



Department of Economics

Competition and the Role of Public Authorities

Mario Mariniello

Thesis submitted for assessment with a view to obtaining the degree of
Doctor of Economics of the European University Institute

Florence, February 2008

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γνωθι σαυτον

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It might sounds weird, but through solitude I realized that I need the others in order to develop my research and ultimately to get to know myself.

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Introduction

This thesis aims at shedding light on three issues which are at the forefront of the European Commission's agenda. The first two chapters deal with the issue of state subsidies and their impact on market competition and development. Both papers design a theoretical setting where such impact can be assessed and provide for the tools needed for welfare analysis. The third chapter, instead, is mainly empirical and aims at measuring the effect on competition due to an increase in advertising in the context of public procurement auctions. Throughout this introduction, I will briefly describe the motivation and the main insights underlying each chapter.

State aid control is one of the main activity of the European Competition Authority. According to the provision reported in the EU Treaty, a state aid is an advantage granted on a selective basis to undertakings by national public authorities. As only some of the (actual or potential) competitors in a market are entitled to get the aid, anytime that such aid is granted, reasonable concerns about a consequential harmful distortion of competition arise. A firm which gets a subsidy might be able to drive out from the market a competitor which is not entitled to get it or it might prevent other firms to enter the market. The same firm might decide to reduce its efforts in developing a better technology which could reduce its costs, because the aid turned it to be not worthy doing. Firms might find unprofitable to invest in innovative activities if their competitors have higher chances to achieve good results thanks to government intervention. And so forth: the list could be much longer. For that reason, the EU Treaty contains a general prohibition of state aid.

The Treaty, however, provides for several exceptions to this ban. The exceptions broadly refer to those cases where the distortion of competition due to the adoption of a state aid system is more than offset by its benefit. Indeed, state aid can be used to stimulate the development of backward economic areas, to rescue firms which are experiencing temporary difficulties or to facilitate firms to access financial markets and funding innovative projects. Thus, if specific conditions are met,

a Member State can be allowed to use subsidy, provided that it has a positive effect on social welfare.

Due to information availability and time constraints the Competition Authority is not always able to check whether that specific state aid had a positive impact on welfare, though. It turns out that some *per se* rules are needed in order to facilitate the screening of those aid schemes which potentially have a negative impact on welfare. One of these rules (which is more properly an established practice) concerns the shape of the aid: according to the European Commission, subsidies which lower firms' variable cost are more distortive than subsidies which lower firms' fixed entry cost. The purpose of the first chapter "European State Aid Policy: Should Variable Cost Aid Be Banned?" is to analyze that statement and check whether it is correct or not.

This question is rather new to the literature: Garcia and Neven (2005) are the first to propose a comparison between variable and fixed cost aid, but in their analysis the government's choice is exogenous and no welfare evaluation of different government's policies can be provided. Chapter 1 instead introduces a simple model where the effect of a general ban of variable cost aid (*VCA*) by a supra-national Authority can be assessed according to the endogenous choices implemented by Member States. The model shows that if the minimum *VCA* necessary to make the entrant break even and enter the market does not cause an incumbent firm to exit the market, then the only type of aid which can occur at the equilibrium is *VCA*, whatever is the shadow cost of subsidization. This happens because while fixed cost aid (*FCA*) has a positive impact on welfare which is given by an increase in competition, *VCA* has an additional positive effect which is due to an increase in the efficiency of one of the competing firms. Given these findings, the model shows that a general ban of *VCA* is unlikely to be an optimal policy. Indeed, Chapter 1 reaches the following conclusions: the European Commission should not prevent governments to use *VCA* if the competing firms do not belong to the European Union or if the Commission adopts a consumer surplus standard and the unique case in which prohibiting *VCA* is welfare enhancing occurs only when the incumbent firm originates from a Member State which is not the one granting the aid.

Difficulties in accessing financial market is claimed to be one of the main factors hampering innovation in Europe. Firms may have good projects without being able to raise the financial resources needed to develop them due to lack of information available to investors. The European Commission reckons this issue to be particularly relevant for small and young enterprises and thus lets Member States implement aid schemes which stimulate innovation of firms which are

smaller or younger than specific thresholds. The purpose of Chapter 2, "Innovation Subsidies and Imperfect Financial Market: Should Small or Young Firms Be Subsidized?", is to analyze the impact of a state aid system according to the size or age of firms, namely to their ability to get funded by banks.

The idea that small or young firms are more affected by market failures is well accepted in the literature (see for example Beck - 2005). This does not mean that subsidizing those firms is necessarily welfare enhancing: indeed, subsidizing firms which are more affected by market failures obviously entails higher costs. Chapter 2 extends the basic model of Holmström and Tirole (1997) introducing asymmetries among firms by considering the amount of information available to banks, which differs from firm to firm. The model shows that, within this setting, a state aid policy which targets only small or young firms maximizes total welfare if the proportion of firms with high probability of success in the economy is sufficiently high. That happens because, even if it is more costly to grant a subsidy to a small or young firm, the positive impact of the subsidy on innovation more than offsets that cost, since the aid targets firms which more likely strictly need it in order to innovate. The model moreover shows that the optimal state aid policy always implies a proportion of firms which do not get the aid even if they would need it in order to innovate. This proportion depends positively on the total cost of investment and negatively on the proportion of firms with high innovative ability in the economy.

In addition, Chapter 2 proposes an alternative aid scheme in which the aid is granted only after the firm has asked a loan to the bank. The advantage of this aid scheme relies on the fact that within it the government can use the bank as a 'filter' in order to select the projects for which the subsidy is strictly necessary. This aid scheme is proved to work better the bigger or the more experienced is the firm.

The last Chapter, "Does Publicity Affect Competition? Evidence from Discontinuities in Public Procurement Auctions" (joint with Decio Coviello), is an empirical analysis of the effect of advertising on tenders for public procurement. There is general consensus in the literature about the existence of a positive relation between number of bidders and auctioneer's rent which, in the context of public procurement auction, is represented by the offered rebate on the price paid by the contracting authority to the winner for the accomplishment of the works. No consensus exists, though, on the effect of an increase in the number of potential bidders. Indeed, the larger is the number of potential participants the lower is the incentive to submit a bid, given the existence of non-negligible participation costs which makes entry risky. As a consequence, advertising a tender

(and thus enlarging the number of potential participants) has an ambiguous effect on auction's final outcome. This result has been proved by Menezes and Monteiro (2000) with a model of auction with endogenous entry but it has not been tested empirically yet. Using a unique dataset on public tenders which took place in Tuscany - Italy in the period 2000 - 2006, Chapter 3 tests the causal effects of publicity by exploiting discontinuities in the Italian law on public procurement auctions. Indeed, the law identifies groups of auctions on the basis of their starting value. To each group a different level of compulsory advertisement policy which might be local, regional, national or European, is associated. Chapter 3 thus implements a Regressions Discontinuity Design (RDD) which allows to compare auctions with similar starting values immediately above or below each discontinuity threshold separating different groups. The empirical analysis reports evidence of a positive and statistically significant effect of publicity on the number of participants to auctions and on the winning rebate. Evidence of a negative correlation between competition and the time to deliver the good put on auction is also reported. Finally, Chapter 3 attempts to identify the effect of publicity on the composition of bidders and finds that advertisement significantly raises the probability that the winner of the auction is a firm which do not belong to the region where the auction takes place. As coordination with outsiders is more difficult, it is thus possible that publicity affects the auctioneer's rent also by decreasing the likelihood of collusive agreements between the participating firms.

Chapter 1

Should Variable Cost Aid Be Banned?

1.1 Introduction

In principle, the use of state aid is banned by the Treaty establishing the European Community. One of the main reasons for the ban lies in the fact that subsidies, altering the relative positions of competing firms, usually lead to welfare reducing distortions in the market. The Treaty, however, allows for a number of exceptions to the general ban whenever the potential distortion of a subsidy is low enough to be overcome by its potential benefits, such as the support of a depressed area or the growth of a particular sector of a country's economy. The purpose of this paper is to analyze a well-established policy of the European Commission on the compatibility of state aid with the Treaty's rules according to which subsidies which lower firms' variable cost (*VCA*) are more distortive than subsidies which lower firms' fixed entry cost (*FCA*). To a certain extent, the definition of variable cost aid coincides with what the Commission calls *operating state aid* i.e. aid ordinarily associated with business' normal operations. As an illustration, consider a recent European competition policy case: the *Ryanair - Charleroi* case.¹ In short, the publicly controlled airport of Charleroi granted some benefits to the air carrier Ryanair in order to encourage the opening of new routes to Charleroi. These benefits have been considered state aid by the Commission, but only some of them have been found to be incompatible with EU rules, given the exceptional features of the depressed area of Charleroi. The Commission decided that those benefits which were sufficiently tied to the start-up of new routes and to the development of the airport could have been considered compatible with the Treaty of Rome under the provision of Article 87(3)(c). On the other hand, those aids which were intended to reduce Ryanair's variable cost had to be given back, since they did not meet the compatibility criteria established by the Commission. Examples of the first type of subsidies - those that were finally allowed - are: 160,000 euros per new route opened, up to a maximum amount of 1,920,000 euros; 200 square meters free of charge to be used for offices and as engineering store; a lump sum contribution to promotional activities. Examples of the second type of subsidies - those that were banned - are: a preferential rate for landing charges of 1 euro per boarding passenger, which is about one half of the official standard rate charged to airlines in Belgium; a rate of 1 euro per passenger for ground-handling services which is about ten times lower than the average rate charged to other airlines.²

¹OJ 2004 L137/1, 12 February 2004

²For reasons which will become clear later (when we will illustrate the basic setting of the model), notice that the complainer in the Ryanair-Charleroi case is AEA, the Association of European Airlines. Among the 31 members, only one (Brussels Airline) is Belgian. Notice, moreover, that Ryanair's competitors in Charleroi are just four (Blue

Rather than being an isolated case, the Ryanair - Charleroi case decision is a manifestation of a general approach which has become evident during past years in the Commission's official documents and decisions. The Commission's guidelines on national regional aid clearly states that, in the context of aid to stimulate the development of depressed areas, *aid to initial investment* is allowed while *aid aimed at reducing a firm's current expenses is normally prohibited*.³ Nevertheless, as a confirmation that this kind of approach is a general one and that it concerns aids which do not fall into the regional aid category, it is sufficient to have a look at the list of decisions taken in the past years and to notice that the likelihood of being considered illegal state aid is much higher for aids which use tax reduction instruments rather than a direct grant instruments. Think for example of cases such as the Italian tax breaks for companies listed for the first time on the EU stock exchanges, where the motivation for outlawing the aid scheme is that the subsidy is proportionate to the revenues earned by the beneficiaries.⁴ Or to the case of three aid schemes implemented by the Basque province, where the Commission states "*...as they [the aid schemes] also constitute operating aid, doubts exist about their compatibility with the common market*". In the words of the Commission, the aid schemes were indeed designed to relieve firms of cost tax charges they would normally have to bear as part of their everyday management of usual activities and are, as a consequence, illegal.⁵

Our aim is to study whether this approach is consistent with a rigorous competition policy analysis. Although it is true that state subsidies may introduce distortions in the market, it is not generally true that banning variable cost subsidies and allowing start-up subsidies is optimal for a welfare maximizing Competition Authority. Any optimal choice requires consideration of the trade-off between the possible gain in welfare due to an increase in competition (which may be brought by variable cost aids too) and the possible loss of welfare brought by the distortions introduced in the market. The approach taken by the European Commission on the Ryanair - Charleroi case and, in general, on state aid seems to lack such a consideration. The model presented in this paper addresses that concern focusing on the competition policy aspect of state aid only and leaving aside alternative possible concerns such as lobbying or public choice issues. The focus is on a specific kind of aid, that is aid to attract foreign direct investment (FDI), and in the basic setting the two competing firms are foreigners. Much have been said on state aid to

Air, Jet4you, On Air, Wizz Air). None of them is Belgian.

³Commission's guidelines on national regional aid, OJ C 74, 10/03/1998 0009-0031

⁴IP/05/304

⁵IP/00/1244

attract FDI (Brander and Spencer [1985], Krugman [1987], Markusen et al. [1995], Markusen and Venables [1997], Barros and Cabral [2000], Fumagalli [2003]) but these works exhibit significant differences with the model presented in this paper. Usually the presence of more than one government competing in order to attract FDI is assumed, local firms are assumed to play a role in host markets and the analysis does not include a comparison among different possible aid instruments which could be implemented. In this paper, on the contrary, I abstract from those features to focus on the welfare effects of different ways of financing foreign direct investments. Therefore, in the model there is only one government, there are no local producers (the incumbent is also supposed to be foreign-owned) and externalities are not modelled for simplicity. That is: the focus is not on what is the reason why the government wants to subsidize entry - spillovers, labor market imperfections, and so on. The robustness of the model's results are however tested when these assumption are relaxed in Section 2.2.

As we shall see, the model outlined in Section 2 suggests that *VCA* is always preferred to *FCA* whenever the government decides to intervene and both state aid instruments do not cause the incumbent firm to exit the market. The conclusion is that a general ban that prevents governments from using variable cost aid may be welfare detrimental by forcing the government to adopt a sub-optimal policy.

Although the basic setting of the model is rather stylized, the results of the paper appear to be robust to generalization. Garcia and Neven [2005] show how the impact of state aid depends on market concentration: they find that the distortions induced by entry of a subsidized firm tend to be reduced when competition between domestic firms is increased. The results of my paper are shown to be robust to the extension of the game to n playing firms and to the introduction of an externality function which links entry to the local economy. The model is extended for the case in which the incumbent firm is domestic as well. In that case the government internalizes the negative effect on the incumbent's profits due to entry and state aid becomes less likely. Moreover, the unique kind of aid which is granted at the equilibrium is *FCA*, because the implicit further reduction in the incumbent's profits due to a reduction of the entrant's marginal cost makes *VCA* always inferior to *FCA* in terms of welfare. This result suggests that the likelihood of a negative impact of a ban on variable cost aid by the European Commission is reduced whenever domestic firms play a significant role in the game.

The model's results have a clear policy implication: a Competition Authority should assess the

impact of an aid on competition and welfare independently of the way in which it is granted, *VCA* or *FCA*. A decision which depends largely on the kind of state aid instrument used might then require additional justification and should be carefully analyzed. We are aware that contingent rules are difficult to administer, though. Indeed, the model suggests a rule of thumb which can be used to select those cases where variable cost aid should be looked at with suspect. These are those cases where the incumbent firm is foreigner with respect to the government granting the aid but domestic with respect to the supranational Competition Authority.

These results may be naturally compared with those few works in the literature where the authors focus more closely on subsidies and competition in the context of European Union's competition policy. Collie [2000, 2002] models a situation where governments subsidize their own firms in order to increase their competitiveness and to catch the increasing oligopolistic profits. He then concludes that the shadow cost of subsidization is crucial in determining whether prohibiting state aid is welfare enhancing. In the model outlined in this paper the shadow cost λ of the subsidy has, instead, a secondary impact on the general conclusions. An increase in λ reduces state intervention's likelihood and increases the advantage given by granting *FCA* rather than *VCA*. It turns out that the impact of a ban of *VCA* on welfare is lower since the government is willing to use *VCA* in fewer cases. Nevertheless, even taking into consideration that *FCA* improves its relative advantage with respect to *VCA* when the entrant is inefficient, *FCA* would never arise for any value of λ in the basic setting i.e. when both the two competing firms are foreigners. Thus only *VCA* can occur at the equilibrium and the general conclusions are unaltered.

Besley and Seabright [1999] analyze the role of subsidies in a static and dynamic framework and suggest a way of using the strategic trade literature to assess the European Union's approach to state aid. Nicolaidis and Bilal [1999] check the validity of EU rules on state aid in promoting efficiency arguing that aid aimed to correct market failure should be allowed even if they may have cross-border effects. Compared to these researches, this paper proposes an analytical approach and a new setting in which to assess the European competition policy on state aid.

The paper is organized as follows. In the following section I describe the basic setting, solve the model and test the robustness of the results obtained through several extensions to the basic model. In Section 3 I describe the conclusions and discuss the policy implications of the model. The proofs of the results are illustrated in Appendix A (Appendix B contains the minor proofs with all the algebraic expressions, which are not reported in the paper for ease of exposition).

1.2 The Model

The players of the game are: the government G of a representative country, an entrant firm E and an incumbent firm I . At the moment the game starts, E is outside the market and I is inside the market producing $q_i^m > 0$. Firm j has constant marginal cost $0 \leq C_j \leq 1$. In addition, E has to pay a fixed cost of entry $K > 0$ if it enters the market. Firm j 's net-of-costs profit is π_j . Consumers' demand is given by:

$$Q = 1 - P$$

where $Q = q_i + q_e$ is total output produced by the two firms and P is the associated market price. The government maximizes total domestic welfare $W(C_e, C_i, K, \lambda)$, where $\lambda \geq 1$ is the shadow cost of the subsidy.⁶ In order to abstract from strategic trade policy (or rent-extraction) considerations, in this basic setting it is assumed that both I and E are foreign firms and that the government maximizes the following welfare function:

$$W(C_e, C_i, K, \lambda) = CS(C_e, C_i) - \lambda S(C_e, C_i, K) \quad (1.1)$$

where $CS(C_e, C_i)$ is the consumer surplus and $S(C_e, C_i, K)$ is the subsidy.⁷ As it can be seen, the welfare function does not explicitly include any positive externalities to the local economy due to the entrance of a foreign firm in the market. This hypothesis is made for the sake of simplicity and it is discussed in Section 2.2.3.

The focus of the analysis is on the effect of subsidies on the competition between E and I . For that reason, we can concentrate on the relative instead of the absolute efficiency of the two competing firms. So, for simplicity, in the rest of the paper it is assumed $C_i = \frac{1}{2}$.⁸

The game has four stages:⁹

⁶ $\lambda = 1$ when lump-sum taxes are feasible (Collie [2002]). Empirical evidence shows that λ may vary from 1 (Kaplow [1996]) to 2.65 (Feldstein [1997]).

⁷Notice that the welfare function maximized by the government would be the same if the government adopts a consumer surplus standard and one of the two or both firms are domestic.

⁸Section 2.2.1 relaxes and discusses this assumption in order to check whether the government would ever grant an aid such that the incumbent firm is crowded out from the market by the entrant firm (this can happen only if $C_i > \frac{1}{2}$). Indeed, Mariniello [2006] lets C_i vary and formally shows that if entry forces the incumbent to exit the market, the government does not grant any subsidy.

⁹Stage 1 and stage 2 could be brought together by saying that in stage 1 the government chooses the level of each type of subsidy which can also be zero. That would have no impact on the solution of the game, though.

In the paper stage 1 and 2 are separated because this structure of the game facilitates the analysis.

1. The government chooses between one of the following actions: financing a reduction in the size of K in order to allow the entrant to enter the market (*fixed cost aid, FCA*); financing a reduction in C_e (*variable cost aid, VCA*) for the same purpose; leaving the entrant's fixed and variable cost unchanged (*no intervention, NI*).
2. The government chooses the amount of subsidy to be provided, if any. Define S_k as subsidy to fixed cost and S_c as subsidy to marginal cost. If the government has chosen *FCA* in the previous stage, it fixes $S_k > 0$ and $S_c = 0$. If it has chosen *VCA*, it fixes $S_c > 0$ and $S_k = 0$. If the government has chosen *NI* in the first stage, it sets $S_k = S_c = 0$.
3. After observing the government's decision, the entrant E chooses whether to enter the market or not.
4. Firms in the market compete *à la Cournot* setting the output levels q_j .

The aim of the model is to outline situations where an entrant firm intends to enter the market but does not choose to do so because the presence of an entry barrier proxied by the fixed cost K makes entry unprofitable. To focus on the interesting case where entry does not occur absent state aid, we need to impose the following restrictions R on the cost parameters:

R 1 *The fixed cost barrier is sufficient to deter entry*

First, we require that E is not efficient enough to overcome by itself the entry barrier, otherwise there would be no need for subsidization. In other words, a sufficiently large subsidy is strictly needed by E in order to profitably enter the market.

R 2 *The fixed cost barrier is necessary to deter entry*

Second, we require that, absent entry barriers, the two firms are able to coexist in the market. Suppose that this was not the case i.e. that the market sustains only one firm. Then the comparison between *FCA* and *VCA* is pointless: both the two aid instruments would force the incumbent out if effective in making the entrant enter the market. Then, regardless of the type of aid instrument implemented, competition would be distorted by an effective subsidy. This case is of marginal interest for the analysis proposed.

R 3 *VCA can be effective in triggering entry*

Third, we assume that the government cannot turn a cost into a benefit and we require that the maximum variable cost subsidy that can be granted (i.e. $S_c = C_e$) is enough to let the entrant enter the market and produce a positive quantity. If that was not the case, there would be no reason to compare *FCA* with *VCA*, because the only state aid instrument that could be implemented by the government would be *FCA*.

Restrictions R1 - R3 are formally summarized in the following table:

	<i>formulation</i>	<i>restriction</i>
R 1	$\pi_e < 0$	$\frac{3}{4} - \frac{3}{2}\sqrt{K} < C_e$
R 2	$q_e > 0$ if $K = 0$ $q_i > 0$ if $K = 0$	$C_e < \frac{3}{4}$ $C_e > 0$
R 3	$q_e > 0$ if $C_e = 0$	$K < \frac{1}{4}$

To understand how each restriction is formally expressed, it is sufficient to notice that in the last stage of the game firm j chooses $q_j = \frac{1+C_{l \neq j}-2C_j}{3}$ if $q_j > 0$ and that E 's profits amount to $\pi_e = \left(\frac{\frac{3}{2}-2C_e}{3}\right)^2 - K > 0$.

1.2.1 The solution of the basic model

Let us solve the game by backward induction:

Stage 4: firms' output choice

In this stage firms in the market compete *à la Cournot* and decide how much to produce.

If the entrant has entered the market in the previous stage, equilibrium quantities and price are:

$$q_e = \frac{3-4(C_e-S_c^*)}{6}, \quad q_i = \frac{(C_e-S_c^*)}{3}, \quad Q = \frac{3-2(C_e-S_c^*)}{6}, \quad P = \frac{3+2(C_e-S_c^*)}{6} \quad (1.2)$$

If the entrant did not enter the market in the previous stage then quantities and price are:

$$q_e^o = 0, \quad q_i^o = Q^o = \frac{1}{4}, \quad P^o = \frac{3}{4} \quad (1.3)$$

Notice that $P^o > P$ and $Q^o < Q \forall C_e$.

Stage 3: the decision of the entrant

Firm E decides to enter the market whenever it obtains non negative profits, i.e. whenever:

$$\pi_e(C_e, K, S_c, S_k) = \frac{\left(\frac{3}{2} - 2(C_e - S_c)\right)^2}{9} - (K - S_k) \geq 0$$

Stage 2: the government chooses the subsidy levels

In stage two the government sets S_k and S_c in order to achieve the highest possible level of welfare, given the method chosen (FCA , VCA , NI) in stage 1. To this aim it proves helpful to define the threshold values $\overline{K}(C_e)$ and $\overline{C}_e(K)$ which are those values for K and C_e at which by entering the market, the entrant makes non-negative profits:

$$\overline{K}(C_e) := \frac{\left(\frac{3}{2} - 2C_e\right)^2}{9} \quad (1.4)$$

$$\overline{C}_e(K) := \frac{3 - 6\sqrt{K}}{4} \quad (1.5)$$

If the government is adopting FCA then it has to set S_k s.t. the new entry barrier faced by the entrant $K - S_k$ is below or equal to \overline{K} . On the other hand, if the government is adopting VCA , then it has to set S_c s.t. the new marginal cost of the entrant $C_e - S_c$ is lower than or equal to \overline{C}_e . In the following the optimal choice of S_k and S_c made by the government is analyzed.

The optimal choice of S_k when FCA has been chosen If the government has chosen FCA in the first stage, in the second stage it chooses S_k such to:

$$\begin{aligned} & \max_{S_k} W_k(C_e, S_k, \lambda) \\ & s.t. K - S_k \leq \overline{K} \end{aligned}$$

where $W_k(C_e, S_k, \lambda) := CS_k(C_e) - \lambda S_k$ is the welfare function when adopting FCA . Not surprisingly, the unique solution for the maximization problem is $S_k^* = K - \overline{K}$ i.e. it is such that E breaks even. The government has no incentive to set $K - S_k < \overline{K}$ because this does not entail any beneficial effects. It would increase the cost of the subsidy keeping constant the gain in consumer surplus associated with entry.

