a_3 x_l^{*\eta_1} + a_4 x_l^{*\eta_2} + p\left[V_l(x_l^*) - K\right] + (1-p)F(x_l^*) - \frac{px_l^*}{r-\alpha+\lambda} + \frac{prK}{r+\lambda}$$

$$\eta_1 a_1 x_l^{*\eta_1 - 1} + F'(x_l^*) = \eta_1 a_3 x_l^{*\eta_1 - 1} + \eta_2 a_4 x_l^{*\eta_2 - 1} + pV_l'(x_l^*) + (1-p)F'(x_l^*) - \frac{p}{r-\alpha+\lambda}$$

$$a_3 x_m^{*\eta_1} + a_4 x_m^{*\eta_2} + p\left[V_l(x_m^*) - K\right] + (1-p)F(x_m^*) - \frac{px_m^*}{r-\alpha+\lambda} + \frac{prK}{r+\lambda} = V_m(x_m^*) - K$$

$$\eta_1 a_3 x_m^{*\eta_1 - 1} + \eta_2 a_4 x_m^{*\eta_2 - 1} + pV_l'(x_m^*) + (1-p)F'(x_m^*) - \frac{p}{r-\alpha+\lambda} = V_m'(x_m^*)$$

where $F'(x_j^*) = \dfrac{\partial F(x)}{\partial x}|_{x=x_j^*}$, $V_j'(x_j^*) = \dfrac{\partial V_j(x)}{\partial x}|_{x=x_j^*}$, and $j = \{l, m\}$.

3 Particular solutions and comparative statics

The model reduces to two well-known solutions for particular values of λ. When $\lambda = 0$ there is no possibility of demonopolization and the model should reduce to the monopolistic option to invest (McDonald and Siegel 1986). Analytically, for $\lambda = 0$, $\eta_1 = \beta_1$ and $b_1 = -c_1$, making the value of the active monopolist, $V_m(x) = \frac{x}{r-\alpha}$, for the upper range in equation (15). The lower range of the same equation also reduces to $\frac{x}{r-\alpha}$, since for $\lambda = 0$, $b_4 = 0$. The value of the active monopolist is, therefore, only the present value of future cash flows for all range of x, since it faces no threat of competition. The value of the option to invest ($G(x)$) and the trigger value (x_m^*), found numerically, should be the same as the solution for the monopolistic case (x^*).

When demonopolization is imminent, $\lambda = \infty$, the solution must converge to the standard leader-follower duopoly solution (e.g.: Smets (1991)). In fact, for $\lambda = \infty$, $b_1 = 0$, reducing $V_m(x)$ in the top range of equation (15), when $x < x_f^*$, to the leader value $V_l(x)$, and $\eta_2 = 0$, reducing also the bottom range to the leader value $V_l(x)$, i.e. the present value of the cash flows when the market is shared by the two firms. The trigger value of the option to invest must be, in this case, the same as the leader's trigger, x_l^*.

For any intermediate value of λ, for which the firm faces a threat of demonopolization, the net value of the active project $V_m(x) - K$ lies between the value of the project given by the monopolistic case and the duopoly solution. The trigger is in the range between the monopolistic trigger and the leader trigger. As the threat of demonopolization increases (λ increases) the value loss induced by the potential competitor also increases and the trigger decreases, leading to an anticipation the optimal timing of investment.

Figures 1 and 2 illustrate the effect of λ on the values and on the triggers. Figure 1 shows the values for the two extreme cases of λ (zero and infinity) and for $\lambda = 0.1$. The option value and the active project value, shown in those figures, behave as described above. Even for a relatively small threat ($\lambda = 0.1$), the value lost is significant. The active project value loss is higher for higher values of x, while the option value loss is higher for lower values of x, in relative terms. Optimal investment occurs sooner as λ increases and the decrease is more pronounced for lower values of λ (Figure 2).

If the objective is to reduce the trigger to the leader solution, the effective demonopolization is the only mean to achieve it, since after a certain level of λ the marginal decrease of the trigger is very low.

Figures 3 to 5 show the impact of uncertainty (σ). Uncertainty increases the trigger value for investment in all the three cases presented: monopolistic case, duopolistic case and the model proposed in this paper (Figure 3). It seems that as uncertainty increases, the trigger for investment of the granted monopolist becomes closer to the perpetual monopolistic solution rather than to the duopolistic solution. If the objective is to approximate the duopoly solution, a higher threat is needed.