The optimal choice of S_c when VCA has been chosen When VCA has been chosen in the first stage, the government chooses S_c to

$$\begin{aligned} & \max_{S_c} W_c(C_e, S_c, \lambda) \\ & \text{s.t. } C_e - S_c \leq \overline{C}_e \end{aligned}$$

where $W_c(C_e, S_c, \lambda) := CS_c(C_e, S_c) - \lambda q_e(C_e, S_c)S_c$ is the welfare function when adopting VCA. The solutions are illustrated by the following lemma:

Lemma 1.1 *If VCA is chosen by the government, then two cases may arise: (i) If the entrant is relatively inefficient ($C_e > \widehat{C}_e(K, \lambda)$), the optimal subsidy level S_c^* is the one that makes the entrant to break even ($S_c^* = C_e - \overline{C}_e(K)$). (ii) If, instead, the entrant is relatively efficient ($C_e \leq \widehat{C}_e(K, \lambda)$), the optimal subsidy level S_c^* is higher than what is strictly needed by the entrant to enter the market ($S_c^* \geq C_e - \overline{C}_e(K)$).*

Proof. See Appendix B. ■

In the first case the entrant is inefficient with respect to the entry barrier. That is: because of a high entry barrier or of an inefficient entrant, facilitating entry is costly. In that case the government limits its intervention to the least subsidy capable to trigger entry. On the other hand, if triggering entry is relatively cheap because K or C_e are low enough, the optimal subsidy reduces the marginal cost of the entrant more than what it is needed to enter the market. Indeed, when subsidizing entry is cheap, the gain in consumer surplus due to a reduction of the entrant's marginal cost offsets the relatively low additional cost represented by a greater subsidy. In this case the entrant enters the market and makes positive profits, while in the former case it just breaks even. Notice that the threshold value $\widehat{C}_e(K, \lambda)$ is decreasing in the shadow cost of subsidization λ as well:

$$\frac{\partial \widehat{C}_e(K, \lambda)}{\partial K} < 0, \frac{\partial \widehat{C}_e(K, \lambda)}{\partial \lambda} < 0$$

the more costly is rising funds to finance state aid the less likely is that subsidization is used by the government as an instrument to increase consumer surplus through a reduction of the marginal costs of those firms that would anyhow enter the market.

It is interesting to notice, moreover, that, since restrictions R1 and R2 defines an upper and a lower bound for C_e , they implicitly identify the intervals of values of the entry cost K for which

just one of the two mentioned variable cost aid types may arise:

$$\begin{aligned} K < \frac{1}{4(12\lambda-1)^2} &\implies S_c^* > C_e - \overline{C_e} \\ \frac{1}{4(12\lambda-1)^2} \leq K \leq \frac{1}{4(6\lambda-1)^2} &\implies S_c^* \geq C_e - \overline{C_e} \\ K > \frac{1}{4(6\lambda-1)^2} &\implies S_c^* = C_e - \overline{C_e} \end{aligned}$$

Since C_e cannot be bigger than $\frac{3}{4}$, if K is very small, it is always the case that $C_e < \widehat{C_e}(K, \lambda)$ and the optimal subsidy is such that $S_c^* > C_e - \overline{C_e}$. On the other hand, since C_e cannot be lower than $\frac{3}{4} - \frac{3}{2}\sqrt{K}$, for sufficiently high values of K it is always the case that $C_e > \widehat{C_e}(K, \lambda)$ and the subsidy is such that $S_c^* = C_e - \overline{C_e}(K)$. For intermediate values of K , both cases arise.

Stage 1: the government chooses among different types of aid

In the first stage of the game the government compares each possible action and then chooses the one which is associated with the highest level of welfare. Given the optimal choices of the subsidy in stage two, the welfare yielded by *NI*, *FCA* and *VCA* are W_o^* , W_k^* and W_c^* respectively, as it is illustrated in the following table:

<i>NI</i>	$W_o^* = \frac{1}{32}$
<i>FCA</i>	$W_k^* = \frac{(1.5-C_e)^2}{18} - \lambda \left(K - \frac{(1.5-2C_e)^2}{9} \right)$
<i>VCA</i>	$W_c^* = \frac{\lambda^2(4C_e-9)^2}{8(12\lambda-1)^2} - \lambda \left(\frac{6\lambda+1-8\lambda C_e}{2(12\lambda-1)} \right) \left(C_e - \frac{3(3\lambda-1)+12\lambda C_e}{2(12\lambda-1)} \right)$ with $C_e \leq \widehat{C_e}(K, \lambda)$ $W_c^* = \frac{1}{2} \left(\frac{1+2\sqrt{K}}{4} \right)^2 - \lambda\sqrt{K} \left(C_e - \frac{3-6\sqrt{K}}{4} \right)$ with $C_e > \widehat{C_e}(K, \lambda)$

Let us compare the three options two-by-two:

- *VCA vs FCA*

First, let us compare *VCA* with *FCA*. We need to consider two cases. In the first case the entrant is efficient ($C_e \leq \widehat{C_e}(K, \lambda)$) and S_c^* is such that the entrant makes positive profits. Appendix A (proof. 1) shows that in this case *VCA* is always preferred to *FCA*. To understand the intuition for that result, consider the limit case where the entrant is almost efficient enough to overcome by herself the entry barrier and $C_e \leq \widehat{C_e}(K, \lambda)$. In that case, if the government chooses to grant *VCA* such that the entrant breaks even, *FCA* and *VCA* are equivalent: at the limit costs are zero and the effect on consumer surplus is the same. However, from Lemma 1.1 we know that if the entrant is very efficient the government prefers to grant a bigger subsidy if

using *VCA*. So *VCA* allows the government to reach a higher level of welfare with respect to *FCA* if the entrant is efficient enough to make the government willing to grant her an additional aid with respect to what is strictly needed to trigger entry.

In the second case, instead, the entrant is inefficient ($C_e > \widehat{C}_e(K, \lambda)$) and the government grants an aid such that she breaks even ($S_c^* = C_e - \overline{C}_e$). To study this case, it proves useful to split the analysis in two parts in order to understand how the two effects, gain in consumer surplus and loss in public resources, influence the government's choice.

Let us discuss the impact on consumer surplus, first. It turns out that the gain in consumer surplus yielded by the optimal *VCA* is always superior to that yielded by *FCA*:

$$CS_c = \frac{1}{2} \left(\frac{1.5 - (C_e - S_c^*)}{3} \right)^2 > CS_k = \frac{1}{2} \left(\frac{1.5 - C_e}{3} \right)^2$$

by $C_e - S_c^* < C_e$. The intuition for that result is simple: while *FCA* raises consumer surplus only through competition, *VCA* has the same effect plus an additional positive effect given by the increase in the efficiency of one of the two firms competing in the market. The two aid instruments have the same effect on consumer surplus only at the limit when *E* is efficient enough to overcome by herself the entry barrier (a case which is excluded by R1). Let us move now to the loss in public resources due to the subsidy. In this case the analysis is less straightforward. It turns out that when the entrant is relatively inefficient, *VCA* costs more than *FCA*. Figure 1 represents the two aids' cost curves as a function of C_e (the algebraic expressions are reported in Appendix B).¹⁰

insert figure 1

As figure 1 shows, the cost of providing *VCA* is linear and increasing in C_e while the cost of providing *FCA* is concave in C_e : as the entrant becomes relatively less efficient (C_e increases) both

¹⁰An interesting issue to be considered is the existence of government's budget constraints. It is possible, indeed, that a domestic government is not able to implement a welfare improving subsidy because the amount of resources needed is greater than the amount of resources available to the agency in charge to grant the aid. In that case, the government may be forced to use the aid instrument which costs less, even if implementing an other aid instrument would lead to higher welfare levels. In the setting here described, it might be that *FCA* is chosen even if $W_c^* > W_k^*$ because *FCA* costs less than *VCA* (Appendix B shows that this is the case when $C_e > \frac{3(1-\sqrt{K})}{4}$) and the budget constraint BC is lower than $\lambda q_e S_c^*$ (which is the least amount of resources needed to implement *VCA*). Moreover, Appendix B shows that whenever *VCA* and *FCA* have the same cost, *VCA* is preferred to *FCA*.

the two aid instruments cost more, but while the cost of granting *VCA* increases at a constant rate, the cost of granting *FCA* is marginally decreasing. Hence the bigger is C_e the higher is the difference between the two cost functions. The intuition for that result is the following: when *VCA* is granted, the quantity produced by the firm once it is in the market is always the same, whatever is the original marginal cost of the entrant. Indeed, when $C_e > \widehat{C}_e(K, \lambda)$, the government chooses S_e^* such that $C_e - S_e^* = \overline{C}_e(K)$. For that reason, the post-entry amount of quantity produced $q_e(C_e)$ remains constant and equal to $\overline{q}_e(\overline{C}_e(K))$ whatever is the original degree of efficiency of the entrant. It turns out that an increase of an $\varepsilon > 0$ in C_e is translated in an equivalent increase of ε in the cost of subsidization with *VCA*. On the other hand, if the government implements *FCA*, an increase in C_e (which now remains unaltered after the subsidy is granted) obviously determines an increase in the cost of the aid because the profits earned by E are reduced and the gap between E 's profits and the entry cost which must be offset by the subsidy is consequently increased. However, the negative effect of a marginal increase in C_e on E 's profits is smaller the bigger is C_e , given firms' quadratic profit function. So the marginal cost of granting *FCA* is decreasing in C_e .

In short, granting *VCA* to an inefficient entrant is costly if compared to granting *FCA*, because with *VCA* the firm that receives the subsidy does not incorporate her efficiency level in her production choices, while with *FCA* she does.

Notice that, for ease of exposition, the analysis just illustrated uses C_e as a proxy of the relative inefficiency of the entrant with respect to the entry barrier, which is held constant. We could nevertheless use K for the same purposes: holding C_e constant, an increase in K reduces the relative efficiency of the entrant as well, and the result explained above would not change: as K increases, *VCA* becomes relatively more expensive with respect to *FCA*.¹¹

We can thus identify those values of K such that *VCA* is preferred to *FCA*. Indeed, the government chooses *VCA* instead of *FCA* if (and only if):

$$K \leq \frac{(3(8\lambda + 3) - 4C_e(8\lambda + 1))^2}{36(4\lambda - 1)^2} = \psi(C_e, \lambda) \quad (1.6)$$

¹¹Notice though that if we let the subsidy cost depends only on K and hold C_e constant, the cost functions of the two aid instruments have different shape: now the *FCA*'s cost function is linear in K and the *VCA*'s cost function is convex in K : indeed, an increase in K needs to be offset either by an equal increase in the lump-sum subsidy (if *FCA*) either with a marginally increasing reduction in C_e (if *VCA*), given firms' convex profit function. The result illustrated holding K constant thus does not change.

Notice that the relationship between $\psi(C_e, \lambda)$ and λ is negative. Indeed:

$$\frac{\partial \psi(C_e, \lambda)}{\partial \lambda} < 0$$

which means that an increase in the shadow cost of subsidy reduces *VCA*'s comparative advantage with respect to *FCA*. The explanation is rather straightforward: we have seen that when the entrant is inefficient, an increase in its marginal cost determines an increase in the (positive) difference between *VCA*'s and *FCA*'s granting costs. An increase in λ then magnifies the relative burden that choosing *VCA* entails with respect to choosing *FCA*.

- *FCA vs NI*

The welfare yielded by *NI* is simply the consumer surplus when only the incumbent is in the market. The difference with the welfare yielded by *FCA* is then made up of two opposite effects: a gain in the consumer surplus due to an increase in competition in the market, and a loss in terms of the public resources needed to finance the aid.¹² The lower is the entry barrier, the cheaper to trigger entry, the more likely the former effect dominates. Indeed, solving for K we get that the government prefers *FCA* to *NI* if (and only if):

$$K \leq \frac{16C_e^2(8\lambda + 1) - 48C_e(4\lambda + 1) + 9(8\lambda + 3)}{288\lambda} = \sigma(C_e, \lambda) \quad (1.7)$$

The threshold $\sigma(C_e, \lambda)$ is decreasing in λ and C_e in the interval defined by restrictions R2 (i.e. whenever $0 < C_e < \frac{3}{4}$): the less efficient the entrant, the lower is the gain in consumer surplus and the more costly to pull down the entry barrier. Hence, the less likely that *FCA* is preferred to *NI*. Similarly, a greater λ implies an higher burden on public resources and the subsidy is less beneficial for welfare.

This result combined with the one reported above, leads us to achieve a first important conclusion concerning the equilibrium. Appendix A (proof. 2) shows that $\psi(C_e, \lambda)$ is always greater than $\sigma(C_e, \lambda)$ for any feasible value of λ . This implies the following proposition:

Proposition 1.1 *whenever FCA is preferred to VCA, NI is preferred to FCA. Hence FCA never arises at the equilibrium.*

¹²Notice that when a subsidy is granted the gain in consumer surplus is always non-negative: since $CS_k(C_e)$ is decreasing in C_e , to show that $CS_k(C_e) \geq CS_o$ it is sufficient to set C_e at its maximum value $C_e = \frac{3}{4}$ and notice that at that value $CS_k(\frac{3}{4}) = CS_o$.

Proof. See Appendix A (proof. 2). ■

The intuition behind this result is the following: for *FCA* to be preferred to *VCA* when the entrant is inefficient ($C_e > \widehat{C}_e(K, \lambda)$) it is necessary that the entry barrier is relatively big. In that case, however, financing entry is too costly if compared to the benefits obtained in terms of consumer surplus. It is thus preferable not to intervene at all instead of granting *FCA*. Hence *FCA* cannot arise at the equilibrium.¹³

- *VCA vs NI*

Now let us compare the welfare yielded by *VCA* with the welfare yielded by *NI*. As in the first comparison studied, two different cases arise. In the first one the government grants a *VCA* higher than what is strictly needed to let *E* enter the market (i.e. $C_e \leq \widehat{C}_e(K, \lambda)$). In that case, it always prefers *VCA* to *NI*: if C_e is so low that S_c^* is higher than the threshold level, then entry is very cheap and the gain in terms of consumer surplus due to *VCA* always offset its cost.¹⁴

Instead, when *E* is sufficiently inefficient so that the government chooses a subsidy such that *E* breaks even (i.e. $C_e > \widehat{C}_e(K, \lambda)$), *VCA* is preferred to *NI* if (and only if):

$$K \leq \left(\frac{6\lambda + 1 - 8\lambda C_e}{12\lambda - 1} \right)^2 = \tau(C_e, \lambda) \quad (1.8)$$

where the threshold $\tau(C_e, \lambda)$ is decreasing in C_e and λ . The intuition for this result is similar to the one illustrated for the previous case.

Appendix A shows that the threshold $\tau(C_e, \lambda)$ is always smaller than the threshold $\psi(C_e, \lambda)$ (proof 2) and greater than the threshold $\sigma(C_e, \lambda)$ (proof 4).

Imagine, by contradiction, that $\tau(C_e, \lambda) > \psi(C_e, \lambda)$: that would mean that there exists an interval of values of the entry barrier ($\psi(C_e, \lambda) < K < \tau(C_e, \lambda)$) such that *FCA* is preferred to *VCA* and *NI* is preferred to *FCA*, since we know the threshold which identifies the values of K for which *NI* is preferred to *FCA*, $\sigma(C_e, \lambda)$, is lower than $\psi(C_e, \lambda)$. However, when $K < \tau(C_e, \lambda)$, *VCA* is preferred to *NI*, and this case is ruled out by transitivity i.e. $FCA \succ VCA$ and $NI \succ FCA \implies VCA \not\succeq NI$.

Similarly, imagine that $\sigma(C_e, \lambda) > \tau(C_e, \lambda)$. That would mean that there exists an interval of values of the entry barrier K where *NI* is preferred to *VCA* (when K is bigger than $\tau(C_e, \lambda)$) and where *FCA* is preferred to *NI* (when K is smaller than $\sigma(C_e, \lambda)$). But since $\sigma(C_e, \lambda) <$

¹³This result is as well illustrated graphically in figure 3-4 below.

¹⁴See Appendix A (proof 3) for a formal proof.

$\psi(C_e, \lambda)$, in the same interval VCA should be preferred to FCA , and this case is ruled out for a reason similar to the one illustrated above: $NI \succ VCA$ and $FCA \succ NI \implies VCA \not\succeq FCA$.

insert figures 2, 3, 4

Figure 2-4 illustrate graphically these results. Figure 2 represents the three thresholds identified and the relative government's choice in stage 1. Figures 3 and 4 describe the welfare functions correspondent to the three possible choices of the government in stage 1 with two different values of λ : as anticipated above, an increase in the shadow cost of subsidy decreases the comparative advantage of VCA with respect to FCA but it is still not sufficient to let FCA occur at the equilibrium.

It turns out that the only two options which might occur at the equilibrium are VCA , if K or C_e are small enough, or NI in the opposite case:

*if either $C_e \leq \widehat{C}_e(K, \lambda)$ or $K \leq \tau(C_e, \lambda)$ then the government's choice is VCA
if $C_e > \widehat{C}_e(K, \lambda)$ and $K > \tau(C_e, \lambda)$ then the government's choice is NI*

It is easy to check, moreover, that $C_e \leq \widehat{C}_e(K, \lambda) \implies K \leq \tau(C_e, \lambda)$.¹⁵ In other words, there cannot exist an interval of values where $C_e \leq \widehat{C}_e(K, \lambda)$ and $K > \tau(C_e, \lambda)$. So the condition for C_e is redundant, and we can thus simplify the equilibrium result as in the following proposition:

Proposition 1.2 *If $K \leq \tau(C_e, \lambda)$ then the government chooses to adopt VCA , if $K > \tau(C_e, \lambda)$ the government chooses not to subsidize the entrant firm.*

Proof. It follows directly from (1.8) and Proposition 1.1. ■

Since at equilibrium the government never chooses to grant FCA , the model may appear to be in contrast with the Ryanair - Charleroi's facts or with all the other cases in which both kinds of aid were granted. This result however depends on the no mix-form aid assumption: if the government in the model is allowed to lower both K and C_e at the same time then both FCA and VCA can occur at the equilibrium.¹⁶ Another possible explanation for observing FCA is

¹⁵Recall $\tau(C_e, \lambda)$ is decreasing in C_e and notice that $\tau(\widehat{C}_e, \lambda) = 4K > K$.

¹⁶If we allow for mixed forms of aid in the model, the conclusions are unaltered. Indeed, the pure form aid choices are a subset of the mix form aid choices (if the government can use mix form aid, it can always set $FCA = 0$ and replicate the no mix form case solution). Thus welfare can only increase if the government is allowed to use both FCA and VCA at the same time.

simply that the government may anticipate that the likelihood of a negative decision from the European Commission is higher when *VCA* is implemented. Indeed, there exists an interval of values for the parameters where if the government cannot grant a *VCA* it grants a *FCA*, adopting a sub-optimal decision. Finally, a third explanation is that the government is not able to choose the optimal aid instrument because it is rationally bounded or because its choices are limited by some budget constraints (see footnote 10).

1.2.2 Extensions

In the following I will illustrate four possible extensions to the basic model and check the robustness of the results obtained above. Here I will report only an informal explanation. The reader interested in the formal treatment may refer to Mariniello [2006].

Crowding out is possible

If we let $C_i \in (0, 1)$ then crowding out becomes feasible. Indeed, by letting the entrant enter the market, the government can indirectly cause the incumbent firm to exit the market, because *VCA* can bring the entrant's marginal cost so low such that the incumbent is not able to sustain competition anymore. It is possible to show, though, that this never happens at the equilibrium: the gain in the consumer surplus (net of subsidy cost) brought by *VCA* when the incumbent firm exits the market is never higher than the gain in consumer surplus (net of subsidy cost) brought by *FCA*. The formal proof follows two steps: first, it is possible to show that when the government can trigger entry with *VCA* without causing the crowding out effect (i.e. C_i is low enough such that $C_e = \overline{C}_e(K, C_i) \not\Rightarrow q_i(C_e, C_i) < 0$) it never grants a subsidy such that I is forced out (i.e. it does not grant *VCA* which is higher than what is needed to pull down the entry barrier). Second, it can be shown that if C_i is so high that triggering entry with *VCA* necessarily causes the incumbent to be crowded out from the market ($C_e = \overline{C}_e(K, C_i) \Rightarrow q_i(C_e, C_i) < 0$), then *FCA* is always preferable to *VCA*. This result is rather intuitive: if E is already efficient, then *FCA* is surely better, because consumer surplus is higher when two firms are in the market. If, instead, both E and I are inefficient, substituting an inefficient incumbent with an efficient entrant by granting *VCA* can yield a higher level of consumer surplus with respect to the case of competition between two inefficient firms, but the cost that should be sustained by the government to trigger entry is so high that still *FCA* would be preferable.

We can conclude that a rational government does not use *VCA* when this aid instrument is capable to force exit of incumbent firms.

More than one incumbent firm

Since the marginal gain in consumer surplus associated with entry is expected to be lower when more than two firms are playing the game, the results that have been shown above might be expected to change if we increase the number of playing firms. This is not the case, though.

Let us suppose that in the domestic market $(n - 1) > 1$ symmetric firms are operating producing $q_i > 0$ and making positive profits. Their marginal cost is $c = \frac{1}{2}$. Restrictions R1-R3 of the basic model are then modified accordingly:

	<i>formulation</i>	<i>restriction</i>
R 1	$\pi_e < 0$	$\frac{1+n}{2n} - \frac{1+n}{n}\sqrt{K} < C_e$
R 2	$q_e > 0$ if $K = 0$ $q_i > 0$ if $K = 0$	$C_e < \frac{1+n}{2n}$ $C_e > 0$
R 3	$q_e > 0$ if $C_e = 0$	$K < \frac{1}{4}$

Solving the game by backward induction as we did in the basic setting, we obtain a generalization of Proposition 1.2:

Proposition 1.3 *when n firms are playing the game, if $K \leq \tau^n(C_e, \lambda, n)$ then the government chooses to adopt *VCA*, if $K > \tau^n(C_e, \lambda, n)$ the government chooses not to subsidize the entrant firm. *FCA* never arises at the equilibrium.*

Proof. Appendix A (proofs 5 - 8) generalize the results needed to prove Proposition 1.2 and hence prove Proposition 1.3. ■

The result of the basic setting are then robust to the generalization to n firms. Appendix A (proof 9) moreover shows that $\frac{\partial \tau^n(C_e, \lambda, n)}{\partial n} < 0$: when the number of incumbents increases, the condition for subsidization becomes stricter (i.e. state aid is less likely). This happens because the marginal positive effect of entry on consumer surplus is reduced and the amount of public resources needed to trigger entry is increased as n becomes larger. Nevertheless, restrictions R1 and R2 are 'elastic' with respect to n : they become less strict when n is larger. It turns out that

the lower bound for C_e is decreasing in n : there always can be an entrant firm which is so efficient with respect to the entry barrier such that VCA is the optimal choice of the government.

Externality associated with entry

The basic model adopts a welfare function in which the local economy is not included. However, when subsidies to attract FDI are granted, a positive spillover effect to other local markets due to entry is usually proposed as the main justification for subsidization. For example, in the Ryanair - Charleroi case, Ryanair and the Walloon government claimed that, opening new routes to Charleroi, Ryanair contributed to the growth of the Walloon's region through an increase in the activities of markets complementary to airport's services such as public transports, hotels, restaurants and so forth.

Including an externality to the domestic economy in the objective function of the government does not undermine the main result of the basic model, though. Indeed, the presence of a spillover correlated with the amount of quantity produced in the market strengthens the validity of the results, since VCA would be even more welfare enhancing: the total quantity produced in the market is increased when the marginal cost of the entrant is reduced.

Domestic incumbent

The basic model assumes that both the incumbent and the entrant are foreign firms: we might then wonder whether playing the game with a domestic incumbent would change the results illustrated above. If the incumbent is domestic, his profits enters the objective function of the government, which now becomes:

$$W(C_e, K, \lambda) = CS(C_e) + \pi_i(C_e) - \lambda S(C_e, K)$$

where π_i are the incumbent's profits. Solving the game by backward induction, we achieve a first result which contrasts with that reached with the basic model:

Lemma 1.2 *If the incumbent is domestic, the government always chooses a subsidy level such that the entrant breaks even.*

Proof. It follows directly from the solution of the optimization problem. ■

Lemma 1.2 tells us that even if the entrant is very efficient, the optimal level of subsidy S_c^* when *VCA* has been chosen is such that $S_c^* = C_e - \overline{C_e}(K)$. Contrary to what happens when the incumbent is foreign, the government internalizes the negative effect that S_c has on the domestic incumbent's profits by reducing its competitor's marginal cost and prefers to choose the minimum level of S_c capable to trigger entry. In addition, it is possible to show that the government never chooses *VCA* in stage 1: when the incumbent is domestic, in fact, subsidy is very unlikely because the gain in consumer surplus due to an increase in competition unlikely offsets the loss in incumbent's profits and the loss in public resources needed to trigger entry. If that happens, however, then *FCA* is better than *VCA* for the reasons just illustrated: the government prefers not to lower E 's marginal cost in order to not lower too much I 's profits.

These results can be summarized as it follows:

Proposition 1.4 *If the entrant is inefficient enough, then at the equilibrium subsidy does not occur regardless of the size of the entry barrier.*

Proof. See Appendix A (proof. 10). ■

Proposition 1.5 *if $K \leq \sigma^d(C_e, \lambda)$ then the government chooses to adopt *FCA*, if $K > \sigma^d(C_e, \lambda)$ the government chooses not to subsidize the entrant firm. *VCA* never arises at the equilibrium.*

Proof. See Appendix A (proof. 11). ■

1.2.3 The European Commission's approach

insert figures 5,6

In this section of the paper I discuss the implication of the model for the European Commission's approach to state aid. Solving the basic model we have seen that for sufficiently low values of K and C_e , granting a *VCA* to an entrant firm is an optimal policy for a government maximizing domestic welfare. It turns out that a specific competition policy which allows *FCA* but bans *VCA* may lead to sub-optimal equilibria where domestic welfare is not maximized. Figures 5 and 6 report the government's optimal choice for given variable cost parameters (the second-best choices when *VCA* cannot be chosen are in brackets). Figure 5 shows the equilibrium

government's choices when *VCA* is allowed while figure 6 shows the government's choices when *VCA* is banned. As expected, in both figures the greater are C_e and K , the wider is the area of no-intervention. Notice that, if the European Commission allows *VCA*, the entrant enters the market with the government's help for the set of combinations for C_e and K which pick out points below $\tau(C_e, K)$. On the contrary, when *VCA* is not allowed, only those points lying below $\sigma(C_e, K)$ lead to equilibria where two firms compete in the domestic market.¹⁷

How detrimental to domestic welfare can the European Commission's policy be? As a limit case, assume that lump sum taxes are feasible ($\lambda = 1$), that K is such that $W_k^* = W_o^* = \frac{1}{32}$ (i.e. the welfare yielded by *FCA* is equal to that obtained without granting any subsidy) and that C_e is very close to its lowest feasible value given the previous conditions (this in turn means that K is very close to its upper bound defined by R3).¹⁸ We thus have the following values for the parameters:

$$K = 0.2499$$

$$C_e = 0.1214$$

which lead to the following levels of welfare:

$$W_k^* = W_o^* = 0.03125$$

$$W_c^* = 0.06432 \approx 2 \times W_k^*.$$

Differently stated, allowing the government to grant *VCA* doubles domestic welfare. Alternatively, one could say that if the European Commission bans *VCA* it might generate a loss of potential gain in welfare of up to 100%. On the other hand, if we let the incumbent firm be domestic rather than foreign, the ban of *VCA* has no effect on domestic welfare, since we know from Proposition 1.5 that in this case *VCA* is never chosen by the government (why would a government subsidize entry of foreign firms which displace domestic ones?).

It is now natural to ask whether the European Commission should or should not ban *VCA*. Answering that question requires taking into account two factors: the competing firms' nationality and the objective function maximized by the European Commission, W^{EU} . If both the incumbent

¹⁷Recall that Appendix A (proof 1) shows that $\tau(C_e, \lambda) - \sigma(C_e, \lambda)$ is greater than zero and the interval is never empty.

¹⁸It is easy to see that at these conditions the the gain in welfare yielded by *VCA* with respect to the other two options is maximized.

and the entrant do not belong to the European Union then the answer is straightforward: *VCA* should not be banned. Indeed, in that case the objective function of the European Commission coincides with that of the Member State which is granting the subsidy: $W^{EU} = W = CS - \lambda$. On the other hand, if the incumbent or both the two firms belong to the European Union, then the answer depends on what is the objective function of the European Commission. If the Commission maximizes consumer surplus only, then *VCA* should not be prohibited, for the same reason illustrated above (even if the competing firms are European, their profits do not enter W^{EU}).

If, on the contrary, the Commission maximizes total welfare, then prohibiting *VCA* can be an optimal policy, because the Member State and the Commission have different objective function (and hence rank the available aid instruments differently). Indeed, suppose that the incumbent originates from a Member State which is not the one in charge to grant the aid: then its profits are not included in the objective function of the government in our model, because the firm is foreigner with respect to it ($W = CS - \lambda S$). However, the incumbent's profits contribute to the European Union's welfare ($W^{EU} = CS + \pi_I - \lambda S$) and the use of *VCA* would be detrimental from the European Commission's perspective, as it follows from Proposition 1.5.¹⁹

The analysis just illustrated can then be summarized as follows:

Proposition 1.6 *(i) If the European Commission adopts a consumer welfare standard, banning VCA is a sub-optimal policy. (ii) If the European Commission adopts a total welfare standard, prohibiting VCA is sub-optimal if the competing firms do not belong to the European Union.*

Proof. The proof follows from Proposition 2. ■

Proposition 1.7 *Prohibiting VCA is an optimal policy if (and only if) the European Commission adopts a total welfare standard and the incumbent firm originates from a Member State which is not the one granting the aid.*

¹⁹Notice that, limit case aside, E enters the market making zero profits, because the aid is such that it breaks even (see Lemma 1). So π_E does not influence W^{EU} even if E belongs to the European Union. If, instead, E is so efficient that *VCA* is granted in a way such that its profits are positive, then the objective function of the European Union is $W^{EU} = CS + \pi_I + \pi_E - \lambda CS$. *VCA* should still be prohibited, though, because the contribution to welfare due to the entrant's profits is lower than the loss in incumbent's profits due to *VCA*. Appendix A (proof 12) proves this result.

Proof. The proof follows from Proposition 5 and Appendix A (proof 12). ■

Proposition 1.6(i) may have relevant implications. Many experts report of an increasing weight attributed by Antitrust Authorities to consumers' welfare rather than to total welfare: for Schmalensee [2004] the benefits of entry are usually assessed by the U.S. Antitrust Authority solely on the basis of its impact on consumers' welfare; Derek Morris, former chairman of the Competition Commission in the U.K., stated that *"...in practice, competition policy effectively gives a very high weighting to consumer welfare and a very low weighting elsewhere"*²⁰. Neelie Kroes, the European Commissioner for Competition Policy, stated very recently: *"The consumer is at the heart of competition enforcement. [...] we are applying this 'consumer welfare standard' through better use of economic analysis in our work"*²¹. And although many economists are still reluctant to suggest the use of a consumers' welfare standard in competition policy analysis,²² there is a growing literature on mergers, which tends to emphasize the benefits of a consumers' welfare approach with respect to a total welfare approach (see, for example, Lyons [2002] and Neven and Roller [2005]). It turns out that Proposition 1.6 can have a broad impact on competition policy analysis of state aid, even if the competing firms belong to the European Union.

1.3 Conclusions

This paper addresses the economic grounds of the European Commission's approach to state aid to attract foreign investment. In particular, it sheds light on a well-established policy of the Commission according to which state aid aimed to reduce variable cost of production (*VCA* or *operating* aid, in the terminology used by the Commission) is more distortive than state aid aimed to reduce fixed cost of entry (*FCA* or *start-up* aid).

In the basic setting of the model, two foreign firms are playing the game: one incumbent firm already present in the domestic market and one entrant firm which is unable to enter the market without the help of the domestic government.

The model allows us to reach the following conclusions: if the minimum *VCA* necessary to make the entrant break even and enter the market does not cause the incumbent firm to exit the market, then the only type of aid which can occur at the equilibrium is *VCA*. This conclusion

²⁰Lecture of the national consumer council, 30 April 2002.

²¹European Press Releases, <http://europa.eu.int/rapid/pressReleasesAction.do?reference=SPEECH/06/691&format=HTML&aged=0&language=EN&guiLanguage=en>

²²For an overview on welfare standards used in competition policy economics, see Motta [2004], pgg. 20-22.

holds independently of the amount of resources wasted in order to implement the subsidy. In other words whatever is the shadow cost of subsidy, *VCA* is always better than *FCA*, if the government is willing to grant a subsidy. This result thus differs with the recent literature on state aid in which the shadow cost of subsidy plays a determinant role (see, for example, Besley and Seabright [1999] or Collie [2000, 2002]).

On the other hand, if the minimum amount of *VCA* necessary to let the entrant enter the market is sufficient to force the incumbent out, then *VCA* is never granted by the government. In other words, a rational government never grants an aid such to give to the more efficient aid-endowed entrant firm the ability to crowd her competitor out from the market.

The same results are obtained when the basic setting is extended in order to allow for positive externalities in the domestic economy given by FDI and for a number n of firms playing the game. In the latter case, an increase in the number of incumbents decreases state aid's likelihood, since the marginal contribution of entry to consumer surplus is reduced. Whatever is the number of playing firms, however, *VCA* can always occur at the equilibrium.

The results mentioned above are not robust to the case of domestic (instead of foreign) incumbent firm, though. If the objective function of the government includes incumbent's profits, then two results are obtained: first, the government is much less likely to subsidize entry. Second, *VCA* never occurs and the only type of aid which can occur at the equilibrium is *FCA*. The reason why this happens is rather obvious: by including the incumbent's profits in its objective function, the government internalizes the negative effect of entry on the domestic competitor. The model shows that this negative effect is not offset by the potential gain in consumer surplus of a more efficient entrant, thus identifying *FCA* as the unique type of aid instrument which can be chosen by the government, when definite conditions for the parameters hold.

Given these findings, the model shows that a general ban of *VCA* is unlikely to be an optimal policy. The main policy implications of the model are expressed in Proposition 1.6 and Proposition 1.7: the European Commission should not prevent governments to use *VCA* if the competing firms do not belong to the European Union or if the Commission adopts a consumer surplus standard; the unique case in which prohibiting *VCA* is welfare enhancing is identified by Proposition 1.7 and it occurs only when the incumbent firm originates from a Member State which is not the one granting the aid.

A more general implication of the model is that an Antitrust Authority should not apply a general a priori rule that discriminates between operative aid and start-up aid. More precisely,

the model casts doubts about the validity of the 'state aid instrument' argument supporting a Commission's decision. There might be several reasons why a *VCA* should not be allowed: bounded rationality of the government or lobbying are examples. But the mere fact of using one state aid instrument instead of another should not be a discriminant for accepting or rejecting the state aid programme: further economic analysis is needed in order for such Commission's decisions to be fully legitimated. In other words, the model suggests a *rule of reason* rather than a *per se rule* of prohibition for variable cost aid. It could be of interest, for example, to address the same issue from a political economy point of view and try to account for lobbying issues which might be one of the main reasons underlying the European Commission's worries for *VCA*. I plan to address that issue in a new research project.

1.A Appendix

1.A.1 Proofs

Proof n. 1. We need to show that $W_c^*(C_e, \lambda) \geq W_k^*(C_e, K, \lambda)$ whenever $S_c^* \geq C_e - \overline{C_e}(K)$. To that purpose, notice that $W_c^*(C_e, \lambda) \geq W_k^*(C_e, K, \lambda)$ if (and only if):

$$K \geq \frac{4C_e^2(60\lambda^2 + 4\lambda - 1) - 12C_e(30\lambda^2 + 5\lambda - 1) + 9(15\lambda^2 + 4\lambda - 1)}{72\lambda(12\lambda - 1)} = \phi(C_e, \lambda)$$

However restriction R1 implies K to be always bigger than $\phi(C_e, \lambda)$. Notice, in fact, that the difference:

$$\frac{(1.5 - 2C_e)^2}{9} - \phi(C_e, \lambda) = \frac{(2C_e(6\lambda - 1) + 3(1 - 3\lambda))^2}{72\lambda(12\lambda - 1)} > 0$$

is quadratic and positive, given $\lambda \geq 1$. It turns out that

$$K > \frac{(1.5 - 2C_e)^2}{9} \geq \phi(C_e, \lambda)$$

and $W_c^*(C_e, \lambda) \geq W_k^*(C_e, K, \lambda)$ i.e. when the government grants a subsidy greater than what is strictly necessary, *VCA* is always preferred to *FCA*. ■

Proof n. 2. We need to show that $\psi(C_e, \lambda) > \sigma(C_e, \lambda)$. Proof 4 shows that $\sigma(C_e, \lambda)$ is always smaller than function $\tau(C_e, \lambda) = \left(\frac{6\lambda+1-8\lambda C_e}{12\lambda-1}\right)^2$ (see below). In order to show that $\psi(C_e, \lambda) > \sigma(C_e, \lambda)$ it is then sufficient to show that $\psi(C_e, \lambda) > \tau(C_e, \lambda) > \sigma(C_e, \lambda)$.

By R2:

$$\begin{aligned} (3(8\lambda + 3) - 4C_e(8\lambda + 1)) &> 0 \\ (6\lambda + 1 - 8C_e) &> 0 \end{aligned}$$

so

$$\sqrt{\psi(C_e, \lambda)} > \sqrt{\tau(C_e, \lambda)} \Rightarrow \psi(C_e, \lambda) > \tau(C_e, \lambda)$$

let

$$\begin{aligned} F^{\psi-\tau}(C_e, \lambda) &:= \sqrt{\psi(C_e, \lambda)} - \sqrt{\tau(C_e, \lambda)} \\ F^{\psi-\tau}(C_e, \lambda) &= \frac{4C_e(48\lambda^2 + 16\lambda - 1) - 3(48\lambda^2 + 32\lambda - 1)}{6(1 - 4\lambda)(12\lambda - 1)} \end{aligned}$$

notice that $F^{\psi-\tau}(C_e, \lambda)$ is decreasing in C_e :

$$\frac{\partial(F^{\psi-\tau}(C_e, \lambda))}{\partial C_e} = \frac{2(48\lambda^2 + 16\lambda - 1)}{3(1 - 4\lambda)(12\lambda - 1)} < 0$$

if we substitute for the maximum value which can be assumed for C_e according to R2, $C_e = \frac{3}{4}$ we get:

$$F^{\psi-\tau}\left(\frac{3}{4}, \lambda\right) = \frac{8\lambda}{(4\lambda-1)(12\lambda-1)} > 0$$

where the positive sign is given by $\forall \lambda > 1$. Hence $\sqrt{\psi(C_e, \lambda)} > \sqrt{\tau(C_e, \lambda)} \Rightarrow \psi(C_e, \lambda) > \tau(C_e, \lambda)$.

■

Proof n. 3. We need to show that $W_{\tilde{c}}^*(C_e, \lambda) \geq W_o^*$ whenever $C_e \leq \widehat{C}_e(K, \lambda)$. Let $F^{\tilde{c}-o}(C_e, \lambda)$ be the difference between the two welfare levels:

$$F^{\tilde{c}-o}(C_e, \lambda) := W_{\tilde{c}}^*(C_e, \lambda) - W_o^* = \frac{\lambda^2(4C_e - 9)^2}{8(12\lambda - 1)^2} - \lambda \left(\frac{6\lambda + 1 - 8\lambda C_e}{2(12\lambda - 1)} \right) \left(C_e - \frac{3(3\lambda - 1) + 12\lambda C_e}{2(12\lambda - 1)} \right) - \frac{1}{32}$$

it is easy to see that $F^{\tilde{c}-o}(C_e, \lambda)$ is convex in C_e and has a minimum in $C_e = \frac{6\lambda+1}{8\lambda}$ where $F^{\tilde{c}-o}\left(\frac{6\lambda+1}{8\lambda}, \lambda\right) = 0$. Hence $F^{\tilde{c}-o}(C_e, \lambda) \geq 0 \forall \lambda, C_e \leq \widehat{C}_e(K, \lambda)$. ■

Proof n. 4. We need to show that $\tau(C_e, \lambda) > \sigma(C_e, \lambda)$.

Let

$$F^{\tau-\sigma}(C_e, \lambda) := (\tau(C_e, \lambda) - \sigma(C_e, \lambda))$$

notice that, given $\lambda \geq 1$, $F^{\tau-\sigma}(C_e, \lambda)$ is convex in C_e :

$$\frac{\partial^2 F^{\tau-\sigma}(C_e, \lambda)}{\partial C_e^2} = \frac{48\lambda^2 + 16\lambda - 1}{9\lambda(12\lambda - 1)^2} > 0$$

moreover:

$$\frac{\partial F^{\tau-\sigma}(C_e, \lambda)}{\partial C_e} = 0 \iff C_e = \underline{C_e^{\tau-\sigma}}$$

$$\underline{C_e^{\tau-\sigma}} = \frac{3(48\lambda^2 + 20\lambda - 1)}{2(48\lambda^2 + 16\lambda - 1)}$$

$$\frac{\partial \underline{C_e^{\tau-\sigma}}}{\partial \lambda} < 0$$

$$\lim_{\lambda \rightarrow \infty} \underline{C_e^{\tau-\sigma}} = \frac{3}{2} > \frac{3}{4}$$

Hence, we know that $F^{\tau-\sigma}(\underline{C_e^{\tau-\sigma}}, \lambda)$ is a global minimum and that $\underline{C_e^{\tau-\sigma}}$ lies to the right of the maximum possible value of C_e , $\frac{3}{4}$ as implied by R2.

Now, if we substitute for $C_e = \frac{3}{4}$ we get:

$$F^{\tau-\sigma}\left(\frac{3}{4}, \lambda\right) = \frac{1}{(12\lambda - 1)^2} > 0$$

we can conclude that $F^{\tau-\sigma}(C_e, \lambda)$ is always positive in the interval of values for C_e defined by R1. So $\tau > \sigma$. ■

Proof n. 5. This is a generalization to n number of firms of proof 1. We need to show that $W_{\bar{c}}^{n*}(C_e, \lambda, n) \geq W_k^{n*}(C_e, K, \lambda, n)$ whenever $S_c^* \geq C_e - \bar{C}_e(K)$. To that purpose, notice that $W_{\bar{c}}^{n*}(C_e, \lambda, n) \geq W_k^{n*}(C_e, K, \lambda, n)$ if (and only if):

$$K \geq \frac{4C_e^2(3n^4\lambda^2 + 2n^3\lambda^2 - n^2\lambda^2 + 2n\lambda - 1) - 4C_e(n+1)(3n^3\lambda^2 + n^2\lambda(2\lambda+1) - n\lambda^2 + \lambda - 1)}{8\lambda(n+1)^2(2n^2\lambda + 2n\lambda - 1)} + \frac{(n+1)^2(3n^2\lambda^2 + 2n\lambda(\lambda+1) - \lambda^2 - 1)}{8\lambda(n+1)^2(2n^2\lambda + 2n\lambda - 1)} = \phi^n(C_e, \lambda, n)$$

I now show that $K > \phi^n(C_e, \lambda, n) \forall C_e, n, \lambda$. Indeed, R1 implies:

$$K > \left(\frac{1 - 2nC_e + n}{2(1+n)} \right)^2 > \phi^n(C_e, \lambda, n)$$

to see that, let:

$$F^\phi(C_e, \lambda, n) := \left(\frac{1 - 2nC_e + n}{2(1+n)} \right)^2 - \phi^n(C_e, \lambda, n)$$

$$\frac{\partial (F^\phi(C_e, \lambda, n))}{\partial C_e} = 0 \iff C_e = \underline{C}_e^\phi$$

as $n \geq 2$ and $\lambda \geq 1$ we have moreover that:

$$\frac{\partial^2 (F^\phi(C_e, \lambda, n))}{\partial C_e^2} = \frac{(n^2\lambda + n\lambda - 1)^2}{\lambda(n+1)^2(2n^2\lambda + 2n\lambda - 1)} > 0$$

finally:

$$F^\phi(\underline{C}_e^\phi, \lambda, n) = 0$$

so $F^\phi(C_e, \lambda, n)$ is convex in C_e and $F^\phi(\underline{C}_e^\phi, \lambda, n) = 0$ is a global minimum. ■

Proof n. 6. This is a generalization to n number of firms of proof 2. We need to show that $\psi^n(C_e, \lambda, n) > \sigma^n(C_e, \lambda, n)$. To do that, it is sufficient to show that $\psi^n(C_e, \lambda, n) > \tau^n(C_e, \lambda, n)$, as $\tau^n(C_e, \lambda, n)$ is shown to be bigger than $\sigma^n(C_e, \lambda, n)$ in proof 8 (see below).

By R2:

$$n^2\lambda + n(\lambda+1) - 1 - 2C_en^2\lambda > 0$$

$$2n^3\lambda + 2n^2(\lambda+1) + n - 1 - 2C_en(2n^2\lambda+1) > 0$$

so

$$\sqrt{\psi^n(C_e, \lambda, n)} > \sqrt{\tau^n(C_e, \lambda, n)} \Rightarrow \psi(C_e, \lambda) > \tau(C_e, \lambda)$$

let

$$F_n^{\psi-\tau}(C_e, \lambda, n) := \sqrt{\psi^n(C_e, \lambda, n)} - \sqrt{\tau^n(C_e, \lambda, n)}$$

notice that $F_n^{\psi-\tau}(C_e, \lambda, n)$ is decreasing in C_e :

$$\frac{\partial(F_n^{\psi-\tau}(C_e, \lambda, n))}{\partial C_e} = \frac{n(n^4\lambda^2 + 2n^2\lambda(1-2\lambda) + 4n\lambda - 1)}{(n+1)(1-2n\lambda)(2n^2\lambda + 2n\lambda - 1)} < 0$$

if we substitute for the maximum value which can be assumed for C_e according to R2, $C_e = \frac{1+n}{2n}$ we get:

$$F_n^{\psi-\tau}\left(\frac{1+n}{2n}, \lambda, n\right) = \frac{2n^2\lambda(n-1)}{(2n\lambda-1)(2n^2\lambda+2n\lambda-1)} > 0$$

where the positive sign is given by $\lambda \geq 1$ and $n \geq 2$. Hence $\sqrt{\psi^n(C_e, \lambda, n)} > \sqrt{\tau^n(C_e, \lambda, n)} \Rightarrow \psi^n(C_e, \lambda, n) > \tau^n(C_e, \lambda, n)$. ■

Proof n. 7. This is a generalization to n number of firms of proof 3. We need to show that $W_{\tilde{c}}^{n*}(C_e, n, \lambda) \geq W_o^{n*}(C_e, n, \lambda) \forall n$.

To see it, let:

$$\begin{aligned} F_n^{\tilde{c}-o}(C_e, n, \lambda) &= W_{\tilde{c}}^{n*}(C_e, n, \lambda) - W_o^{n*}(C_e, n, \lambda) \\ \frac{\partial F_n^{\tilde{c}-o}(C_e, n, \lambda)}{\partial C_e} &= 0 \iff C_e = \underline{C_e} \\ \frac{\partial^2 F_n^{\tilde{c}-o}(C_e, n, \lambda)}{\partial C_e^2} &= \frac{n^2\lambda^2}{2n^2\lambda + 2n\lambda - 1} > 0 \\ F_n^{\tilde{c}-o}(\underline{C_e}, n, \lambda) &= 0 \end{aligned}$$

hence $F_n^{\tilde{c}-o}(C_e, n, \lambda)$ reaches a minimum and is equal to zero whenever $C_e = \underline{C_e}$. That in turns means that $W_{\tilde{c}}^{n*}(C_e, n, \lambda) \geq W_o^{n*}(C_e, n, \lambda)$. ■

Proof n. 8. This is a generalization to n number of firms of proof 4. We need to show that $\tau^n(C_e, \lambda, n) > \sigma^n(C_e, \lambda, n)$ and we proceed in the same way of proof 4.

Let

$$F_n^{\tau-\sigma}(C_e, \lambda, n) := (\tau^n(C_e, \lambda, n) - \sigma^n(C_e, \lambda, n))$$

notice that, given $\lambda \geq 1$ and $n \geq 2$, $F_n^{\tau-\sigma}(C_e, \lambda, n)$ is convex in C_e :

$$\frac{\partial^2 F_n^{\tau-\sigma}(C_e, \lambda, n)}{\partial C_e^2} = \frac{4n^4\lambda^2 + 2n^2\lambda(1-2\lambda) + 4n\lambda - 1}{\lambda(n+1)^2(2n^2\lambda + 2n\lambda - 1)^2} > 0$$

moreover:

$$\frac{\partial F_n^{\tau-\sigma}(C_e, \lambda, n)}{\partial C_e} = 0 \iff C_e = \underline{C_e}^{\tau-\sigma}$$

we know then that $F_n^{\tau-\sigma}(C_e^{\tau-\sigma}, \lambda, n)$ is a global minimum. It is easy to notice, moreover, that $C_e^{\tau-\sigma}$ lies at the right hand side with respect to $\frac{1+n}{2n}$ which is the maximum value that can be assumed for C_e according to R2:

$$\frac{C_e^{\tau-\sigma}}{n} - \frac{1+n}{2n} = \frac{n\lambda(n^2-1)}{4n^4\lambda^2 + 2n^2\lambda(1-2\lambda) + 4n\lambda - 1} + \frac{n^2-1}{2n} > 0$$

Now, if we substitute for $C_e = \frac{1+n}{2n}$ we get:

$$F_n^{\tau-\sigma}\left(\frac{1+n}{2n}, \lambda, n\right) = \frac{(n-1)^2}{(2n^2\lambda + 2n\lambda - 1)^2} > 0$$

we can conclude that $F_n^{\tau-\sigma}(C_e, \lambda, n)$ is always positive in the interval of values for C_e defined by R1. So $\tau^n > \sigma^n$. ■

Proof n. 9. To show that $\frac{\partial \tau^n(C_e, \lambda, n)}{\partial n} < 0$, first of all, notice that the numerator of $\tau^n(C_e, \lambda, n)$ is positive:

$$n^2\lambda + n(\lambda + 1) - 1 - 2C_e n^2\lambda > 0$$

since by R2

$$C_e < \frac{n+1}{2n}$$

and substituting $C_e = \frac{n+1}{2n}$ into the previous expression gets:

$$n^2\lambda + n(\lambda + 1) - 1 - 2\left(\frac{n+1}{2n}\right)n^2\lambda = n - 1 > 0$$

(the denominator of $\tau^n(C_e, \lambda, n)$ is positive as well, as can be easily noticed)

then, let

$$F^{\sqrt{\tau}}(C_e, \lambda, n) := \sqrt{\tau^n(C_e, \lambda, n)} = \frac{n^2\lambda + n(\lambda + 1) - 1 - 2C_e n^2\lambda}{2n^2\lambda + 2n\lambda - 1}$$

as $F^{\sqrt{\tau}}(C_e, \lambda, n) > 0$, $\frac{\partial F^{\sqrt{\tau}}(C_e, \lambda, n)}{\partial n} < 0 \Rightarrow \frac{\partial \tau^n(C_e, \lambda, n)}{\partial n} < 0$.