Although the trigger increases with uncertainty, the impact on the value functions varies for different ranges of x. For the parameters used in the analysis the impact is quite small (Figure 4), but differs for the option value and active project value. Figure 5 shows the difference of those values for two levels of σ. The active project value ($V_l(x)$) decreases for low values of x and increases for higher values of x, and the difference converges to zero as x approaches infinity. When uncertainty increases, two opposing effects take place: the value of waiting to be the follower increases, creating an incentive to the leader to delay investment, and the deferment of the follower investment, makes early investment by the leader more profitable since he stays longer as monopolist. The net effect in terms of the trigger is always dominated by the waiting incentive, while the effect on the value functions is not monotone. The net effect is dominated by the waiting value for lower values of x, while the opposite occurs for higher values of x. These effects that drive the values of the two duopoly firms affect the value of the granted monopolist under the threat

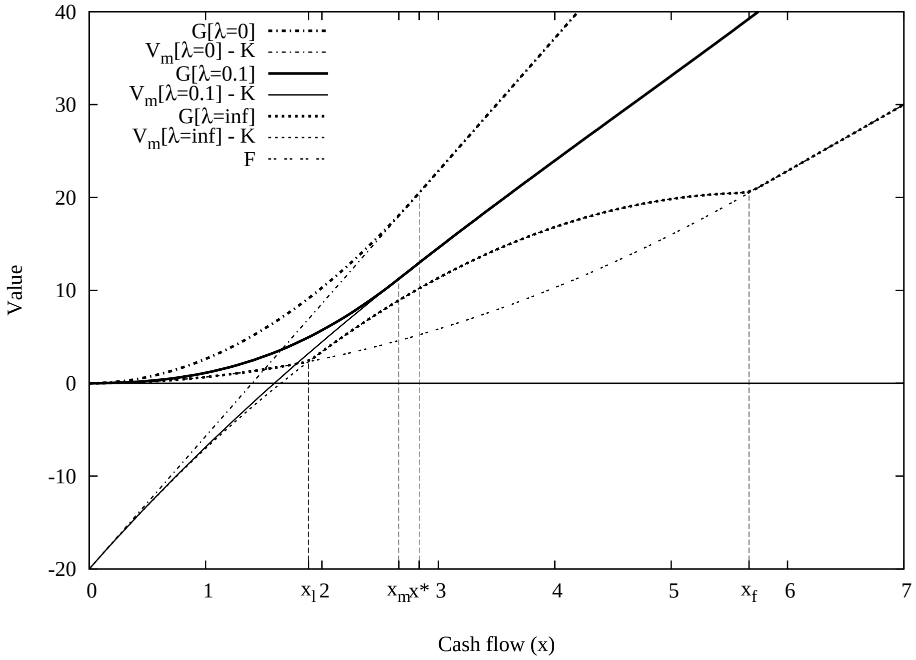

Figure 1: Value functions as a function of x and λ. $\sigma = 0.25$, $r = 0.08$, $\alpha = 0.01$, $K = 20$.

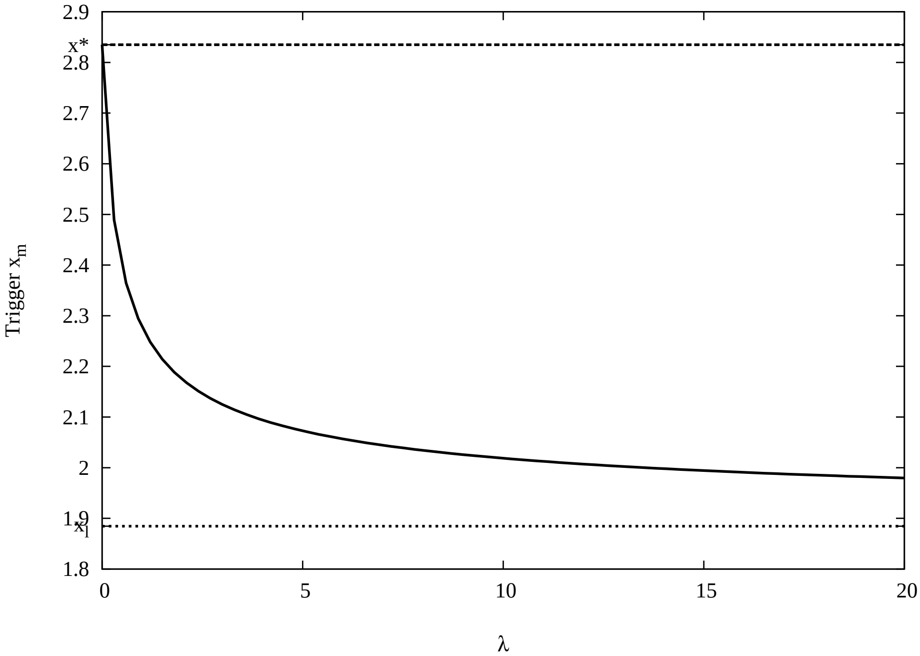

Figure 2: Investment triggers as a function λ. $\sigma = 0.25$, $r = 0.08$, $\alpha = 0.01$, $K = 20$.

of demonopolization ($V_m(x)$) in a similar way: a higher uncertainty reduces the value for low values of x, and increases the granted monopolist value for high values of x.