Let us take the first order partial derivative of $F^{\sqrt{\tau}}(C_e, \lambda, n)$ with respect to n :

$$\frac{\partial F^{\sqrt{\tau}}(C_e, \lambda, n)}{\partial n} = - \left(\frac{4C_e n\lambda(n\lambda - 1) + 2n\lambda(n-1) - \lambda + 1}{(2n^2\lambda + 2n\lambda - 1)^2} \right)$$

the denominator is obviously positive. The numerator is positive as well; notice in fact that

$$2n\lambda(n-1) - \lambda > 0$$

as $n \geq 2$. Given the negative sign, that means that $\frac{\partial \tau^n(C_e, \lambda, n)}{\partial n} < 0$. This in turn means that $\frac{\partial \tau^n(C_e, \lambda, n)}{\partial n} < 0$ in the interval defined by R2. ■

Proof n. 10. We need to show that if the entrant is sufficiently inefficient, regardless of the size of K , subsidization does not occur if the incumbent is domestic. To do so, notice that FCA is preferred to NI if $K \leq \sigma^d(C_e, \lambda)$ and a necessary condition for VCA to be preferred to FCA is $C_e > \frac{3(8\lambda+1)}{4(8\lambda+3)}$ (algebraic expressions are reported in Appendix B). Here I am showing that $C_e > \frac{3(8\lambda+1)}{4(8\lambda+3)} \implies K > \sigma^d(C_e, \lambda)$. If we solve $\sigma^d(C_e, \lambda)$ as a function of K , we get that $FCA \succ NI$ if (and only if):

$$C_e < \frac{3(2(4\lambda + 1) - \sqrt{32K\lambda(8\lambda + 3) + 1})}{4(8\lambda + 3)} = \Sigma^d(K, \lambda)$$

let

$$F^{\Sigma^d}(K, \lambda) := \frac{3(8\lambda + 1)}{4(8\lambda + 3)} - \Sigma^d(K, \lambda)$$

$$F^{\Sigma^d}(K, \lambda) = \frac{3(\sqrt{32K\lambda(8\lambda + 3) + 1} - 1)}{4(8\lambda + 3)} > 0$$

hence $\frac{3(8\lambda+1)}{4(8\lambda+3)} > \Sigma^d(K, \lambda)$. That implies $K > \sigma^d(C_e, \lambda)$ whenever $C_e > \frac{3(8\lambda+1)}{4(8\lambda+3)}$. That means that if the entrant is sufficiently inefficient, regardless of the size of K , subsidy does not occur at the equilibrium. ■

Proof n. 11. In this proof I show that VCA is never an optimal choice for the government. To see that, we know that a necessary condition for VCA to be preferred is that it contemporaneously yields an higher level of welfare with respect to both NI and FCA . That implies the following necessary (but not sufficient) conditions (algebraic expressions are reported in Appendix B):

$$C_e < \frac{6\lambda - 1}{8\lambda}$$

$$K < \psi^d(C_e, \lambda)$$

However $C_e < \frac{6\lambda-1}{8\lambda} \implies K > \psi^d(C_e, \lambda)$. Indeed, notice that R1 implies:

$$K > \frac{(1.5 - 2C_e)^2}{9}$$

taking the difference

$$\frac{(1.5 - 2C_e)^2}{9} - \psi^d(C_e, \lambda) = \frac{6\lambda - 1 - 8C_e\lambda}{4\lambda - 3} > 0$$

it is easy noticing that the above condition always holds whenever $C_e < \frac{6\lambda-1}{8\lambda}$. ■

Proof n. 12. When the entrant is efficient, i.e. $C_e < \widehat{C}_e(K, \lambda)$, and the government has chosen *VCA* in stage 1, the amount of subsidy granted exceeds the one strictly necessary to trigger entry. That means that *E*'s profits are positive. From a total welfare perspective, however, *VCA* is a suboptimal policy. To see that, assume that $C_e < \widehat{C}_e(K, \lambda)$. Total welfare is then:

<i>NI</i>	$W_o^{tw*} = W_o^{d*} = \frac{1}{32} + \frac{1}{16}$
<i>FCA</i>	$W_k^{tw*} = W_k^{d*} = \frac{(1.5-C_e)^2}{18} - \lambda \left(K - \frac{(1.5-2C_e)^2}{9} \right) + \frac{C_e^2}{9}$
<i>VCA</i>	$W_c^{tw*} = \frac{\lambda^2(4C_e-9)^2}{8(12\lambda-1)^2} - \lambda \left(\frac{6\lambda+1-8\lambda C_e}{2(12\lambda-1)} \right) \left(C_e - \frac{3(3\lambda-1)+12\lambda C_e}{2(12\lambda-1)} \right) +$ $+ \frac{\left(\frac{3(3\lambda-1)+12\lambda C_e}{2(12\lambda-1)} \right)^2}{9} + \left[\frac{\left(1.5-2 \left(\frac{3(3\lambda-1)+12\lambda C_e}{2(12\lambda-1)} \right) \right)^2}{9} - K \right]$

where the term in square brackets represents *E*'s profits. *VCA* is superior to *NI* iff:

$$K < \frac{192C_e^2\lambda^2(4\lambda+3) - 16C_e\lambda(72\lambda^2 + 42\lambda + 11) + 432\lambda^3 + 180\lambda^2 + 96\lambda + 13}{32(12\lambda-1)^2} = \tau^{tw}(C_e, \lambda)$$

since the comparative advantage of *VCA* with respect to *NI* is surely decreasing in λ in the interval defined by $C_e < \widehat{C}_e(K, \lambda)$, let us impose $\lambda = 1$, so that *VCA* yields the maximum possible level of welfare. We thus have:

$$\tau^{tw}(C_e, 1) = \frac{1344C_e^2 - 2000C_e + 721}{3872}$$

By R1, K has to be bigger than $\frac{(1.5-2C_e)^2}{9}$. It turns out that it can never be below $\tau^{tw}(C_e, 1)$. Indeed, let

$$F^{tw}(C_e) := \frac{(1.5-2C_e)^2}{9} - \tau^{tw}(C_e, 1) = \frac{3392C_e^2 - 5232C_e + 2223}{34848}$$

It is easy to see that $F^{tw}(C_e)$ is strictly convex in C_e and that

$$\arg \min F^{tw}(C_e) = \frac{5}{848} > 0$$

hence $F^{tw}(C_e)$ is always greater than zero and K cannot be lower than $\tau^{tw}(C_e, \lambda)$, so *VCA* is never an optimal strategy for an Authority which maximizes total welfare if the incumbent is European, even if the entrant is very efficient and European as well. ■

1.A.2 Minor Proofs

The optimal choices of the subsidy levels in the basic model

The optimal choice of S_k When *FCA* has been chosen in stage 1, the government chooses S_k as to:

$$\max_{S_k} W_k(C_e, S_k, \lambda) := CS_k - \lambda S_k = \frac{(1.5 - C_e)^2}{18} - \lambda S_k$$

The optimal level of S_k is then:

$$S_k^* = K - \frac{(1.5 - 2C_e)^2}{9}$$

The optimal choice of S_c When *VCA* has been chosen in stage 1, the government chooses

S_c as to:

$$\max_{S_c} W_c(C_e, S_c, \lambda) := CS_c - q_e \cdot \lambda S_c = \frac{(1.5 - (C_e - S_c))^2}{18} - \frac{3 - 4(C_e - S_c)}{6} \cdot \lambda S_c$$

The optimal level of S_c is:

$$S_c^* = C_e - \frac{3(3\lambda-1)+12\lambda C_e}{2(12\lambda-1)} \quad \text{if} \quad C_e \leq \frac{6\lambda+1-2\sqrt{K}(12\lambda-1)}{8\lambda} = \widehat{C}_e(K, \lambda)$$

$$S_c^* = C_e - \frac{3-6\sqrt{K}}{4} \quad \text{if} \quad C_e > \widehat{C}_e(K, \lambda)$$

it can be easily seen that $C_e - \frac{3(3\lambda-1)+12\lambda C_e}{2(12\lambda-1)} \leq C_e - \frac{3-6\sqrt{K}}{4}$ whenever $C_e \leq \widehat{C}_e(K, \lambda)$.

Notice that:

$$\frac{\partial \widehat{C}_e(K, \lambda)}{\partial K} = -\frac{12\lambda - 1}{8\lambda\sqrt{K}} < 0$$

$$\frac{\partial \widehat{C}_e(K, \lambda)}{\partial \lambda} = -\frac{2\sqrt{K} + 1}{8\lambda^2} < 0$$

The comparison between FCA and VCA in the basic model

The cost of the subsidy The cost of granting a *FCA* and of granting a *VCA* is given by the following expressions respectively:

$$C(FCA) = \lambda S_k^*$$

$$C(VCA) = \lambda q_e S_c^*$$

Let $\Delta(C_e, K, \lambda)$ be a positive function of the difference between the total cost of subsidizing *E* with *VCA* minus the total cost of subsidizing *E* through *FCA*:

$$\Delta(C_e, K, \lambda) := \frac{C(VCA) - C(FCA)}{\lambda} = \sqrt{K} \left(C_e - \frac{3 - 6\sqrt{K}}{4} \right) - \left(K - \frac{\left(\frac{3}{2} - 2C_e\right)^2}{9} \right)$$

notice that *VCA* costs more than *FCA* ($\Delta(C_e, K, \lambda) > 0$) whenever $C_e > \frac{3(1-\sqrt{K})}{4}$ or $K > \left(\frac{4C_e-3}{3}\right)^2$.

Notice that whenever $\Delta(C_e, K, \lambda) = 0$ (the two aid instrument have the same cost), *VCA* \succ *FCA*. To see that notice that:

$$\psi(C_e, \lambda) - \frac{3(1-\sqrt{K})}{4} > 0 \text{ if } C_e < \frac{3}{4} \leq \frac{3(16\lambda+1)}{4(16\lambda-1)}$$

which is satisfied by R2.

If we differentiate $\Delta(C_e, K, \lambda)$ for C_e we get:

$$d\Delta = \sqrt{K} dC_e - \left(\frac{2}{3} - \frac{4}{9}C_e\right) dC_e$$

notice that for any $C_e > \frac{3}{2} - \frac{9}{4}\sqrt{K}$, $dC_e > 0 \implies d\Delta > 0$.

The negative relationship between $\psi(C_e, \lambda)$ and λ :

$$\frac{\partial \psi(C_e, \lambda)}{\partial \lambda} = \frac{2(4C_e - 5)(4C_e(8\lambda + 1) - 3(8\lambda + 3))}{3(1 - 4\lambda)^3} < 0$$

The extension of the model to n competing firms

In stage 1 welfare levels are:

<i>NI</i>	$W_o^{n*} = \frac{(n-1)^2}{8n^2}$
<i>FCA</i>	$W_k^{n*} = \frac{(1+n-2C_e)^2}{8(1+n)^2} - \lambda \left(K - \frac{(1-2nC_e+n)^2}{4(1+n)^2} \right)$
<i>VCA</i>	$W_{\hat{c}}^{n*} = \frac{\lambda(4C_e^2 n^2 \lambda - 4C_e(n^2 \lambda + n(\lambda+1)-1) + n^2(\lambda+2) + 2n\lambda + \lambda - 2)}{8(2n^2 \lambda + 2n\lambda - 1)}$ with $C_e \leq \widehat{C}_e^n(K, \lambda, n)$ $W_{\hat{c}}^{n*} = \frac{4\sqrt{K}(n^2 \lambda + n(\lambda+1)-1) + n^2 - 2n + 1 - 8C_e \sqrt{K} n^2 \lambda - 4K(2n^2 \lambda + 2n\lambda - 1)}{8n^2}$ with $C_e > \widehat{C}_e^n(K, \lambda, n)$

The corresponding thresholds are:

- *FCA* is preferred to *NI* if:

$$K \leq \frac{4C_e^2 n^2 (2n^2 \lambda + 1) - 4C_e n^2 (n+1)(2n\lambda + 1) + (n+1)^2 (2n^2 \lambda + 2n - 1)}{8n^2 \lambda (n+1)^2} = \sigma^n(C_e, \lambda, n)$$

- *VCA* is preferred to *NI* if:

$$K \leq \left(\frac{n^2 \lambda + n(\lambda + 1) - 1 - 2C_e n^2 \lambda}{2n^2 \lambda + 2n\lambda - 1} \right)^2 = \tau^n(C_e, \lambda, n)$$

- *VCA* is preferred to *FCA* if:

$$K \leq \left(\frac{2n^3 \lambda + 2n^2(\lambda + 1) + n - 1 - 2C_e n(2n^2 \lambda + 1)}{2(n+1)(2n\lambda - 1)} \right)^2 = \psi^n(C_e, \lambda, n)$$

The extension of the model to domestic incumbent

In stage 1 welfare levels are:

<i>NI</i>	$W_o^{d*} = \frac{1}{32} + \frac{1}{16}$
<i>FCA</i>	$W_k^{d*} = \frac{(1.5 - C_e)^2}{18} - \lambda \left(K - \frac{(1.5 - 2C_e)^2}{9} \right) + \frac{C_e^2}{9}$
<i>VCA</i>	$W_c^{d*} = \frac{1}{2} \left(\frac{1+2\sqrt{K}}{4} \right)^2 - \lambda \sqrt{K} \left(C_e - \frac{3-6\sqrt{K}}{4} \right) + \left(\frac{3-6\sqrt{K}}{12} \right)^2$

where the last term in each expression are the incumbent's profits.

The corresponding thresholds are:

- *FCA* is preferred to *NI* if:

$$K < \frac{16C_e^2(8\lambda + 3) - 48C_e(4\lambda + 1) + 9(8\lambda + 1)}{288\lambda} = \sigma^d(C_e, \lambda)$$

- *VCA* is preferred to *NI* if:

$$K < \left(\frac{6\lambda - 1 - 8\lambda C_e}{3(4\lambda - 1)} \right)^2 = \tau^d(C_e, \lambda) \cap C_e < \frac{6\lambda - 1}{8\lambda}$$

- *VCA* is preferred to *FCA* if:

$$K < \frac{(4C_e(8\lambda + 3) - 3(8\lambda + 1))^2}{36(4\lambda - 3)^2} = \psi^d(C_e, \lambda) \cap C_e < \frac{3(8\lambda + 1)}{4(8\lambda + 3)}$$

1.B Figures

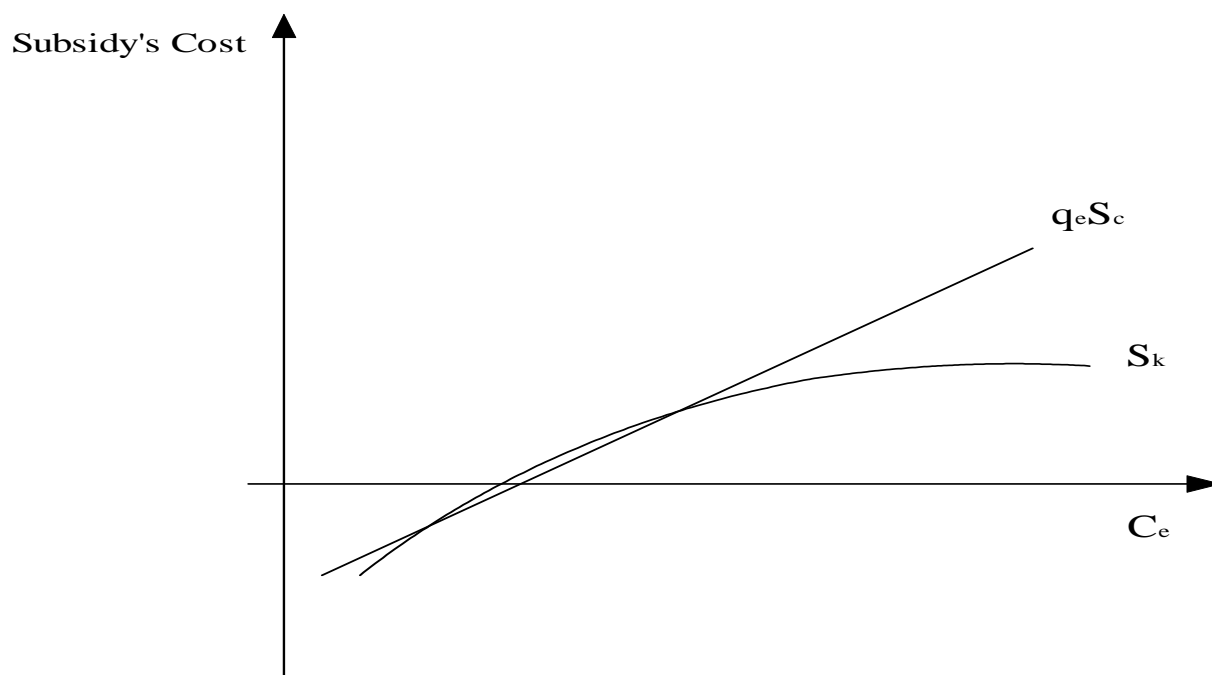
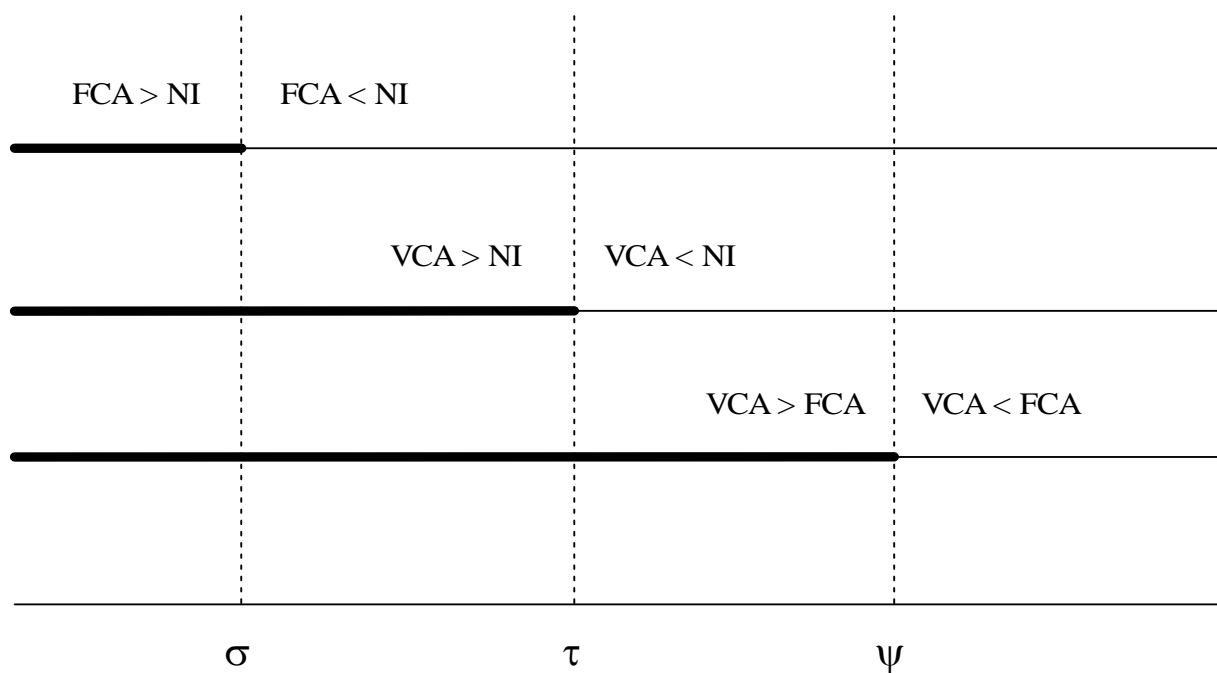


figure 1 - State aid instruments' cost

figure 2 - The thresholds for K

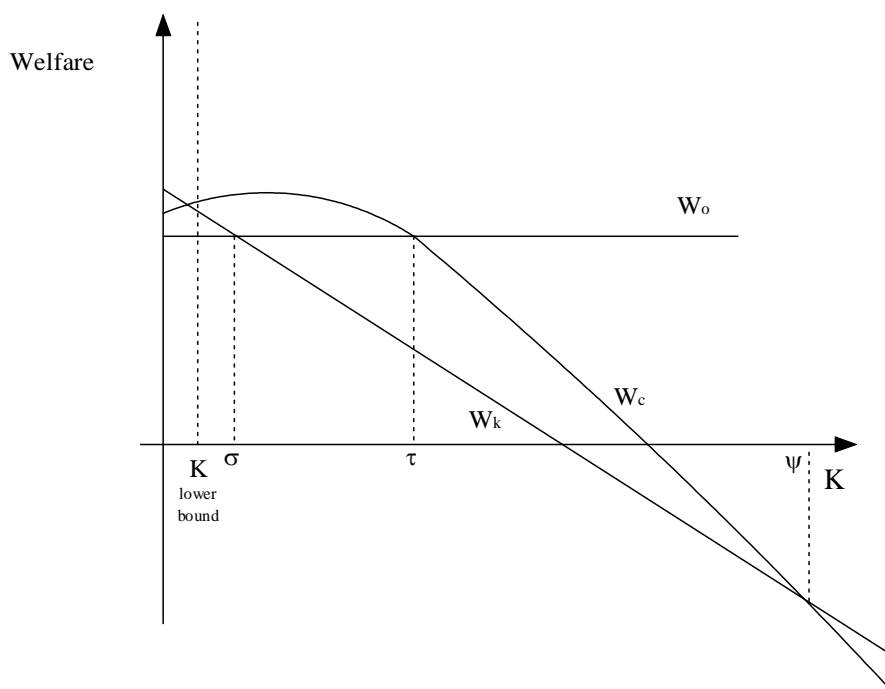


figure 3 - Welfare levels for given $C_e = .675$ and $\lambda = 1$

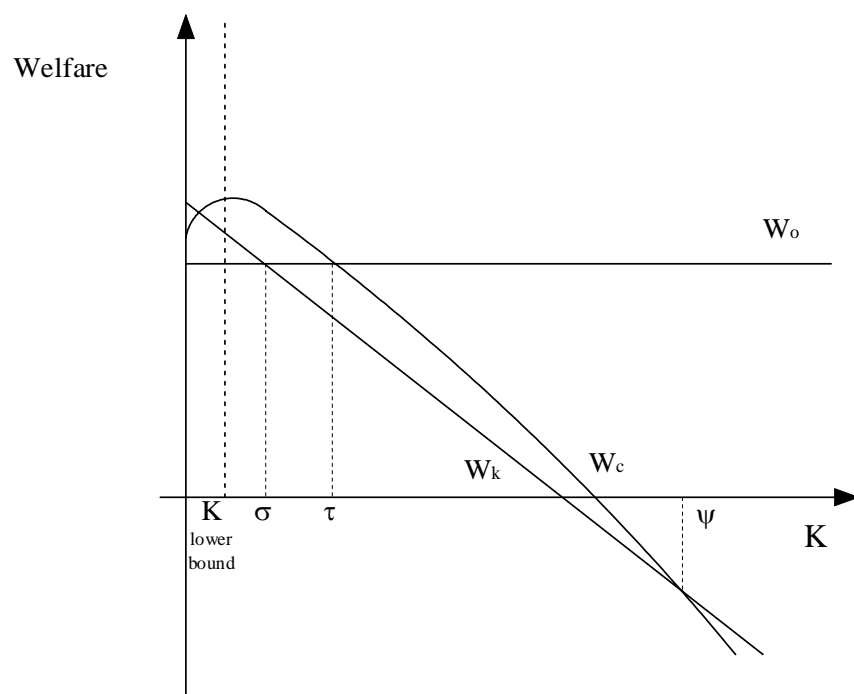
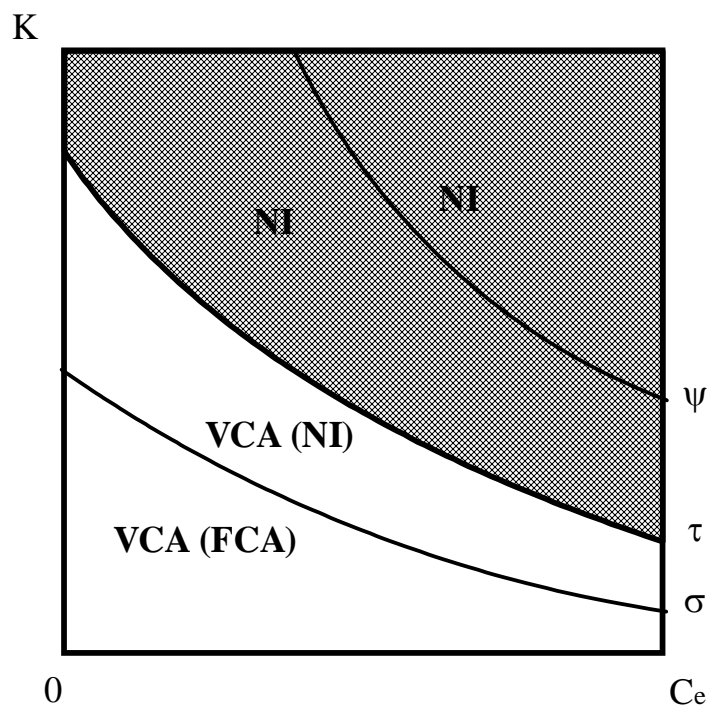
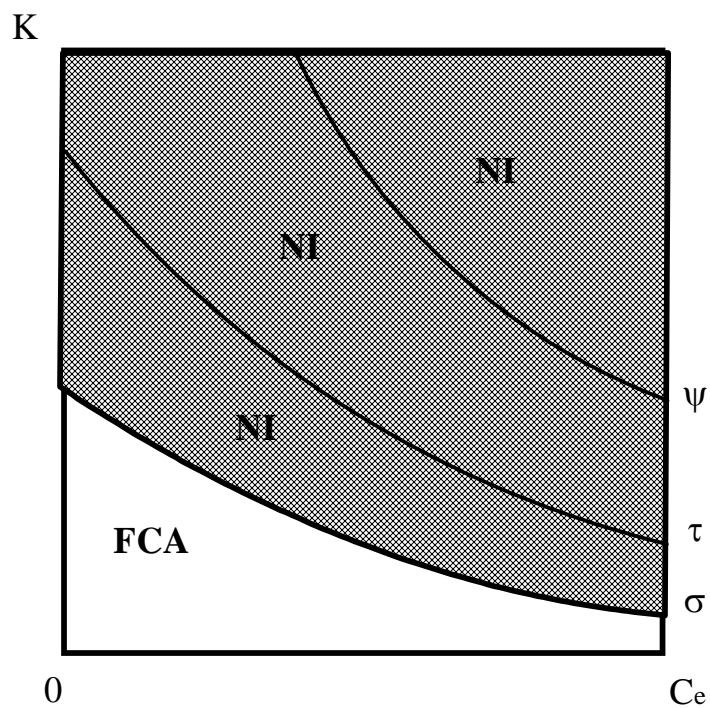


figure 4 - Welfare levels for given $C_e = .675$ and $\lambda = 2$

figure 5 - The government's choice when *VCA* is allowedfigure 6 - The government's choice when *VCA* is banned

Chapter 2

Should Small or Young Firms Be Subsidized?

2.1 Introduction

In March 2000, the European Council committed the European Union to become 'the most dynamic and competitive knowledge-based economy in the world' through a series of actions which came to be known as Lisbon strategy. After two years, in Barcelona, the European Council set the goal for overall spending on Research & Development (R&D) to 3% of GDP to be reached by 2010.

In the light of Lisbon and Barcelona, the European Commission has recently launched the "State Aid Action Plan" (SAAP) a road map to the modernization of the current Community framework for state aid. The proposed goal of the SAAP is a refined economic approach which would allow Member States to target market failures limiting market's distortions.

Within this context, the Commission shows to be particularly worried by young and small-medium enterprises (SMEs) which more likely are affected by asymmetric information and hence experience difficulties to develop and carry on R&D projects at most. SME's and young firms are thus allowed to benefit from exceptions to the general provision of the European Treaty according to which state aid should not be used by Member States.

The 'market failure' argument is, however, not sufficient to support such policy: a comprehensive economic analysis which takes into consideration the cost of introducing a state aid scheme targeting small firms is indeed needed in order to assess its optimality from a total welfare perspective.

The purpose of this paper is to analyze the impact of the proposed rules on a specific issue where this conflict is particularly relevant: state aid to overcome financial market's imperfections.

A large body of the economic literature has tackled the problem of stimulating R&D through state subsidy, starting from the consideration that, due to its public good features, private investment in R&D tends to be less than socially desirable. A subset of this literature, mainly empirical, focuses on the assessment of the incentive effect of public funding, asking whether the relationship between public and private R&D investments is on balance characterized by 'complementarity' or by 'substitution'. David et al. (2000) and Klette et al. (2000) survey the existing literature concluding that a complementary relationship between privately and publicly financed R&D is often found in the empirical analyses but also that these results are usually not sustained by appropriate econometric methodology. García-Quevedo (2004) studies the existing empirical literature with a meta-econometric analysis and finds that no clear answer can be deduced by

evidence, given the ambiguity of the reported results.

This paper moves from the same concern about the effectiveness of public support to R&D and proposes a theoretical framework focused on firms' access to capital market where such concern is addressed. The aim is to reproduce in a simple setting some of the results which have been found in the theoretical¹ and empirical literature in imperfect financial market and to assess in that setting the impact of different state aid policies.

The model that is described in Section 2 is based on a simplified version of Holmström and Tirole (1997, henceforth HT). HT describe an incentive model of financial intermediation in which firms as well as intermediaries are capital constrained. They define a two periods game where players sign a financial contract in the first period and investment returns are realized in the second one. Due to moral hazard and limited borrowing capacity, capital-poor firms are unable to invest, whilst firms with strong balance sheets have better access to market finance and are less affected by credit crunches. The moral hazard problem is partially solved by monitoring which reduces managers' private benefit of shirking.

The model developed in this paper does not explore the monitoring issue nor it considers differences in firms' balance sheets. Instead, firms differ by the quantity and quality of information they are able to provide to banks when they present their projects. This is a particularly relevant issue since, coherently with the new capital requirement agreement (Basel II), banks are progressively turning to an internal assessment process rather than using the initial capital measurement system (Basel I) when deciding whether to grant a loan or not. Thus a good project presented by a firm which is more easily ranked by banks is more likely to be funded. On the other hand, a firm which is almost unknown to the bank, which has no or few experience in innovation or which is unable to provide enough details on the proposed activity, has a high probability of not being funded regardless of the quality of its project. The 'informative ability' of a firm in the model is proxied by a variable s_i and it is assumed to be directly correlated with firm's size and experience. As noted above, the European Commission considers firms' size and age very relevant in the context of imperfect financial market due to asymmetric information.² The asymmetric information problem relies, in fact, on the assumption that the proposing subject has

¹For a review on corporate financing, see Cestone (1999).

²In the Community Guidelines for Aid to Risk Capital (pg. 8), the Commission states: *'the main source of the market failures relevant to the supply of risk capital affecting in particular SMEs at an early stage of their development is imperfect and asymmetric information. This implies that potential investors face large difficulties and high costs in gathering reliable information on the business prospects of a SME or a new company. These*

usually better information on the likelihood of success of the project than the possible investor. The premium offered to compensate this lack of information represents the reason why external finance is more costly than internal finance (Akerlof, 1970 - Stiglitz and Weiss, 1981). This kind of problems is most likely to be observed whenever a firm has greater difficulties to signal its own degree of reliability and, consequently, it affects more young and small-medium enterprises justifying public intervention.³

Recent surveys on managers' opinion confirm that the existence of this information problem is felt particularly by young firms and SMEs. According to the 'Observatory of European SMEs' (2003):

- 41% of European SMEs have credit lines with one single bank, only 5% have credit lines with more than three banks
- A basic condition for providing loans to enterprises is that the banks have sufficient information about the enterprises to access the applications
- Often the problem of inadequate information is mentioned as one of the main aspects hampering bank finance to SMEs.
- There is a positive correlation between the size of an enterprise and the information provided to banks.
- Access to bank finance has become more difficult within the last twelve months because of collateral demand, increased transparency requirements and increased documentation requirements.

According to 'UNICE' (Union des Industries de la Communauté Européenne - 2005):

many banks have begun determining the individual risk profile of the borrower through an internal rating procedure. This implies increased scrutiny on the part of the lending institutions of a borrower's business operations and financial structure.

In order to properly assess the risk involved in a lending transaction, the financial

problems are particularly significant for companies where the assessment of the risks involved is more uncertain, i.e. for companies without any track record and/or available collateral and/or proprietary intellectual property, or for highly innovative or risky projects such as those related to the development of new technologies" .

³Several empirical works confirm these theoretical predictions (see for example: Devereux and Schiantarelli - 1990, Schiffer and Weder - 2001, Beck et al. - 2005). Hall (2002) provides a nice survey on that literature. According to Hall, there is clear evidence that 'small and start-up firms in the R&D-intensive industries face a higher cost of capital than their larger competitors and than firms in other industries'.

institutions need to have sufficient knowledge about the line of business a company is involved in. This applies, in particular, to start-up companies.

Given these remarks, the model described in the following Section sets up a coherent theoretical framework where state aid is analyzed according to those characteristics that, as we have just seen, appear to be crucial in hampering firm's access to funding. To that purpose, two new variables with respect to the HT framework are introduced: S and s_i :

- S is an exogenous fixed (sunk) cost sustained by firms willing to get funding. Whenever a firm has an idea for an innovative project and needs external financing to develop it, it is required to produce some information. This information concerns the project but also the firm itself. Typically the following information are required:
 - a description of the project
 - identity, background and audited financial statements of managers (i.e. information concerning the promoter's capability to implement the planned project)
 - analysis of the products/services demand over the project's life
 - information on project costs and its detailed components
 - information on financial and economic profitability.⁴

In the model it is assumed that S is a fixed cost which is the same regardless of firm's characteristics. Small firms are obviously more penalized since the effort they are required to make is higher if proportioned to their internal resources. The model in the paper does not take into consideration that issue because the focus is on another source of asymmetry which is the intrinsic different ability that firms have to show the quality of their projects. But the model could be easily adapted by differentiating firms in their assets too.

- s_i represents the probability that the bank has to detect firm's type. When a firm presents a project, the bank has s_i probability to understand if the project has high probability of success (the firm is 'good' in the terminology used in the model) or it has low probability (the firm is 'bad') and $1 - s_i$ probability of having no knowledge on the type of the firm. s_i is assumed to be exogenous and independent of firm's type but directly correlated to firm's

⁴Source: European Investment Bank

size or experience. The idea is that a bigger or well established firm is more easily assessed by banks with respect to a young firm which is just starting a new activity or with respect to a SME which has relationship with only one or few banks. As we have seen above, SMEs feel the inadequacy of the information they are able to provide as one of the main barrier to their access to bank's financing. Big firms have often specific division and hire experts on purpose for assessing the quality of their projects. Young and small firms usually spend all their resources in the development of a project and are not able to provide detailed information on its success' likelihood.

The model described in the following Section shows that granting a subsidy to a small or young firm can be optimal for a welfare maximizing authority if the proportion of firms with a high probability of success in the economy is sufficiently large. This result is less trivial than it might appear. Indeed, subsidizing small or young firms has a greater positive effect on innovation (because those are the firms which are more affected by the market failure) but it entails a higher cost for society. This cost is due to the fact that the probability that the subsidy benefits a firm with low probability of success is higher when the 'informative power' of the firm is lower i.e. when the firm is small or young.

One way to reduce that source of costs is to grant the subsidy only after the bank has screened the firms; this allows the government to exploit the bank's filter in order to identify only those firms which would not be able to develop the innovative project without the government's intervention. As we are going to see, the model shows that this kind of aid is more effective with bigger or more experienced firms, as the costs' saving is greater when the firm's informative power is higher.

The rest of the paper is organized as it follows: Section 2 describes and solves the model; conclusions are discussed in Section 3. Proofs are reported in the Appendix.

2.2 The Model

2.2.1 The Basic Set-up

There are two players: a borrowing firm i and a lending bank l . Firm i can be of two types: with probability $\alpha \in [0, 1]$ the firm is good type ($\theta = g$); with probability $1 - \alpha$ the firm is bad type ($\theta = b$). The type of the firm is strictly related to the probability of success if the firm invest

in an innovation project. The parameter α can thus be interpreted as the proportion of good firms in the economy i.e. the proportion of firms which present a project with high probability of success.⁵

Having enough financial resources, firm i could invest I in a project which yields R with probability $p(\theta)$. A good firm has probability 1 of success while a bad firm has probability 0 of success. Both types have an outside option of B with probability 1 if they invest the money received somewhere else and not in the research project. The value of the outside option is assumed to be lower with respect to the expected value of the project for a good firm: $R > B$. The parameters' values are known to all players. In addition, investing in the outside option is socially inefficient: $B < I$.⁶

Firm i has zero net private asset and it needs a loan from the bank in order to invest.⁷ To do so, firm i has to sustain some fixed cost of entry S which represents the amount of effort required by the bank for providing information concerning firm's type. The bank may guess the firm's type with probability s_i while it gets no information with probability $1 - s_i$. Both S and s_i are assumed to be exogenous and unrelated to firm's type. s_i , however, is an idiosyncratic term which is specific of the firm and depends positively on its size or experience.

The total cost of the investment is hence $T = I + S$. It is assumed that the total cost of investment is higher than the expected return from a project developed by a bad type: $T > 0$. Financing a bad firm is thus welfare detrimental, besides being not profitable for the bank. Financing a good firm is, instead, profitable if R is sufficiently large. In order to have such result, it is sufficient to restrict our analysis to the interval for which $R > T + B$, for a reason which will become clearer later.

During the bargaining phase, the bank proposes a contract to firm i making a take-it or leave-it offer. The contract is such that the gain from success in the development of the innovation is split between the firm and the bank according to their bargaining power.

$$E(R_i^\theta) = \mu(R - T)p(\theta) + \xi \quad (2.1)$$

⁵To have an idea on how much could be α in the real economy, notice that the percentage of successful innovators in some Member States varies from 19% (UK, low-technology sector) to 70% (Germany, high technology sector). Source: CIS3 (Community Innovation Survey).

⁶For ease of exposition, here I am not discussing the origin of these parameters and consider them exogenous. Notice, however, that these parameters are coherent with the setting depicted by Holmstrom and Tirole (1997) where moral hazard is possible.

⁷The gross private asset is however sufficient to cover administrative costs such as S as it is defined later.

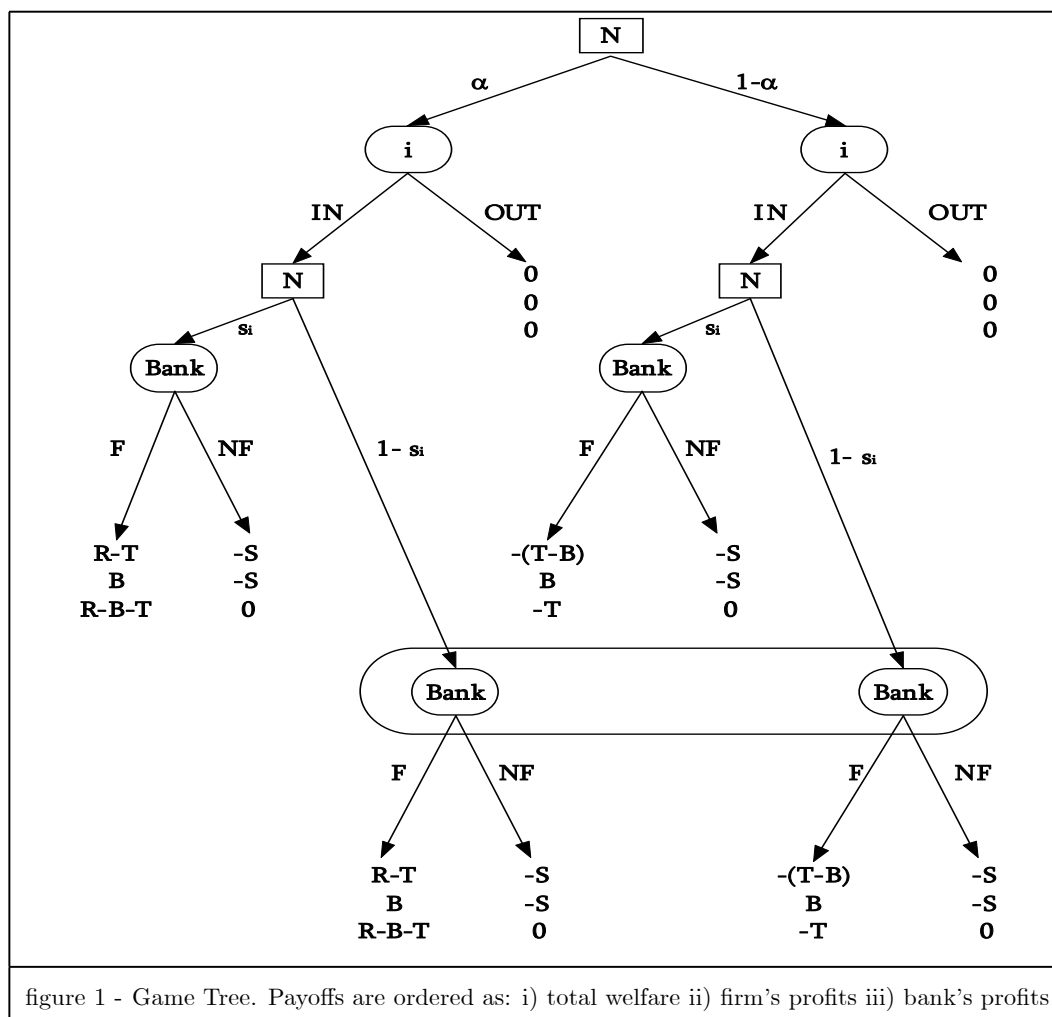
$$E(R_i^\theta) = (1 - \mu)(R - T)p(\theta) - \xi \quad (2.2)$$

where $E(R_i^\theta)$ and $E(R_l^\theta)$ are the expected profits of the firm and the lender, respectively, and $\mu \in [0, 1]$ is the fraction of revenue going to firm i in case of success. ξ is a lump sum benefit that the bank grants to the firm in order to prevent moral hazard. It can be easily shown that $\xi = B$ whenever $\mu = 0$ and $\theta = g$.

In the following it is assumed that $\mu = 0$ i.e. the bank gets all the surplus generated by the project in case of success. This assumption helps to simplify the model and it is relatively innocuous: as long as $\mu \neq 1$, a reduction in the total cost of the investment due to a subsidy increases the bank's willingness to finance, as we are going to see in the following. A different μ would imply a different size of the subsidy necessary to trigger a financing decision. The effect of a change in the size of the needed subsidy is however already totally captured by an increase in B or a reduction in R , which are the determinants of the bank's profits. Summarizing:

- nature plays and chooses the firm's type. The firm can be either good (with probability α) or bad (with probability $1 - \alpha$).
- firm i observes its own type and decides whether to present a project proposal to the bank (*IN*) or to stay out from the innovation market (*OUT*). In the first case, firm i has to bear a fixed cost S . In the second case the firm makes zero profit.
- if firm i has presented the project, nature plays and chooses whether the bank detects the firm i 's type (with probability s_i) or not (with probability $1 - s_i$).
- the bank decides whether to finance (*F*) or not (*NF*) firm i .

Figure 1 represents the game tree of the basic model:



2.2.2 Solution of the Basic Model

Suppose that the bank can detect the firm's type with certainty: $s_i = 1$. By assumption, lending to a bad firm is unprofitable. Thus only good firms are financed. In that case, the bank would offer a contract such that:

$$E(R_i^g) = B \tag{2.3}$$

$$E(R_i^g) = (R - T) - B \tag{2.4}$$

under these conditions, indeed, the good firm has no incentive to deviate the money received from the bank in the outside option.

Now, suppose that no information on the firm's type is available to the bank: $s_i = 0$.

Two pooling equilibria and a mixed strategy equilibrium may arise. Depending on the proportion of good types α (i.e. on the probability that a good firm is knocking at the bank's door), the bank may or may not find it profitable to finance an 'unknown' type firm. Formally, the bank grants a loan to a firm if:

$$E(R_l) = \alpha(R - B) - T \geq 0$$

that is: the loan is granted only if the expected gains of the lender are higher than the total investment cost.

To have lending (and thus possible innovation) at the equilibrium, the proportion of good types must hence be sufficiently high:

$$\alpha \geq \underline{\alpha} := \frac{T}{R - B} \quad (2.5)$$

Two pure strategy equilibria may arise: an equilibrium where both the good and the bad type enter and the bank finances the firm if $\alpha \geq \underline{\alpha}$ and an equilibrium where nobody enters the market for innovation since the bank does not finance an unknown type firm if $\alpha < \underline{\alpha}$. In the first case, probability of innovation is α , the firm's profits are B (whatever the type) and the bank's profits are $\alpha(R - B) - T$.

Since the firm has to sustain a fixed cost to propose the project (i.e. entry is risky), a mixed strategy equilibrium where a good firm enters with probability 1 and a bad firm randomizes between entering or staying out can arise too if $\alpha < \underline{\alpha}$.⁸ This happens whenever the bank has belief such that it attaches $\underline{\alpha}$ probability to the left node of the info set i.e. whenever it believes a firm the type of which has not been detected to be good with probability $\underline{\alpha}$. In that case, the bank randomizes between financing and not financing. Formally, let σ_θ be the probability attached by type θ to entering and η be the probability attached by the bank to the financing decision whenever it is unaware of firm's type, we have:

$$\begin{aligned} \sigma_g &= 1 \\ \sigma_b &= \frac{\alpha(R - B - T)}{T(1 - \alpha)} \\ \eta &= \frac{S}{B + S} \end{aligned}$$

In this equilibrium the probability of innovation is $\alpha \frac{S}{B+S}$ and both the firm (no matter the type) and the bank have zero profits. The intuition why the good type is also making zero profit is the following: the bad type randomizes between *IN* and *OUT*, so in both cases it has zero

⁸Indeed, if entry was not risky, the bad firm would always enter the market for innovation with probability 1.

expected profits. Since $s_i = 0$, there is no way the bank can distinguish between the two types and they are both treated in the same way. Hence the good type's expected profits are zero as well.

Since the pure strategy equilibrium where no lending occurs and the mixed strategy equilibrium coexist when $\alpha < \underline{\alpha}$, we need to select one of them in order to go on with the analysis. The mixed strategy equilibrium is superior with respect to the pure strategy one according to a forward induction criterion since the good type has always at least a weak incentive to enter whenever $s_i \geq 0$. I henceforth assume that the mixed strategy equilibrium occurs if $\alpha < \underline{\alpha}$.

Now let $s_i \in (0, 1)$. That is: there is a positive probability that the bank is able to guess the firm's type.

We first need to define the following threshold:

$$\bar{s} := \frac{B}{B+S} \quad (2.6)$$

\bar{s} represents the level of s_i above which the equilibria reached are the same of the full detection benchmark. When $s_i > \bar{s}$, in fact, a bad firm has negative expected profits when entering the market for innovation since the probability of being detected is too high compared to the benefit it gets by being financed. It turns out that when $s_i > \bar{s}$ only a good firm asks a loan to the bank. The bank is thus able to select the firms and offer a contract just to good firms.

Within the interval $s_i \in [0, \bar{s})$ the mixed strategy equilibrium arises whenever $\alpha < \underline{\alpha}$. As we have seen, in that case, a good firm enters the market for innovation with probability 1 while a bad type randomizes between entering and not entering. Formally:

$$\begin{aligned} \sigma'_g &= 1 \\ \sigma'_b &= \frac{\alpha(R-B-T)}{T(1-\alpha)} \\ \eta' &= \frac{S}{B+S} + \frac{Ss_i}{(1-s_i)(B+S)} \end{aligned}$$

Notice that given these parameters, if a firm's type is not detected, the bank has $\underline{\alpha}$ probability of facing a good type (this is why the bank randomizes between the two different choices).

In this equilibrium the probability of innovation is $\alpha \left(s_i + \frac{S}{\bar{s}+B} \right)$ and welfare is composed as it follows: a good firm has expected profits $s_i(B+S)$, a bad firm has expected profits equal to zero and the bank has expected profits equal to $\alpha s_i(R-B-T)$. Notice that the good type's expected profits tend to 0 for $s_i \rightarrow 0$ and to B for $s_i \rightarrow \bar{s}$.

After having solved the basic model, we can then conclude that innovation likelihood is below its potential because of imperfection in the financial markets whenever $s_i < \bar{s}$ and $\alpha < \underline{\alpha}$. In that case, social welfare is given by:

$$W = \alpha s_i (R - I)$$

and a government G may be willing to subsidize the firm in order to stimulate innovation and maximize welfare. The following Section deals with that issue.

2.2.3 The State Aid Game

Let us assume that $s_i < \bar{s}$ and $\alpha < \underline{\alpha}$. A state aid system is now introduced in the basic model. Players are now three since a government is also playing the game. At the beginning of the game, the government may grant a lump-sum subsidy x with a certain probability q . If granted, the subsidy reduces the total cost of investing T by x if the bank accepts to finance the project. The aid is thus not a free grant: since it is granted in the form of a reduction of the total cost of the investment, the firm is entitled to get the aid only if it will be financed by the bank. Notice, however, that the government is not able to discriminate among firms on the basis of their type since it does not have access to the same information provided to the bank. All players know if the aid is granted before firm i decides whether to enter the market for innovation or not. As the subsidy is granted before the firm and the bank play, this scheme is called the *ex-ante* aid scheme.