The option value presents a different impact variation. Although, for the most part, uncertainty increases the option value, it can reduce the option value, for intermediate values of x, where the reduction in the value of the active project induces a lower value of the option to invest. It is interesting to note that when the active project loses value with uncertainty, the option value still increases for a large range of x values.

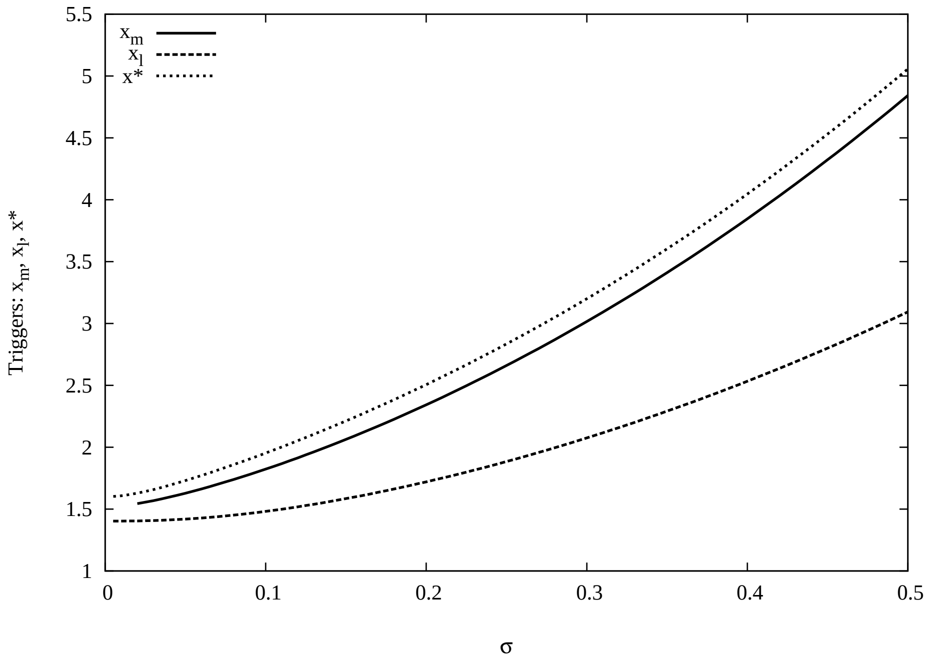

Figure 3: Investment triggers as a function σ. $r = 0.08$, $\alpha = 0.01$, $K = 20$, $\lambda = 0.1$.

4 Concluding remarks

This paper presents a model to determine the value of an active granted monopolistic firm facing the threat of demonopolization, and also the value of the option to invest and optimal investment timing of an idle granted monopolist facing the same threat.

A demonopolization process may have different origins such as changes in the policy of a government or a regulator, or new invention or innovation competing with existing patented ones. The demonopolization of the market represents a threat for the granted monopolist and is a relevant source of risk.

The demonopolization corresponds to a change in the market structure, from a monopoly to a duopoly, which in the existing literature is assumed to be steady state, not allowed to change. In the current paper, this assumption is relaxed. The demonopolization is a