The amount of aid x is assumed to be sufficiently large to induce a financing decision when the bank does not know the firm's type i.e. $x = T - \alpha(R - B)$: a greater subsidy would be inefficient; a lower one would be useless. Indeed, a bank finds financing to yield non negative profits if and only if $T - x \leq \alpha(R - B)$.

Expected welfare is given by:

$$E(W) = \alpha E(R_i^g) + (1 - \alpha)E(R_i^b) + E(R_l) - \lambda x q \quad (2.7)$$

where λ is the shadow cost per unit of subsidy and q is the probability that the firm gets the subsidy at the beginning of the game. I henceforth assume that $\lambda = 1$ that is: the tax system is efficient. We can accept such (unrealistic) assumption for two reasons: first of all it simplifies the model helping us to focus on the parameters of interests. Secondly, and most important, this assumption does not imply that granting a subsidy is not costly for the government, in this

context. Since the government is not able to guess the type of the firm, there is a possibility that the subsidy is granted to a bad firm. In that case welfare is reduced since, by assumption, the outside option B has lower value with respect to I , the cost of investing in the development of an innovation. Hence, granting a subsidy might be welfare detrimental even if the transfer of resources from the government to firms is perfectly efficient.

It turns out that, whatever is its type, if the firm knows to be entitled to get the subsidy at the beginning of the game, it enters the market for innovation and it is financed by the bank, with the exception of the case in which its type is bad and its type is detected by the bank.

The following payoff structure then occurs:

$$E(R_i^g) = qB + (1 - q)s_i(B + S) \quad (2.8)$$

$$E(R_i^b) = q((1 - s_i)B - s_iS) \quad (2.9)$$

$$E(R_l) = q(\alpha(1 - \alpha)s_i(R - B)) + (1 - q)(\alpha s_i(R - B - T)) \quad (2.10)$$

$$E(W) = q((1 - \alpha)(B(1 - s_i) + Is_i) + \alpha R - T) + (1 - q)\alpha s_i(R - I) \quad (2.11)$$

$$\chi = q\alpha + (1 - q)\alpha \left(s_i + \frac{S}{S + B} \right) \quad (2.12)$$

where χ is the probability that innovation takes place. Let us discuss each single equation in order to clarify the origin of these expressions. Notice that when the subsidy is not granted (with probability $1 - q$) the payoffs are the same of those obtained with the basic model.

(2.8) represents the expected profits for a good firm. By definition, if a firm is subsidized, it is financed by the bank when the bank is not able to guess its type. Since the good firm enters the market for innovation with probability 1, that means that if the good firm is entitled to the subsidy, it is financed with certainty: indeed, if its type is not detected, it is still profitable for the bank to finance it because of the subsidy. Thus, if the good firm receives a subsidy it has expected profits equal to B .

(2.9) represents the expected profits for a bad firm. The bad firm can be financed only if its type is not detected. In addition, recall that the bad firm has 0 expected profits when the government does not play the game. If the subsidy is granted, the bad firm enters the market for innovation with probability 1 (recall that $s < \bar{s}$ and hence the firm has expected profits which are higher than expected loss in case the bank detects its type).

By entering the market for innovation, the bad firm gets B with probability $1 - s_i$ if it is not detected and loses S with probability s_i if the opposite happens.

(2.10) is the expression of the bank's expected profits. Since both types enter with probability 1, when the subsidy is granted the bank's profits are given by the sum of:

- (i) the probability that the firm is good times the gain from financing a good firm:

$$\alpha(R - B - (T - x))$$

- (ii) the probability that the firm is bad and it is erroneously financed times the loss given by financing a bad firm:

$$(1 - \alpha)(1 - s_i)(-(T - x))$$

Substituting for x we get that the expected profits when the subsidy is granted are indeed $\alpha(1 - \alpha)s_i(R - B)$.

(2.11) represents the expected welfare which is computed as in (2.7). When the subsidy is granted, indeed, welfare is given by the sum of: the profits of the good firm times the probability that the firm is good (αB); the profits of the bad firm times the probability that the firm is bad ($(1 - \alpha)((1 - s_i)B - s_i S)$); the profits of the bank ($\alpha(1 - \alpha)s_i(R - B)$) minus x times the probability that a firm which is entitled to get the subsidy actually uses it: $x(1 - (1 - \alpha)s_i)$, i.e. if a firm is bad and its type is detected (this happens with probability $(1 - \alpha)s_i$), it is not financed even if it is entitled to get the subsidy. Putting the terms together and simplifying results in the expression reported in (2.11). Another way to look at it is the following: when the subsidy is granted, welfare is the sum of the total gain for society, which is given by $\alpha R + (1 - \alpha)(1 - s_i)B$, minus the total cost, which is given by S (which is always sustained since both types enter the market with probability 1) plus $(1 - s_i(1 - \alpha))I$ (which is the cost of the investment in the case the firm is financed).

(2.12) finally is the probability that innovation occurs at the equilibrium. As it can be noticed, the probability of a subsidy increases innovation likelihood by $\left(1 - \left(s_i + \frac{S}{S+B}\right)\right)\alpha q$. That is: the lower are s_i or S , the more effective in raising innovation is the subsidy.

2.2.4 The Subsidization Choice

Let us suppose that the government can observe only s_i . That is: the government does not know whether a firm is good or bad but it knows whether the bank is more or less able to detect its type on the basis of the available information. In particular, the government may adopt the following

rule: if the firm has a low informative ability, it can be subsidized. Notice that this kind of policy is usually implemented by governments, provided that s_i is a proxy of firm's experience or size (i.e. young or small firms have a low s_i). What is the optimal threshold for subsidization from the point of view of the government? Let \tilde{s} be the threshold below which a firm is entitled to get the subsidy and recall that we are focusing on the interval where the intervention of the government is needed in order to boost innovation (i.e. $s_i < \tilde{s}$ and $\alpha < \underline{\alpha}$). Notice that letting just one firm play the game is equivalent to assume that firms with different s_j parameter are drawn from a uniform distribution.

The government defines the function $q(s_i)$ as to maximize the following welfare function:

$$E(W) = [(\alpha R + (1 - \alpha)(1 - s_i)B - S - (1 - (1 - \alpha)s_i)I)]q(s_i) + [\alpha s_i(R - I)](1 - q(s_i)) \quad (2.13)$$

Maximizing (2.13) we get the following claim:

Claim 2.1 *The optimal subsidy function is*

$$\begin{aligned} q(s_i) &= 1 && \text{if } s_i < \tilde{s} \text{ and } \alpha > \tilde{\alpha} \\ q(s_i) &= 0 && \text{otherwise} \end{aligned}$$

where $\tilde{s} = 1 - \frac{S}{\alpha(R-B) - (I-B)}$ and $\tilde{\alpha} = \frac{I-B}{R-B}$.

Proof. Equation (2.13) can be rewritten as follows:

$$E(W) = \varphi(s_i, \alpha, R, B, I, S)q(s_i) + \varepsilon(s_i, \alpha, R, I)$$

where $\varphi(\cdot) = S + (1 - s_i)(\alpha(R - B) - (I - B))$ and $\varepsilon(\cdot)$ is a known function of parameters which are independent of $q(s_i)$. It turns out that the optimal subsidy policy implies $q(s_i) = 1$ whenever $\varphi(\cdot) \geq 0$ and $q(s_i) = 0$ whenever $\varphi(\cdot) < 0$. ■

We can then state the following proposition:

Proposition 2.1 *Provided that the proportion of high innovative ability firms is sufficiently high, the higher is the total investment's cost, the smaller (or younger) should be the firm which is entitled to get the aid.*

Proof. It follows directly from Claim 2.1. ■

Proposition 2.1 suggests that it might be optimal for the government to target only firms which are smaller or younger than a defined threshold if the probability of success for firms in the economy is sufficiently high (because otherwise it would not be worthy to induce a financing decision of the bank).⁹ As the total cost of subsidization increases (that happens whenever B , S or I increase), this threshold gets smaller, because a greater positive effect of the subsidy on welfare is needed in order to compensate its higher cost. And obviously the subsidy is relatively more effective when the market failure due to asymmetric information is more evident i.e. when s_i is small. Interestingly, the positive effect of granting a subsidy to a small firm dominates the cost of subsidizing a firm which might be bad with an higher probability, given that it is harder for the bank to screen it.

In addition, notice that \tilde{s} is always smaller than \bar{s} . Indeed:

$$\rho(\bar{s}, \tilde{s}) = \bar{s} - \tilde{s} = \frac{S(T - \alpha(R - B))}{(S + B)(\alpha(R - B) - (I - B))} > 0 \quad (2.14)$$

Since we are assuming that firms are uniformly distributed, $\rho(\bar{s}, \tilde{s})$ represents the proportion of firms which need the aid without getting it. They need the aid because there is a probability that they will not be financed even if they are good, since their informative power is lower than what should be in order to trigger a financing decision by the bank with probability 1 ($s_i < \bar{s}$). However, they do not get the aid, because their informative power is so high that the relative gain from stimulating innovation is inferior to the relative cost of the aid, which is represented by the risk of making a bad firm to be financed ($s_i > \tilde{s}$). Indeed, $\rho(\bar{s}, \tilde{s})$ is increasing in S and I and decreasing in α and R , that is: $\rho(\bar{s}, \tilde{s})$ depends positively on the total cost of investment and negatively on the proportion of firms with high innovative ability in the economy and on the expected gain from innovation.

Proposition 2.2 *The optimal subsidy threshold implies always a proportion of firms which do not get the aid even if they would need it in order to innovate.*

Proof. It follows directly from (2.14). ■

We can then conclude that under the *ex-ante* aid scheme where firms apply for the subsidy before submitting their project to banks, only small or unexperienced firms should be entitled to get the subsidy.

⁹Indeed it is possible to prove that the government would never choose to implement a state aid system if $\alpha < \tilde{\alpha}$.

In the next Section I propose an alternative aid scheme in which the aid is granted *after* the project is submitted to banks. As we are going to see, this changes the government's target policy.

2.2.5 A Proposal for an Alternative Subsidy Scheme

In the aid scheme which has been analyzed in the previous section, subsidization is suboptimal when firms are not small enough ($s_i > \tilde{s}$). In this section, I propose an alternative aid scheme which might suggest a different target policy for the government. The idea is to find a way to exploit the ability that the bank has to guess the firm's type in order to grant the subsidy only when it is strictly necessary i.e. when the bank is not able to recognize the firm's type. In the previous aid scheme that does not happen: since the aid is granted before the project is submitted to the bank, even if the firm is recognized to be good (and hence, in principle, it would not need the aid for being financed by the bank) it is still entitled to get it. If, instead, the aid is granted only when it is strictly necessary, i.e. when the type of the firm is not detected, there is a comparative advantage for granting a subsidy to bigger firms since the bigger is s_i the lower is the expected cost of the grant.

Let us assume that players know if the aid is granted only *after* the project has been submitted to the bank and the aid does not depend on firm's characteristics. In other words, while in the previous aid scheme the government was granting the aid on the basis of firm's size/experience, now the government is subsidizing firms randomly: now whatever is the firm's size or experience, it has γ probability to get a subsidy (γ is assumed to be exogenous). After having assessed the project, the bank has three possibilities: to finance the firm directly (F), not to finance the firm (NF) or to sign a contract which conditions the financing on the state's subsidy (FG). If FG is chosen, the firm applies for the subsidy and receives it with probability γ . In that case the project is financed. Otherwise, with probability $1 - \gamma$, the project is discharged. Indeed, the bank may choose this last possibility whenever it believes that the riskiness of the project is too high with respect to the cost of investing if the aid is not granted while it is not if the aid is granted, since the aid reduces the investment's cost. As the aid is granted only after the firm and the bank have played, this scheme is called the *ex-post* aid scheme.

The *ex-post* aid scheme is equivalent to a scheme where banks and not firms are the subject entitled to ask for a subsidy to the government, assuming that this procedure is costly. Here the cost is represented by the possible loss of profits that happens when the bank applies for the

subsidy without getting it.

The advantage of this aid scheme consists in the fact that now the government grants a subsidy only after the bank has evaluated the project. That reduces the cost of subsidization for two reasons: first of all because if the bank guesses the type of the firm and the firm is good, the subsidy is not granted (as we are going to see below, γ is assumed to be sufficiently low so that the bank prefers to finance directly a firm which is surely good). Secondly, because as far as the subsidy is not granted with certainty before the entry decision, bad firms have a lower incentive to enter the market for innovation, since the probability that they are not going to be financed is higher with respect to the previous aid scheme.

On the other hand, notice that this aid scheme may be not effective when firms are very small/unexperienced. That happens because very small firms are not financed if the probability of subsidization is not equal to 1.

When the game is played within this new setting, we get the following results. First of all, let us define the following thresholds:

$$\bar{\gamma} := \frac{R - B - T}{R - B - (T - x)} = \frac{1}{1 - \alpha} \left(1 - \frac{T}{R - B} \right) \quad (2.15)$$

$$\underline{s} := \bar{s} - \frac{1 - \gamma}{\gamma} \frac{S}{S + B} \quad (2.16)$$

Concerning threshold (2.15), notice that whenever $\gamma > \bar{\gamma}$, the bank always prefers FG with respect to F , that is: the bank prefers to condition the funding decision on the state aid instead of directly financing the firm.¹⁰ The intuition for this result is simple: suppose $\gamma = 1$. Why should a bank not apply for government's subsidy? it raises its expected profits (because total investment cost is reduced by the subsidy) without running any risk (because the subsidy is granted with certainty). More generally, if $\gamma > \bar{\gamma}$, implementing this aid scheme does not save any cost with respect to the previous aid scheme because even if the firm is surely good the bank chooses FG . On the contrary, if $\gamma < \bar{\gamma}$ that means that if a firm is good and the bank detects its type, the bank prefers to finance the firm directly instead of relying on a possible subsidy, because in the last case it would run the risk of loosing a profitable investment opportunity with a sufficiently high probability $1 - \gamma > 1 - \bar{\gamma}$. The probability of getting the subsidy is then assumed to lie below threshold (2.15): $\gamma < \bar{\gamma}$.

¹⁰Indeed, suppose the bank knows that the firm is good. With F , the bank has profits equal to: $\pi_F = R - B - T$; with FG , instead, its profits are: $\pi_{FG} = \gamma(R - B - (T - x))$. It turns out that if $\gamma > \underline{\gamma}$ then $\pi_{FG} > \pi_F$.

Concerning threshold (2.16), notice that since the aid is now drawn after a firm has already entered the market for innovation, the firm's entering strategy changes according to the probability of getting the subsidy. Indeed, threshold (2.16) identifies the value for s_i according to which only one or both types enter with probability 1. If $s_i < \underline{s}$ then both types enter the market for innovation (notice that \underline{s} is increasing in γ). On the contrary, if $s_i > \underline{s}$, a mixed strategy equilibrium where the good type enters with probability 1 and the bad type randomizes occurs. The reason for that depends on bad type's expected profits which are negative if the probability of being detected is too high. Notice that if γ were equal to 1, we would have the same threshold \bar{s} which we observed in the previous aid scheme. Indeed, by making the subsidy uncertain, the government enlarges the interval of values for s_i for which entering the market with probability 1 is unprofitable for bad firms.

It is possible to show that if $s_i < \underline{s}$, implementing the ex-post aid scheme makes the government to reach a lower level of welfare with respect to the ex-ante aid scheme. The intuition is as follows: when s_i is very low, the proposed aid scheme increases the likelihood of innovation but it does not equally reduce the cost of subsidization. Indeed, suppose that $s_i = 0$. The proposed aid scheme does not let the government save any money because the firm would always need the aid (i.e. the bank cannot be sure about the firm's type, so no money is saved when the firm is good) and a bad firm would enter with probability 1. Proof 1 in the Appendix shows this result.

Proposition 2.3 *The ex-post aid scheme is suboptimal if granted to very small or young firms with respect to the ex-ante aid scheme. The threshold which identifies those firms, \underline{s} , is a positive function of the exogenous probability of getting the subsidy after having applied for it.*

Proof. See proof 1 in the Appendix. ■

If $\bar{s} > s_i > \underline{s}$, instead, a mixed strategy equilibrium arises. When the bank does not guess the firm's type, it attaches $\bar{\alpha} = \underline{\alpha} + \frac{\gamma}{(1-\gamma)} \frac{1}{(p_h R - B)} x$ probability to be dealing with a good type, given that a good type is entering with probability 1 and a bad type randomizes. Notice that $\bar{\alpha} > \underline{\alpha}$ because with the new state aid system the bank's incentive to finance directly a firm are changed. Indeed, the proportion of good types must be higher in order to have direct financing, since the bank may now find it convenient to condition the financing decision on the subsidy instead of financing directly the firm. Under this perspective, the new aid scheme may crowd out investment.¹¹ The equilibrium strategies are the following:

¹¹In particular, for the bank to be indifferent between F and FG an higher probability of facing a good type

$$\begin{aligned}
\sigma_g'' &= 1 \\
\sigma_b'' &= \frac{\alpha((1-\gamma)(R-T-B)) - \gamma\alpha x}{(1-\alpha)T - \gamma(1-\alpha)(T-x)} \\
\eta'' &= \frac{S(1 - (1-s_i)\gamma) - \gamma B(1-s_i)}{(1-\gamma)(1-s_i)(S+B)} \\
\eta_{fg} &= 1 - \eta''
\end{aligned}$$

η_{fg} being the probability attached by the bank to FG . Notice: for $\gamma = 0$ the same mixed strategy equilibrium of the no-aid case is reached. Notice moreover that when γ raises, σ_b'' goes down since $\bar{\alpha}$ increases together with γ . Paradoxically, if the probability of receiving a subsidy is increased, the likelihood of entry of a bad type is decreased. That happens because by increasing γ , FG becomes more convenient for the bank with respect to F . It turns out that entry for a bad guy is riskier. More generally speaking, we can state that this aid scheme reduces the probability of entry of a bad type when $s_i > \underline{s}$. The total effect on welfare of this aid system with respect to the previous one is then twofold: first, a good firm recognized to be such now does not receive the subsidy and, second, the inefficiencies due to funding of a low quality project are reduced, as it is more unlikely that a bad type enters the market for innovation.

Given the above equilibrium strategies, the expected total welfare can be shown to be:

$$E(W) = \alpha s_i (B+S) + \frac{\alpha((R-B-s_i T)\gamma x + s_i T(1-\gamma)(R-B-T))}{T(1-\gamma) + \gamma x} - \frac{\alpha\gamma(R-B)(B(1-s_i) - s_i S)}{(S+B)(\gamma x + (1-\gamma)T)} x \quad (2.17)$$

if we substitute for x and take the derivative with respect to s_i , we get:

$$\frac{\partial E(W)}{\partial s_i} = \alpha(R-I) > 0 \quad (2.18)$$

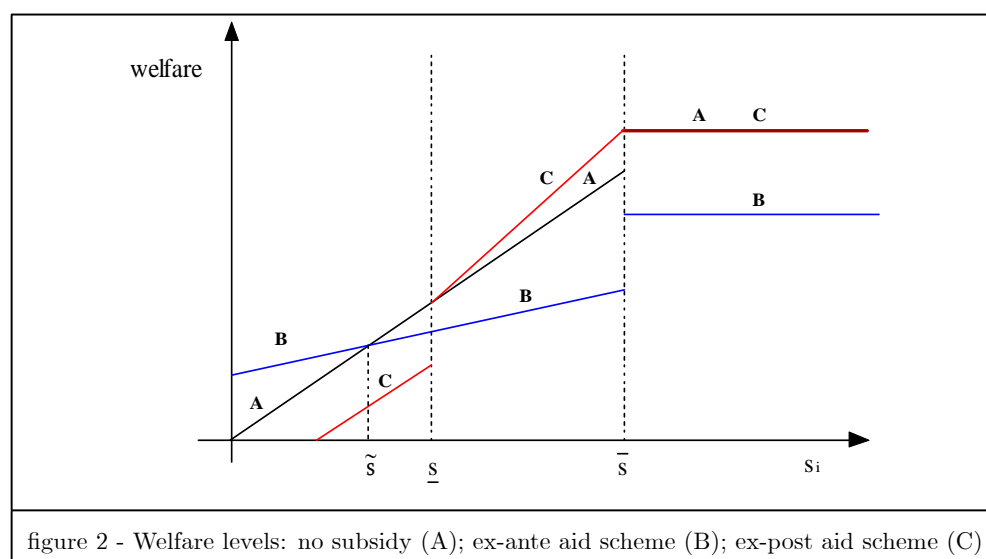
It turns out that, independently of γ , expected welfare is increasing in s_i . The intuition for this result is easy to guess: on the one hand, the subsidy reduces a bad type's probability to enter. On the other hand, the subsidy scheme costs less the higher is s_i since the subsidy is when the type is unknown is required. To clarify, think about a game where a player j has to choose among two options: a and b which yield respectively 1 and 0 if status A is realized and -1 and k if status B is realized. Initially $k = 0$, so for j to be indifferent between a and b it is necessary that $P(A) = \frac{1}{2}$. Suppose then that k increases: $k = 1$. For j to be indifferent between a and b it is now necessary that $P(A) = \frac{2}{3}$. So: since in this aid scheme the value of b (FG) is increased it is now necessary that the probability of being at the left node of the info set is itself increased in order for the bank to be indifferent between F and FG . That is why $\bar{\alpha} > \underline{\alpha}$.

strictly correlated with its necessity. When the firm has a high s_i it is unlikely that the subsidy will be needed by the firm (indeed, η'' , the probability of being directly financed by the bank when it is unable to guess the type, is increasing in s_i). However, for the mere fact of existing, the aid scheme changes the firm's entry strategy and the positive impact on welfare is higher the bigger is s_i . In addition notice that, contrary to what happens with the first aid scheme, even if a big/experienced firm ($s_i > \bar{s}$) is by mistake entitled to get the subsidy, it does not get it, because when the bank is sure to be dealing with a good firm (this is always true when $s_i > \bar{s}$ because project submission is not profitable for bad firms) it prefers not to run the risk of not financing it by conditioning the financing decision on the uncertain subsidization.

Proposition 2.4 *If the introduction of the ex-post aid scheme has a positive impact on welfare, this impact is higher the bigger or the more experienced is the firm.*

Proof. It follows directly from (2.18) ■

Figure 2 compares the different level of welfare within the three different analyzed settings: without aid (A), with the ex-ante aid scheme (B), with the ex-post aid scheme (C). As it can be noticed, the ex-ante aid scheme is associated with higher levels of welfare when the informative power of the firm is very low ($s_i < \tilde{s}$) whilst the ex-post aid scheme is associated with higher level of welfare whenever $s_i > \underline{s}$.



2.3 Conclusions

The purpose of this paper is to analyze the impact of a state aid system aimed at stimulating innovation in the presence of imperfect financial market. To that intent a simple theoretical framework is proposed. The model adopted in Section 2 extends the basic model of Holmström and Tirole (1997) introducing asymmetries among firms by considering the amount of information available to banks, which differs from firm to firm. When assessing the quality of a firm proposing a project, banks may consider that the available information is not enough for funding, because they are not able to guess the actual probability of success of the proposed project. In the model it is assumed that this happens more often with small or young firms, since they usually lack of the information required by banks to that purpose.

In particular, when the proportion of firms with high probability of success is low (in the model: $\alpha < \underline{\alpha}$) and the likelihood that the bank has enough information to guess the firm's probability of success is low ($s_i < \bar{s}$), innovation is below its potential because a profitable and potentially successful project is not financed with probability 1 as a consequence of imperfect information.

When innovation is below its potential, it can be increased through the implementation of an aid scheme.

In the simplest setting, the aid is granted at the beginning of the game and it is supposed to reduce the total amount of investment in a way such that the bank is induced to finance a firm the type of which is not able to guess.

The model shows that, within this setting, a state aid policy which targets only small or young firms (i.e. firms with $s_i < \tilde{s}$) maximizes total welfare if the proportion of firms with high probability of success is sufficiently high ($\alpha > \tilde{\alpha}$). That happens because, even if it is more costly from the social point of view to grant a subsidy to a small/young firm (i.e. the likelihood of subsidizing a firm with a low probability of success is higher, given that banks find more difficult to assess small/young firms' projects' quality), the positive impact of the subsidy on innovation more than offset that cost, since the aid targets firms which more likely strictly need it in order to be able to innovate. The model moreover shows that the optimal state aid policy always implies a proportion of firms which do not get the aid even if they would need it in order to innovate. This proportion depends positively on the total cost of investment and negatively on the proportion of firms with high innovative ability in the economy.

The ex-ante aid scheme in which the aid is granted before the firm asks a loan to the bank entails a positive probability that the aid is granted to a firm which does not strictly need it in order to be funded. Indeed, since the aid is granted at the beginning of the game regardless of the type of the firm (which is assumed to be unknown to the government), a firm which has a high probability of success still gets the aid even if its profitability is recognized by the bank and thus would have been financed anyway. The relative magnitude of this inefficiency obviously increases with the size/experience of the firm, since the bigger/experienced is the firm the less necessary is the subsidy. In order to overcome that problem, an alternative aid scheme is proposed. In the alternative aid scheme, a firm must first ask the loan to the bank and then, if the bank decides to condition the financing decision on the (uncertain) state aid, apply for the subsidy. The advantage of this aid scheme relies on the fact that within it the government can use the bank as a 'filter' in order to select the projects for which the subsidy is strictly necessary. The model shows that this ex-post aid scheme might be preferable when firms are bigger/older than a certain threshold ($s_i > \underline{s}$) while it is suboptimal with smaller/younger firms if compared to the ex-ante aid scheme. As a general implication, the model provides a theoretical justification for subsidization to small/young firms from a welfare maximizing authority's point of view. The idea that smaller or younger firms should be entitled to get subsidies is usually taken for granted on the basis of a market failure argument, which does not take into consideration the cost of implementing a state aid system. This paper attempts to go beyond that showing that subsidizing small or young firms increases total welfare if the average likelihood of success for firms in the economy is not too small.

2.A Appendix

Proof n 1. We need to show that welfare is lower with respect to the first aid scheme when the second aid scheme is implemented and $s_i < \underline{s}$. In that interval, the payoff structure is as it follows:

$$\begin{aligned}
 E(R_i^g) &= s_i B + (1 - s_i)(\gamma B - (1 - \gamma)S) \\
 E(R_i^b) &= -s_i S + (1 - s_i)(\gamma B - (1 - \gamma)S) \\
 E(R_l) &= \alpha(s_i(R - B - T) + (1 - s_i)\gamma(R - B - (T - x))) - (1 - \alpha)(1 - s_i)\gamma(T - x) \\
 E(W_2) &= \gamma x(1 - s_i) - S + B(1 - s_i)(\gamma - \alpha\gamma) - I(s_i(\alpha - \gamma) + \gamma) + R\alpha(\gamma + (1 - \gamma)s_i) + \\
 &\quad - \lambda\gamma(1 - s_i)x
 \end{aligned}$$

where $E(W_2)$ is the expected welfare with the second aid scheme. Setting $q = \gamma$, we get that welfare is increased under the second aid scheme iff:

$$E(W_2) - E(W_1) = \frac{S}{x s_i} \frac{1 - \gamma}{\gamma} < 0$$

where $E(W_1)$ is the expected welfare with the first aid scheme. Substituting for x and rearranging we get:

$$E(W_2) - E(W_1) = \frac{S(1 - \gamma)}{\gamma s_i (T - \alpha(R - B))}$$

■

Chapter 3

Does Publicity Affect Competition?

3.1 Introduction

Suppose you are an entrepreneur. Your company is in construction and your customers are mainly local governments which put works out to tender. Participating to a public procurement auction is costly: you need to have a complete knowledge of the kind of work you are supposed to do, to write a project proposal which complies with the technical requirements defined by the tender and to be registered in the specific book of the authorized companies. Then you need to build your bidding strategy by balancing winning probability and expected costs. Eventually, you may apply to the auction, submit your bid and, hopefully, win with a certain probability.

Imagine that yours is one of the few companies which know that the tender is taking place. That is: the contracting agency did not advertise the tender (you may have some friends who work for the agency and you got the information from them). When deciding whether to participate or not to the auction, you will take into account that the number of competitors that you will face is small and that the likelihood of submitting a winning bid is high. You might even think that it will be easier to coordinate (tacitly or not) with your competitors, in order to get a better deal from the contracting authority. As a result, your incentives to join the auction are likely to be very high.

Now, suppose that one day you open your favorite national newspaper and realize that another contracting authority is advertising a similar tender. If the agency did not advertise the tender, surely you would not have participated: you actually would not have any clue that the tender was taking place. However, your incentives to participate are now smaller: since the tender is advertised on a national newspaper, you expect competition to be harsh. You might then decide not to participate because your expected profits (which are a function of the probability of submitting a winning bid) are not enough to offset your participation costs.

From the contracting authority point of view, thus, it is not clear whether increasing the advertising effort is always worthy doing. In other words, increasing the number of potential participants has an ambiguous effect on auctions' outcome.

This issue is relevant. Public procurement contracts in Member States amount to a huge slice of the European Union's GDP: 16% in 2002. Member States as well as the European Commission are pushing to increase the use of advertising policies by the contracting authorities. For instance, Directive 2004/18/CE stresses the importance of an extensive use of advertisement in order to let European firms be able to participate to all the tenders taking place within the European Union.

Likewise, the European Commission promotes online advertising of public contracts EU-wide in order to increase transparency and to enhance public procurement auctions' efficiency level.

This paper uses a unique dataset to address that issue and empirically test the impact of publicity on competition in public procurement auctions.

Assessing the benefits of publicity in public procurement auctions, requires going through the following steps: first, one should ask whether and to which extent advertising rises competition; second, one should ask how competition, as it is influenced by advertising policy, decreases the price to be paid by the auctioneer to the winning bidder i.e. it increases the auctioneer's rent.

As for the first point, notice that a firm can join an auction only if the firm knows that the auction exists. Since participating to an auction requires to sustain some fixed cost, however, a firm might decide not to participate if it thinks that competition will be too harsh.

As for the second point, it is well accepted that an increase in the number of participants increases the auctioneer's rent: firms are pushed to bid more aggressively if the number of bids is increased.¹ Beyond that, advertising can affect participants' characteristics, by stimulating entry of outsiders (i.e. those firms which are located outside the region where the auction is taking place). Outsiders might decrease the likelihood of collusion, since local firms find it more difficult to coordinate, having fewer contacts with competitors.² Outsiders can even have a different cost structure: firms located far from the auctioneer participate only if their transport costs are very low or if they are not able to compete in their local market. On the other hand, publicity may discourage entry of local firms since, *ceteris paribus*, the incentive to participate is lower when more firms are applying. Local firms may have a deeper knowledge of the procedure implemented and of the work's features and they can exploit scale economies by dealing with the same authority more than once. It is not clear, then, what is the magnitude of the effect on auctioneer's rent which is associated to publicity and its selective effect rather than to its direct effect on the number of participants. Figure 1 offers a graphical intuition of those simple concepts.

Our paper aims at identifying the total effect of publicity on the number of actual bidders and on the auctioneer's rent.

Based on the recent theoretical contributions of Levin and Smith (1994) and Menezes and Monteiro (1996, 2000) we discuss the link between publicity and competition in a stylized model of endogenous entry in auctions where entry is costly and advertising tenders decreases firms'

¹See, for example, Brannman et al. (1987).

²See Compte et al. (2005).

search costs. Both Levin and Smith and Menezes and Monteiro consider a mechanism by which firms decide whether or not to participate to an auction. They differ, though, in the timing dimension of their models: in Levin and Smith firms incur a fixed cost of entry before seeing their values for the object while in Menezes and Monteiro firms learn their values prior to incurring bid preparation costs. Their conclusions are thus different: Levin and Smith suggest that the seller should not limit entry through a restriction policy (e.g. an entry fee) while Menezes and Monteiro find that entry fees may be optimal for the seller since they help to screen low valuation bidders when increased competition reduces the seller's expected revenue. Our model follows the one used by Menezes and Monteiro and integrates it with the possibility for the seller to advertise the tender.

From an empirical point of view, the effect of advertising tenders on competition has never been directly tested. Bajari and Hortacsu (2003) use a structural analysis to test the model of Levin and Smith with a dataset of E-Bay coin auctions. They find that the expectation of one additional bidder decreases bids by 3.2% in a representative auction. In addition, they find that the value of the object is among the main determinants of entry. They do not consider advertising, though. The choice of advertising an auction may be seen as the choice between choosing a mechanism which allows for free entry or restricts it. Lundberg (2005) investigates empirically the choice of procurement procedure in public auctions in Sweden where the contracting entity may choose one among several available mechanisms which are linked with different restrictions on entry. Her (descriptive) results do not show any significant impact from contract specifications and municipality characteristics on the probability that the contracting authority does not restrict entry.

Our database contains data on public procurement first price sealed bid auctions which took place in Tuscany (Italy) between 2000 and 2006. The database includes information on the auctioneers and their advertisement policy, on the type of work which is put out to tender, on bidding behavior and on the winning firms. The dataset is informative on the question under study because it keeps track of detailed information on all the public procurement auctions with a value greater than 150,000 euros and, in particular, because it offers a unique quasi-experimental setting to analyze the effect of publicity on competition. The Italian law prescribes that every public procurement auction should be advertised at 3 different publicity levels on the basis of their starting value. A Regression Discontinuity Design (RDD) can then be used to compare the outcomes of auctions with starting value immediately above or below each discontinuity threshold.

Auctions above and below the thresholds have different publicity levels, but should otherwise be identical in terms of observable and unobservable characteristics determining the outcome of interest, which in our case is the number of bidders and the winning rebate.

Using this source of identification of the causal effect, we show that an increase of publicity determines an increase in the average number of bidders of 8.3 with respect to a benchmark average of 30 and an increase in the average rebates of 1.5% with respect to a benchmark average of 13%.

We further analyze auctions' outcomes deeper. In particular, we ask whether publicity has an impact on the nature of the winner and whether a relationship between competition in auctions and works' accomplishment exists. As for the first question, we find that publicity significantly raises the probability that the winner is located outside the region where the auction takes place and the probability that the winner is a group of firms rather than a single one. As for the second question, notice that it might well be that an increase in the number of participants encourages firms to over-bid when the auction takes place and then to reduce the quality of the works after having won the auction. Using duration analysis models with right censoring, we report evidence of a negative and statistically significant correlation between auctions' level of competition and the time it takes to the winner to finish the tendered works.

The rest of the paper is organized as follows. In the next section we introduce the theoretical model. Section 3 describes the institutional framework; Section 4 reports the empirical analysis. Conclusions and policy implications are discussed in Section 5.

3.2 The Model

We model a public procurement auction as a first price sealed bid auction where the number of bidders is endogenously determined in a way which is very similar to Menezes and Monteiro (MM) (2000). A single contract is put out to tender. The auctioneer is assumed to have zero reserve price. Firms bid a rebate b on the auction's starting amount for which they would be willing to do the works. Bidder i knows her own value v_i of the contract and the distribution $F(v_i), \forall i \neq j$ of other n bidders' values. $F(\cdot)$ is continuous with support $[0, \bar{v}]$. Participating to the auction requires sustaining a fixed cost c plus some searching cost δ which for the moment

are assumed to be 0.³ Each bidder decides whether to submit a bid before knowing how many competitors will participate to the auction. Assuming that everyone else except i use the same strategy b , we have that i 's expected profits are:

$$\pi_i(v_i, b_i, b) = (v_i - b_i)(F(\max\{b^{-1}(b_i), v_\rho\}))^{n-1} - c$$

where v_ρ solves $v_\rho F(v_\rho)^{n-1} - c$ and it is such that $\pi_i(v_\rho, b^*) = 0$ i.e. v_ρ is the cut-off value when all bidders use the same equilibrium strategy b^* .⁴ The optimal bidding strategy which maximizes i 's expected profits is then given by:

$$b^*(v) = \begin{cases} \frac{\int_{v_\rho}^v (n-1)x F(x)^{n-2} f(x) dx}{F(v)^{n-1}}, & v \geq v_\rho \\ 0, & v < v_\rho \end{cases} \quad (3.1)$$

Equation (3.1) is crucial. It tells us that increasing the number of potential participants has two opposite effects on the optimal bidding strategy. On the one hand, since the cut-off value v_ρ value is increasing in n (provided that $c < 1$), it decreases the probability that a player i participates to the auction (since that happens only if $v_i > v_\rho$). On the other hand, it increases the equilibrium bid, since participating players take into account that, in equilibrium, other bidders participate only if their value is greater than v_ρ .

The expected revenue generated by the auction is then given by the highest bid among those submitted:

$$R = \int_{v_\rho}^{\bar{v}} b^*(x) n F^{n-1}(x) f(x) dx$$

MM then show that the revenue generated by a first price sealed bid auction is equivalent to that generated by a second price sealed bid auction when the number of potential players is fixed and participation is endogenous. Thus R can be rewritten as follows:

$$R = n(n-1) \int_{v_\rho}^{\bar{v}} (1 - F(x)) x (F(x))^{n-2} f(x) dx$$

Now suppose that the auctioneer is able to control the number of participants in order to maximize her revenue. MM uses a variable $\delta \in (-c, 1 - c)$ which represents an entry fee (if positive) or a subsidy (if negative). In our context, δ represents firms' searching cost, which are assumed to be decreasing in the level of publicity. Let us introduce a new continuous variable $p \in [0, \delta]$ which is directly correlated with the auctioneer's advertising effort. Let us assume that a marginal increase

³You may well think about c as the cost of preparing a project and submit a bid, while δ is the cost of looking around for existing tenders.

⁴Menezes and Monteiro show that such strategy exists. Notice that for any $c < 1$, $v'_\rho(n) < 0$.

in p is translated in an equivalent reduction in δ at a cost $\frac{p^2}{2}\lambda z$, where z is the advertising cost (e.g. the cost of publishing the tender on a national newspaper) and λ is the shadow cost of public expenditure.

Thus, total revenue can be maximized maximizing the following expression:

$$\varphi(\widehat{\delta}) = \max_p \left(n(n-1) \int_{v_\rho(\delta-p)}^{\bar{v}} (1-F(x))x(F(x))^{n-2}f(x)dx - \frac{p^2}{2}\lambda z \right)$$

which yields:

$$\varphi'(\delta-p^*) = -n(n-1)(1-F(v_\rho(\delta-p^*)))v_\rho(\delta-p^*)(F(v_\rho(\delta-p^*)))^{n-2}f(v_\rho(\delta-p^*))v_\rho'(\delta-p^*)-p^*\lambda z = 0 \quad (3.2)$$

which implicitly defines the optimal level of publicity p^* .

Equation (3.2) has a simple and powerful implication which motivates our empirical analysis: the optimal level of publicity may be lower than its maximum possible level even if its cost is zero i.e. $z = 0 \not\Rightarrow p^* = \delta$. In other words, it might be optimal for the auctioneer not to increase the number of potential bidders in order to increase its revenue, even it would not spend anything to do so. The intuition comes directly from equation (3.1). Indeed, to show that this is the case, it is sufficient to find at least one case in which the optimal level of δ is positive notwithstanding $z = 0$. The following example illustrates this possibility.⁵

Example 3.1 *Assume that the n players are represented by random draws from the distribution $F(x) = x^4$ and $p = z = 0$. Expected revenue is then:*

$$R = 4n(n-1) \left(\frac{1-c-\delta}{4n-3} - \frac{1-(c+\delta)^{\frac{4n-1}{4n+3}}}{4n+1} \right)$$

Assume further that $n = 20$ and $c = 0.1$. It turns out that the level of δ which maximizes R is positive and it is $\delta = 0.031$.

We can then state the following proposition:

Proposition 3.1 *Independently of its cost, the optimal level of publicity can be below its maximum possible level.*

Proof. It follows directly from example 3.1. ■

⁵Example 1 is similar to Example 4 of MM.

3.2.1 An intuitive IO model

The result stated in Proposition 3.1 is not necessarily limited to the context of auctions. Indeed, suppose you have a pool of 2 firms which may enter a market where demand is linear and given by $Q = 1 - P$. When two or more firms are in the market they compete à la Cournot. Each firm has marginal cost $c = \frac{1}{2}$ and has to sustain a fixed (sunk) cost $K < \frac{1}{36}$ in order to enter the market

In a two-stages game where firms first decide whether to enter the market and then they set their output, the equilibrium is the following. Each firm enters the market and produces $q = \frac{1}{6}$ making profits $\pi = \frac{1}{36} - K > 0$. Total quantity produced is then $Q = \frac{1}{3}$. Welfare is $W = \frac{1}{9} - 2K$.

Now suppose that the pool of potential entrants is enlarged. This might be the outcome of an advertisement policy, in our context. The new pool is made of the two firms plus another firm j which is more efficient than the others. That firm has marginal cost $c_j < 3\sqrt{K} < \frac{1}{2}$.

Notice that under these conditions only j enters the market. If even only one of the inefficient firms enters the market it would indeed make negative profits: $\pi = \left(\frac{c_j}{3}\right)^2 - K < 0$.

The equilibrium with the new pool of firms is thus the following: j is the unique firm in the market. It produces $q_j = Q = \frac{1-c_j}{2}$ making profits equal to $\pi_j = \left(\frac{1-c_j}{2}\right)^2 - K$. Thus, if c_j is sufficiently high ($c_j > \frac{1}{3}$) the advertisement policy which has enlarged the pool of potential entrant firms had a negative impact on total competition in the market (now there is just one firm instead of two) and on consumer surplus (now the quantity produced is lower). Notice, however, that total welfare is increased as it is now equal to $W' = \frac{(1-c_j)^2}{8} + \frac{(1-c_j)^2}{4} - K$ which is always greater than W in the considered interval of K and c_j . Total welfare is increased because as only one firm enters the market a duplication of the fixed cost K is prevented. Consider, though, that in our context the auctioneer maximizes her revenue (which might be represented by consumer surplus) and not total social welfare.⁶

We now introduce the institutional framework from which our data are drawn and then proceed with the empirical analysis motivated by Proposition 3.1

⁶Indeed, suppose that the auctioneer is a municipality. If her objective was total welfare she would restrict the auction to firms which belongs to the local area. A possibility which is ruled out by law.

3.3 Institutional Framework

We base this empirical analysis on novel and detailed administrative data from the Italian Authority for Surveillance of Public Procurement (*Autorita' Vigilanza Lavori Pubblici, AVL*), which collects data on each single public procurement auction with starting value greater or equal than 150,000 euros which takes place in Italy. Tables 1 and 2 report the descriptive statistics relative to the sample. Our database amounts to 5,735 auctions, a vast majority of which (85%) are auctions with direct participation of firms (*pubblico incanto*) while in the remaining ones participation is subject to auctioneer's invitation after firms have applied for it (*licitazione privata*). The two types of auctions do not show any substantial difference, though. The contracting authorities are mainly municipalities (52% of the sample). The rest of the sample is made of tenders invited by provinces (11%), health-care public bodies (ASL) and other public bodies or corporations.

The contracting authority must define all the details concerning the works that have to be carried on by the winning firm, including the starting price that the auctioneer would pay to the winner if only one firm participates to the auction. On average, the auctions' starting value in the sample amounts to 974 thousands of euros though the standard deviation is rather high: indeed, the median starting value is 363 thousands of euros. Notice, moreover, that most of the auctions are done to contract out road's constructions (30.5% of the total) which include maintenance and reconstruction and whatever is necessary to guarantee truckage, by rail and air transport. The contracting authority must define the requirements which have to be satisfied by bidders as well. Bidders have to be certified that they are able to carry on the works of that particular size and in that particular sector i.e. they need to be audited by an attestor society (*SOA, società organismo di attestazione*) and be registered for the required category in a specific book. So, for example, if the construction of a road is put out to tender and the contracting authority estimates that the amount of qualified work that has to be done is valued 700,000 euros, the required SOA category will likely be: 3-OG3, where 3 refers to the size of the works and OG3 to the category "road constructions". The size requirements are mainly based on firms' turnover.⁷

All the considered auctions are first-price sealed-bid: firms bid the price for which they are willing to do the works in the form of a percentage reduction - rebate - with respect to the auction's starting value. In all the auctions which are included in our database the selection

⁷Notice that the required SOA category is not a direct function of the auction's starting value. Indeed, the works to be done are usually a complex combination of several expertises and hence the required SOA categories may be more than once. For our analysis we consider just the primary required SOA category.

criterion for the winner is uniquely based on the rebate i.e. the technical component of firms' offer plays no role (provided that the winner will satisfy some minimum quality standards which are set by the contracting authority).⁸ Table 1 reports descriptive statistics of our data. In the sample, it is observed that the average number of firms participating to the auction is 30 with standard deviation 30, and a median of 21. The winning rebate is on average 13.4% with standard deviation 5.9, which is very close to the median value (14.1%). In addition, to explore the nature of competition three main indicators are considered: the probability of a winner coming from outside the region, the legal nature of the winner, and the indication of whether the winner is a member of a group of firms. The probability that the winner is coming from outside the region is 0.48 with standard deviation 0.5; only 11% of the winners are public companies with standard deviation 0.31 and 22% of the winners are member of a group of firms (standard deviation 0.41). Concerning tenders' advertisement, until July 2006, auctions were classified by the law according to their starting value as it is illustrated by the following table, where the first column reports y , the auction's starting value (in hundreds of thousands), the second column reports the level of publicity required by the law and the third column reports an approximation of the average potential population which can be reached through the correspondent level of publicity.⁹

⁸The winning rebate is not necessarily the highest bidden. In order to prevent firms from over-bidding (i.e. bidding a price which does not allow to recoup works' expenses) a complex (and criticizable) mechanism is implemented. According to this rule, all the bids which exceed the average bid by more than the average deviation from the average are automatically excluded. Bidders thus have to guess which will be this 'anomaly threshold' (as it is called) and try to place a bid below it.

⁹Notice that the level of publicity (the *treatment* in our model) is an ordinal variable where the first (lowest) level is associated with the smallest set of potential participants (proxied by the population).

y	publicity	average potential population
$y \geq 50 \text{ SRD}$	EU - Official Journal (<i>GUCE</i>)	460,000,000
	Italian Official Journal (<i>GURI</i>)	58,000,000
	National Newspapers (at least 2)	58,000,000
	Regional Newspapers (at least 2)	3,500,000
$10\text{€} \leq y < 50 \text{ SRD}$	Italian Official Journal (<i>GURI</i>)	58,000,000
	National Newspapers (at least 2)	58,000,000
	Regional Newspapers (at least 2)	3,500,000
$5 \leq y < 10\text{€}$	Regional Official Journal (<i>BUR</i>)	3,500,000
	Provincial Newspapers (at least 2)	360,000
$y < 5\text{€}$	Notice Board	12,500

table A

According to Table A, auctions with starting value below 500 thousands of euros have to be published on the contracting authority's notice board. This is considered the least amount of possible publicity, since only firms which have direct access to the auctioneer's premises or have direct contact with its staff may get information on the tender. The cost of publishing on the notice board is zero. The second interval goes from 500 to 1,000 thousands and it identifies those auctions for which the compulsory level of publicity is local i.e. those tenders that must be advertised in at least two newspapers spread all over the province where the works should be made and in the official regional journal (*Bollettino Ufficiale Regionale, BUR*). Publishing on BUR is very cheap: an average tender should not cost more than 500 euros. Provincial newspapers are cheap as well, since advertisement's price is proportional to the number of printed copies. The third level of publicity is national and concerns those tenders with starting values above 1,000 thousands of euros and below the community threshold (5,000 thousands of SDR, *special drawing rights*¹⁰). These tenders must be published on two national and two regional newspapers and on the national official journal (*Gazzetta Ufficiale della Repubblica Italiana, GURI*). The average cost for publishing on a national newspaper is about 800 euros (somewhat less for a regional newspaper). GURI, though, is very expensive: publishing a tender's abstract may cost around 7-8 thousands of euros. Finally, the maximum amount of publicity is enforced when tenders'

¹⁰At the time of writing, 5,000,000 SDR were equivalent to 6,771,500 euros.

starting value is above the community threshold. In that case the contracting authority must also advertise on the European official journal (*Gazzetta Ufficiale Comunità Europea, GUCE*) in addition to the obligations defined for the tenders belonging to the previous group. Notice, however, that publishing on GUCE is free of charge, so no additional cost is sustained by the contracting authorities. From July 2006, Law Dlgs 163/2006 removes the thresholds and forces the contracting authorities to publish on GURI at a national newspaper level, regardless of the auction's starting value (if it is greater than 150,000 euros). This paper may then provide a way to measure the impact of the law reform. In our sample, 88% of the tenders were published on the contracting authority's notice board, 20% on the Tuscan BUR and about 18% on the GURI. On the other hand, the average number of newspapers on which the advertisement of the tender appeared is: 0.187 for provincial newspapers, 0.493 for regional newspapers and 0.583 for national newspapers. From a more general perspective we can conclude that the sample show a sufficiently large variation in the data leaving the possibility for the econometric analysis which is illustrated in the following section.

3.4 The Empirical Analysis

3.4.1 Identification strategy

Contracting authorities which maximize the auctioneer's revenue implement different advertisement strategies with respect to contracting authorities which pursue other aims, such as maximize political rent through collusion with local firms. Because of this endogeneity problem, we expect OLS to be unable to give us unbiased estimation of the model. To disentangle the causality relationship between publicity and auction's outcome we thus implement a more refined technique: the Regression Discontinuity Design (RDD). In Section 3 we saw that an higher level of publicity (the *treatment*) is assigned to auctions if an observed covariate, the starting value of the auction, crosses a known threshold.

We are aware that using exogenous thresholds which are identified by the law is not equivalent to a controlled experiment because individuals' assignment might be not completely random. Lee (2007), however, shows that in these cases the RDD can nevertheless identify impact estimates that share the same validity as those resulting from a randomized experiment.

As in the summary guide to practice by Imbens and Lemieux (2007), to implement the RDD to our analysis we go through the following steps:

1. Inspect the Graphical Analysis.
2. Estimate the treatment effect using TSLS where standard errors can be computed using the usual (robust) TSLS standard errors.
3. Assess the Robustness and Identification assumptions by looking at possible jumps in the value of pre-treatment variables at the cut-off point.