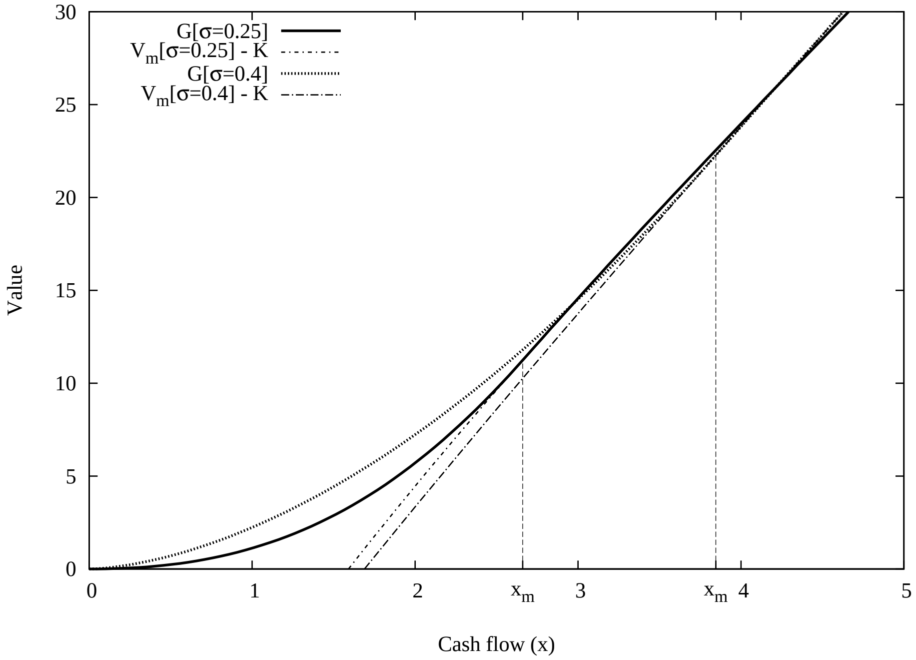

Figure 4: Value functions as a function of x and σ. $r = 0.08$, $\alpha = 0.01$, $K = 20$, $\lambda = 0.1$.

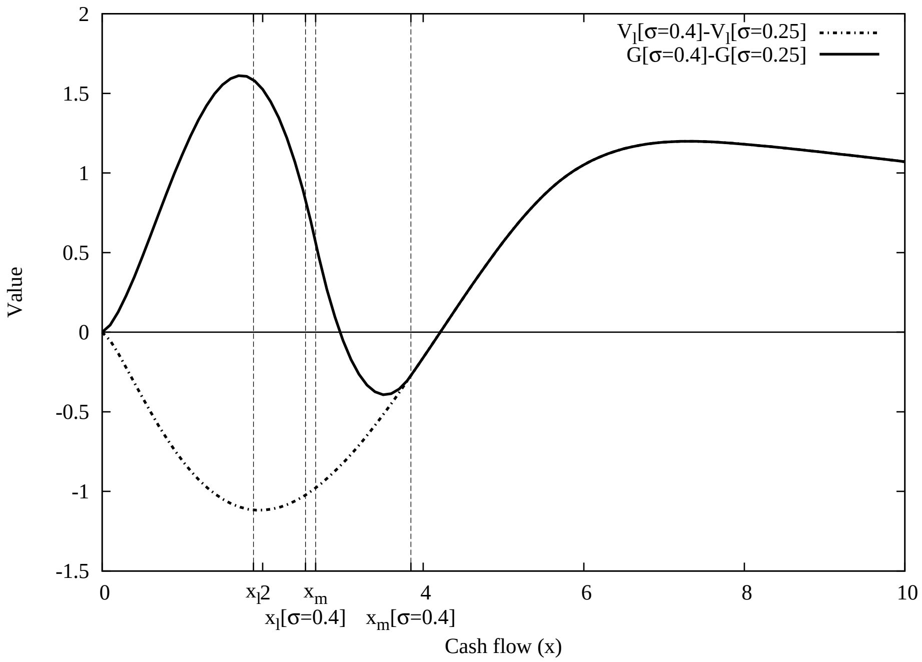

Figure 5: Difference of the value functions as a function of x and σ. $r = 0.08$, $\alpha = 0.01$, $K = 20$, $\lambda = 0.1$.

random exogenous source of uncertainty, modeled as a poisson process with intensity λ, and represents an additional risk, both for a granted monopolistic operating firm, and for a company having a granted monopolistic option to invest.

The model reduces to two well-known solutions for particular values of λ. When $\lambda = 0$ there is no possibility of demonopolization and the solution reduces to the perpetual monopolistic solution (McDonald and Siegel 1986). When the demonopolization is certain, $\lambda = \infty$, the solution converges to the duopoly leader-follower solution as in Smets (1991) and Dixit and Pindyck (1994, section 9.3).

For any intermediate value of λ, for which the firm faces a threat of demonopolization, the net value of the active project lies between the value of the project given by the perpetual monopolistic case and duopoly solution, and the trigger is in the range between the perpetual monopolistic trigger and the leader trigger. As the threat of demonopolization increases (λ increases) the value loss induced by the potential competitor increases, and the trigger decreases, anticipating the optimal timing of investment. Uncertainty increases the trigger value for investment but has an impact in the firm value that varies depending on current value of the firm.

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