In this section we discuss the theory and the assumptions required to implement the RDD. We define y_j as the j -th threshold in the auctions' starting value which determines a discontinuity point in the amount of publicity, as established by the law. The j -th discontinuity point separates the j and $j+1$ levels in publicity assignment imposed to contractors. We call these levels 'publicity brackets'. We aim at identifying the causal effect of publicity on auctions' outcomes by focusing on auctions in the neighborhood of those discontinuity points. Let Y be the auction's real starting value (the 'running variable'), and Z be the level of theoretical publicity that the contractor should implement under perfect compliance to the assignment rule. We denote by P the level of publicity actually observed in the auction. P may differ from its theoretical level if the contracting authority does not comply with the law assignment: indeed, it is very unlikely that a contracting authority would be punished from AVLP if P differs from Z .¹¹ Finally let C represent the outcome of auctions indicating the level of competition. In the analysis we alternatively consider C to be the number of bidders or the winning rebate. Let C_l and C_h being the values of C respectively below and above the generic discontinuity point j . To identify the causal effect of publicity on competition we need the following continuity assumptions:

$$E\{C_l|Y = y_j^+\} = E\{C_l|Y = y_j^-\} \quad (3.3)$$

$$E\{P_l|Y = y_j^+\} = E\{P_l|Y = y_j^-\} \quad (3.4)$$

where y_j^+ and y_j^- represent the left and the right limits of the starting value of the auction. As in Hahn et al. (2001) and Garibaldi et al. (2007), under the continuity conditions, for an auction in a neighborhood of the cut-off point the mean effect of being assigned to a higher theoretical publicity bracket $Z = h$ (instead of the lower one $Z = l$) on the actual publicity level P and on the competition level C are:

¹¹We then use a version of RDD called *Fuzzy Regression Discontinuity Design*, which is used when there is not perfect compliance by individuals.

$$E\{P|y_j^+\} - E\{P|y_j^-\}. \quad (3.5)$$

$$E\{C|y_j^+\} - E\{C|y_j^-\}. \quad (3.6)$$

(3.5) and (3.6) are usually called the *intention-to-treat* (ITT) effects.¹²

Following Angrist et al. (2000)'s seminal paper we interpret the ratio of the two ITT effects of expressions (3.5) and (3.6) as the causal effect of P on C (of publicity on competition). This can be done only if two more conditions are satisfied: the validity of the exclusion restriction and the monotonicity condition. The exclusion restriction requires that the theoretical publicity Z affects the outcome, C , only through the observed level of publicity (which is reasonable in our context). The monotonicity condition requires that no auction is induced to display a lower (higher) actual level of publicity if the theoretical publicity is exogenously moved from l to h (from h to l).

If the three assumptions are satisfied, then the ratio:

$$\Pi(y_j) = \frac{E\{C|y_j^+\} - E\{C|y_j^-\}}{E\{P|y_j^+\} - E\{P|y_j^-\}}, \quad (3.7)$$

identifies the average effect of a change in the actual level of publicity on the level of competition at $Y = y_j$ for those who are induced to show a higher level of publicity because their theoretical publicity increases from l to h .¹³

3.4.2 Graphical Analysis

We model the publicity function according to Table A which assigns different levels of publicity according to the auction's starting value. We thus have:

$$P = \begin{cases} P & \text{Geographical Level} & \text{Running Variable} \\ 0 & \text{Local} & \text{if } 1.5 \leq Y < 5 \\ 1 & \text{Regional} & \text{if } 5 \leq Y < 10 \\ 2 & \text{National} & \text{if } 10 \leq Y < Y^* \\ 3 & \text{EU} & \text{if } Y \geq Y^* \end{cases}$$

¹²To keep the notation as simple as possible, we omit time subscripts. In the empirical analysis we consider all the relations conditioned on time periods.

¹³For details on the average nature of the effect see Garibaldi et al. (2007).

Where Y is the starting value of the auction expressed in 100,000 euro (real value year 2000) and Y^* varies across the year of analysis. Due to non perfect compliance, we construct an indicator of theoretical publicity, which will be used as the instrument for actual publicity:

$$Z = \begin{cases} 0 & \text{if } 1.5 \leq Y < 5 \\ 1 & \text{if } 5 \leq Y < 10 \\ 2 & \text{if } 10 \leq Y < Y^* \\ 3 & \text{if } Y \geq Y^* \end{cases}$$

Under perfect compliance Z and P should coincide. Figure 2 shows that this is not the case in our context: the green line (which represents the actual publicity) indeed do not overlap with the orange line (which represents the theoretical publicity).

Figure 3 represents graphically non-parametric estimates of the main variables of interest. The two boxes on the left plot P on Y at the discontinuity thresholds 1 and 2, respectively. The other two boxes on the right plot the number of bidders on Y for the same discontinuity points. We estimate these locally weighted smoothing regression separately on the left and on the right of the cut-off points. Jumps in the plots show the effect of the threshold on the variable of interest thus offering a graphical interpretation of the intention-to-treat effects as defined by (3.5) and (3.6). As it can be noticed, the figures show that the actual publicity is uniformly not lower than the theoretical publicity on both discontinuities at the left of the threshold. At the right of the threshold we observe some problems of compliance with the law on publicity but not that big to violate the monotonicity condition required by RDD, as pointed out in Garibaldi et al. (2007). Concerning the number of bidders, we observe a jump at the right of both cut-off points. The mean impact of the actual publicity on competition, which is the ratio of the jump of the level of competition and the jump of the level of actual publicity, turns out to be larger at the first discontinuity rather than at the second. The figures show that there is a substantial effect of publicity on competition at the right of the thresholds. The impact weakens at discontinuity 2. We implement a graphical test on the continuity assumption following Lee (2007) to support the identification strategy required by our estimation technique, as in Garibaldi et al. (2007). We proceed in two steps: first, we plot the histograms of the auctions' starting value around the thresholds (see figure 4) to identify any form of manipulation of the running variable. Second, we inspect the pre-intervention variables as defined below. Figure 4 shows that the distribution of the auctions' starting value is right skewed. No significant mass probability around the single thresholds is identified, although a single peak is observable at discontinuity one. The presence

of the peak may raise identification problems. We thus further analyze that issue through the pre-intervention variables.

We define our set of pre-intervention variables from the detailed available information. These variables, in principle, should meet the following two conditions: they should not be affected by the publicity law, but they may depend on the same unobservables (e.g. efficiency/collusion of the contractors with participants), likely to affect the level of competition C . To test the continuity condition we use the information available on the person in charge to take care of the auction's administrative process. In particular we plot her professional qualification (engineer or geometrician) against Y and we analyze the behavior of the plots around the thresholds. In the graphical analysis we focus just on these two pre-treatment variables while in the regression analysis we enlarge the set of information available to include several other variables. Since these are observed before the determination of the publicity level, they can be used as pre-treatment variables. The graphical test for the continuity assumption would suggest evidence of sorting and lack of continuity if the plots of these indicators against Y would show a jump at the cut-off points. Identification would not be possible in those cases since auctions assigned to high theoretical level of publicity Z_h would be not comparable to auctions assigned to a low level of publicity Z_l with respect to unobservables relevant for the outcome C . Figure 5 shows that there are no jumps at the first threshold while jumps are very small at the second. Thus the graphical analysis suggests the presence of no manipulation of the running variable Y .

In the following section we further investigate these graphical results by considering a battery of regression based tests.

3.4.3 Regression Framework and Aggregation of the Effects

Following Angrist and Lavy (1999) and Garibaldi et al. (2007), we consider the aggregate effects of publicity on competition estimating the following equation:¹⁴

$$C = g(Y) + \beta P + \delta X + \epsilon \quad (3.8)$$

where $g(Y)$ is a fourth order polynomial in Y and P the observed level of publicity. To reduce the amount of observed heterogeneity we consider three information sets which include several

¹⁴Given the size of the Tuscany sample we choose to focus on the across discontinuities average results. We plan to focus on each single discontinuity once we will get access to the whole Italian dataset.

covariates. We define the matrix X respectively being SMALL, MEDIUM, or LARGE. The SMALL information set includes year indicators only, MEDIUM includes year indicators plus the fourth order polynomial in Y , $g(Y)$, while LARGE includes MEDIUM plus indicators of the nature of the auction. These are observable characteristics for both the good and the contractor: the typology of works which are put out to tender (i.e. road constructions, educational buildings, health-care building-units and other typologies); whether the contractor is a municipality, a province, or the region;¹⁵ the firms' technical requirements needed by the bidders to participate to the auction. None of these covariates are determined by the publicity law but are clearly correlated to the starting value of the auction and thus have to be included as controls.

We estimate via TSLS equation (3.8) and we interpret this instrumental variables estimate as a weighted average of the RDD estimates at each discontinuity point with weights that are function of the covariances between the actual and the theoretical publicity at the cut-off point, $cov(P, Z|Y = y_j)$, $j = 1, 2, 3$.

Table 3 reports the sample average of the outcome considered, the intention-to-treat, the OLS and the TSLS-IV estimates with the (robust) standard errors for the coefficients of publicity only. The odd rows, starting from the third, report the estimates considering the three different information sets: SMALL, MEDIUM, and LARGE. In the table we report the analysis of the number of bidders and the rebates based on equation (3.8) estimated over all the discontinuities. We do not report estimates obtained separately for each discontinuity point and we focus our discussion on the overall estimates that appear to be sufficiently precise. Column 1 of Table 3 reports the intention-to-treat effect of theoretical publicity on actual publicity. The estimates indicate that an increase from a lower starting value bracket, say 1.5 – 5 hundreds of thousand of euros, to an higher one, say 5 – 10 hundreds of thousand of euros, shifts the actual publicity by 0.74 if we consider the LARGE information set, by the 0.81 if we consider the MEDIUM one, and by 0.86 if we consider the SMALL one. We interpret these results as a lack of full treatment compliance due to non perfect law enforcement. We believe that this problem is not such big to invalidate the monotonicity assumption required by the RDD.

The overall intention-to-treat estimation of the theoretical publicity on both the number of bidders and rebates (columns 2 and 5 respectively) suggests that following an increase of one unit in the theoretical publicity, the number of bidders would increase from 6 to 9, with respect to

¹⁵There are several typologies of contractors which are excluded by the analysis. We focus on municipalities, provinces, and regions because they represent a big fraction of the sample.

a sample average of 30 bidders considering the different information sets. On the other hand, following an increase in one unit in the theoretical publicity, the winning rebate would increase from 1 to 1.5 percentage points with respect to a sample average winning rebate of 13.4%.

The OLS regression of the number of bidders and the winning rebate on the actual publicity suggests a positive correlation between publicity and competition (columns 3 and 6). The TSLS estimates of the same effects are 8.3 for the number of bidders and 1.5 for the winning rebate (columns 4 and 7), once we consider the LARGE information set. In this IV estimation we use as excluded instrument the theoretical level of publicity, Z . All the estimated results are statistically different from zero at 1 % significance level where standard errors are computed using the robust formula. If we compare these coefficients with the sample averages, we get that an increase of one level in publicity (for example by shifting from regional to national level) leads to a 27% increase in the number of bidders and a 11% increase in the winning rebate. In addition, we observe a large bias towards zero of the OLS results due to endogeneity and unobserved heterogeneity (e.g. collusion/efficiency of the contractors) which are removed in the Regression Discontinuity Design analysis.

As shown in Section 4.1, the RDD identification strategy is mainly based on the validity of the continuity conditions. In Section 4.2 we already performed a graphical test of such assumptions. Here, we report preliminary evidence based on regression analysis following Lee (2007), Imbens and Lemieux (2007), and Garibaldi et al. (2007) to further test those conditions. We perform the tests by estimating the same models as in equation (3.8) using as outcomes the set of pre-treatment variables. As in Section 4.2, the analysis is focused on the available information on the person in charge for the auction's administrative process. The first pre-treatment outcome that we consider is an indicator of the professional qualification. This variable can take five values: 1 if the person in charge is an engineer, 2 if she is an architect, 3 if she is a geometrician, 4 if she has a generic qualification, 5 in all the other cases. Table 4 reports the evidence. If the estimates of the coefficients on the actual publicity indicator using the theoretical publicity as an instrument are statistically different from zero, that would indicate that auctions below the threshold show systematic differences in the profession of the person in charge compared to auctions above the thresholds. This would suggest the possibility that in some of the auctions there was selection around the thresholds and lack of continuity in the baseline outcomes. We find no evidence of selection by looking at the overall results reported in Table 4. The intention-to-treat estimates

in the first column indicates that a one unit increase in the publicity level is associated with a reduction of 0.024 of the indicator of profession. This estimates is small and statistically not different from zero. Similar results are reported by the TSLS estimates in the last column of the table. We can therefore exclude the existence of sorting around the thresholds. We further enquire this issue by using other information on the person in charge such as: whether he/she is a male, her age, the second letter of her name and the last number of the year of born.¹⁶ As in the first row of Table 4, also in the other rows each coefficient comes from a separate regression. For example, the left cell of the row corresponding to the gender of the person in charge indicates that being male reduces the amount of publicity implemented by 0.0042 and this estimate is small and statistically not different from zero. This is exactly what we should find if our identification strategy is correct and such conclusion is confirmed by the rest of the table. In the first two columns of Table 4 we find no systematic differences with respect to these proxies among auctions assigned to alternative level of theoretical publicity. Moreover, no systematic difference emerges with respect to the actual level of publicity in the TSLS estimates, although the actual publicity and the pre-treatment outcomes appear to be correlated in the OLS regressions.

Table 4 supports the validity of the continuity conditions once we consider both the MEDIUM and the LARGE information sets and thus allows us to conclude that there is no evidence of manipulation of the running variable Y .

The Nature of the Winner

As suggested in the Introduction, publicity might have a direct effect on the nature of competition through participating firms' selection. In this paragraph we briefly derive some insights on that issue by analyzing the impact of publicity on the nature of the auction's winner. We are aware, though, that a proper analysis would require data on the whole sample of participating firms (winners + losers).

Table 5 reports the OLS and the IV estimates and their robust standard errors of the effect of publicity on three variables: the location of the winner, the legal identity of the winner and whether the winner is a member of a group of several joined firms.

According to the IV estimates, an increase in the level of publicity is associated with a positive and significative increase by 25 percentage points, with a standard error of 0.052, of the

¹⁶We obtained this information from the fiscal code.

probability that the winner is located outside the region where the auction takes place. This result is consistent with our ex-ante expectations: publicity helps contracting authorities to attract firms which do not belong to the local area.¹⁷ No significant impact of publicity on the probability that the winner is a public company is observed: apparently publicity equally targets firms with limited legal responsibility and public companies. Finally, publicity raises the likelihood that the winner is a group of firms instead of a single one: an increase in one level of publicity is indeed associated with an increase of 16 percentage points in the probability that the winner is a group, with a standard error of 0.042. This might be due to the expected level of competition: when publicity is high, firms expect a higher level of competition. A higher level of efficiency (reachable through the scale economies of a group, for example) is thus needed in order to win the auction.

3.4.4 Duration Analysis

In this section we report evidence of a negative correlation between the number of participants or the winning rebate and the duration of the works. In particular we describe the behavior of the hazard function, $h(l) = \frac{f(s)}{S(s)}$, defined as the (instantaneous) probability of accomplishing the works at s given survival until s . Let $L \geq 0$ be the random variable representing the duration of the works (expressed as the number of days between the moment in which the auction takes place and the accomplishment of the works) and l the realized duration. $F(l) = Pr[L \leq l]$ is the cumulative distribution function, while $S(l) = Pr[L > l] = 1 - F(l)$ is the survival function. We use a duration analysis because our data are right-censored: indeed, several works are still not accomplished at the day the Authority collected the data. Hence, for each i the observed duration $T_i = t$ is the minimum among the complete duration $L_i = l$ and the censored duration $C_i = c$.

We first report non parametric hazard estimates and then we add some structure to the hazard function in order to link its behavior to auctions' indicators of competition.

In the non parametric analysis we let $d_i(t)$ be the number of works accomplished at duration t and $r_i(t)$ be the number of works at risk of being accomplished at time t with duration t (where $r_i(t)$ includes the works censored at t or later). The estimated hazard function is

$$\hat{h}_i(t) = \frac{d_i(t)}{r_i(t)} \quad (3.9)$$

¹⁷We might suppose that the likelihood of collusion among the competing firms is then reduced, since it is more difficult to coordinate with outsiders.

and the, the Kaplan-Meier estimated survival function is

$$\hat{S}_i(t) = \prod_{s \leq t} \left(1 - \frac{d_i(s)}{r_i(s)} \right) \quad (3.10)$$

Figure 6 plots the Kaplan-Meier (KM) estimates of the survival function of the duration of the works, by the number of bidders for road constructions in year 2000 only. From left to right, the orange line represents the KM estimates considering all the auctions where the number of bidders are above the median of the distribution of the number of bidders. The green line pools together all the observations while the blue line represents auctions with the number of bidders below the median. According to Figure 5 the survival function is always higher for auctions with number of bidders below the median, which implies that they have a higher overall duration rate.

To add more structure to the analysis we implement a battery of parametric models and test the statistical significance of this finding. In the parametric models we pool together all the available information and control for it. As in Section 4.3, we add as regressors the MEDIUM and the LARGE information sets. We then propose a particular functional form of the hazard that includes the observables, as it is usual in parametric analysis. The focus is on the specific effect of the number of bidders or the winning rebate on the duration of the works. We base our analysis on the partial-likelihood approach proposed by Cox (1972).¹⁸ We report the estimates of the $\hat{\beta}$ of a series of models as follow:

$$h_i(t|x, \beta) = h_0(t)e^{X'\beta} \quad (3.11)$$

Table 6 reports the results of the analysis on works' duration. Columns 1 and 2 show the effects of a shift of the number of bidders and of the winning rebate above the median of their sample distribution respectively. Columns 3, 4 and 5 report the effects of the nature of the winner. Rows 1 and 2 of the same table refer to the MEDIUM and LARGE info sets to reduce the observed variability due to heterogeneity. The estimated coefficients are reported in the form of $\hat{\beta}$ (and not as hazard ratios) with the robust standard errors in parentheses. For instance, the first row $\hat{\beta} = 0.31$ indicates that a shift of the number of bidders above the median determines an

¹⁸We report the COX-PH model only. Results for Exponential, Weibull, and Gompertz are available on request. Notice that this class of models requires the proportionality assumption to write the hazard function as in equation (11). As suggested in Jenkins' class notes (<http://www.iser.essex.ac.uk/teaching/degree/stephenj/ec968/>), we inspect the shape of the survival function and we observe a parallelism among them. We thus considered feasible the implementation of the proportional hazard class of models.

increase in the hazard of 31% (and hence a significant reduction in the duration of the works). This effect is significant at 1% level.

On the other hand (and rather surprisingly) no significant effect is observed for the winning rebate. Evidence thus suggests a negative correlation between the number of bidders and the duration of the works while no correlation with the winning rebate.

Concerning the nature of the winner, the only significant effect on the hazard rate reported is the one of being member of a group. The estimates thus suggest that the economy of scales associated with firms' grouping matters in reducing the time of accomplishment. On the other hand, it is interesting to notice that while publicity affects the origin of the winner, coming from outside the region does not impact the duration of the works (which might be interpreted as one of the determinants of their quality).

3.5 Conclusions

Economic theory suggests that increasing the actual number of bidders in an auction has a positive effect on the auctioneer's rent. Increasing the number of potential bidders via an increase in the level of publicity made to advertise the tender has an ambiguous effect on the auction's outcome, though. On the one hand, a firm may be not aware that a tender is taking place if the contracting authority does not advertise it. On the other hand, a firm might be discouraged to participate if it observes a high level of publicity because that signals that competition in the auction will be harsh: if the probability of recouping the participation cost is too low, the firm might decide not to enter the competition.

Using a unique dataset on public tenders which took place in Tuscany - Italy in the period 2000 - 2006, this paper tests the effects of publicity on competition in public procurement auctions. Our empirical analysis reports evidence of a positive and statistically significant effect of publicity on the number of participants to auctions and on the winning rebate, i.e. on the auctioneer's rent.

In the paper we first adapt the model of Menezes and Monteiro (2000) on endogenous entry in auctions allowing for the optimal choice of publicity and show that it can be the case that the optimal level of publicity is not the maximal one even if publicity comes for free to the auctioneer. That is: it might be the case that keeping the number of potential bidders smaller than what it could be is an optimal policy, because of the trade-off illustrated above.

Next, we apply our econometric analysis to the database collected by the Italian Authority for Surveillance of Public Procurement.

Thanks to the Italian law on publicity for public procurement auctions, we are able to identify the publicity rule that contractors should follow according to the auction's starting value: the bigger is the value of the works which are put out to tender the broader the advertisement policy implemented by the contracting authority must be. Within this framework we implement a Regressions Discontinuity Design (RDD) which allows us to compare auctions with similar starting values immediately above or below each discontinuity threshold which separate different levels of due publicity.

By using this source of identification, we are able to disentangle the causal effect of publicity on competition. We show that an increase in one level of publicity (for instance from local to regional) increases the number of bidders by 8.3 with respect to a sample average of 30. That is: it increases the number of participants by 27%. We also show that such increase in publicity rises the winning rebate by 1.5 percentage points with respect to a sample average of 13.4% (i.e. the winning rebate is increased by 11%). These results are supported by the tests of the continuity conditions which we perform both graphically and within the regression analysis' framework. We also report evidence of a negative correlation between competition and the time to deliver the good put on auction within a duration analysis framework. Indeed, a shift of the number of bidders above the median determines an increase in the hazard of 31% (and hence a significative reduction in the duration of the works). This effect is significant at 1% level. The empirical analysis suggests that, within the context of our data, increasing the level of publicity has a positive effect on auctions' outcomes. Indeed, it seems that the deterrence effect due to an increase in the number of potential competitors is more than offset by the knowledge effect due to the fact that firms get information on tenders more easily. At this level of the analysis, however, we cannot disentangle the positive effect which is due just to the number of potential competitors from several other effects which publicity might have on the nature of competition. Indeed, increasing the publicity level might determine a reduction of the probability of collusion (simply because a 'maverick entry' from outsiders become more easy) or it might attract a particular kind of competitor which might induce local firms to bid more aggressively. The paper, however reports some preliminary explorations on this issue suggesting that publicity affects the origin of the winner and the the probability of the winner being a group of firms rather than a single one. We plan to address that issue with further research.

3.A Figures and Tables

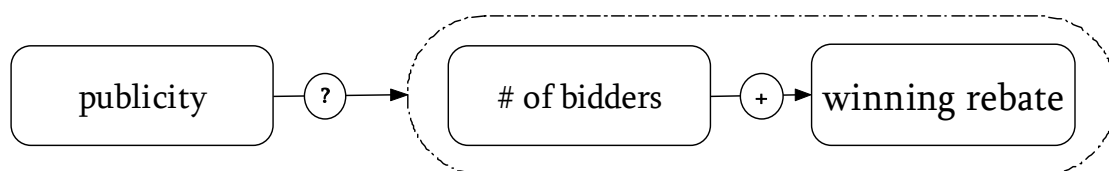


figure 1 - The effect of publicity on competition

	Percentiles							n
	mean	sd	p10	p25	p50	p75	p90	
Number of Bidding Firms	30	30	3	9	21	43	70	5735
Winning rebate	13	5.9	5	11	14	16	19	5735
Winner outside the region	.48	.5	0	0	0	1	1	5735
Winner public company	.11	.31	0	0	0	0	1	5735
Winner member of a group	.22	.41	0	0	0	0	1	5735
Notice Board	.9	.29	1	1	1	1	1	5735
Regional Official Journal	.21	.41	0	0	0	0	1	5735
Italian Official Journal	.19	.39	0	0	0	0	1	5735
Number of Province Newspapers	.19	.56	0	0	0	0	1	5735
Number of Regional Newspapers	.5	.84	0	0	0	1	2	5735
Number of National Newspapers	.59	.9	0	0	0	1	2	5735
Euro (in 100000)	9.6	42	1.8	2.3	3.7	7.5	17	5735
The Contractor is a Municipality	.52	.5	0	0	1	1	1	5735
The Contractor is a Province	.11	.32	0	0	0	0	1	5735

table 1 - Descriptive Statistics

	Roads	Education	Culture	Others
Number of Bidding Firms	42.5	23.4	29	24.7
Winning rebate	12.9	13.6	14.1	13.5
Winner outside the region	.406	.5	.517	.524
Winner public company	.115	.0534	.111	.101
Winner member of a group	.181	.192	.255	.224
Notice Board	.931	.902	.899	.888
Regional Official Journal	.139	.197	.241	.251
Italian Official Journal	.129	.146	.198	.246
Number of Province Newspapers	.176	.183	.215	.201
Number of Regional Newspapers	.373	.421	.532	.606
Number of National Newspapers	.436	.564	.67	.687
Euro (in 100000)	10.5	6.39	8.66	10.1
The contractor is a Municipality	.588	.684	.619	.416
The contractor is a Province	.209	.212	.0613	.0367
Fraction of the total	29.9	13.7	8.82	47.6

table 2 - Descriptive statistics by object's typology

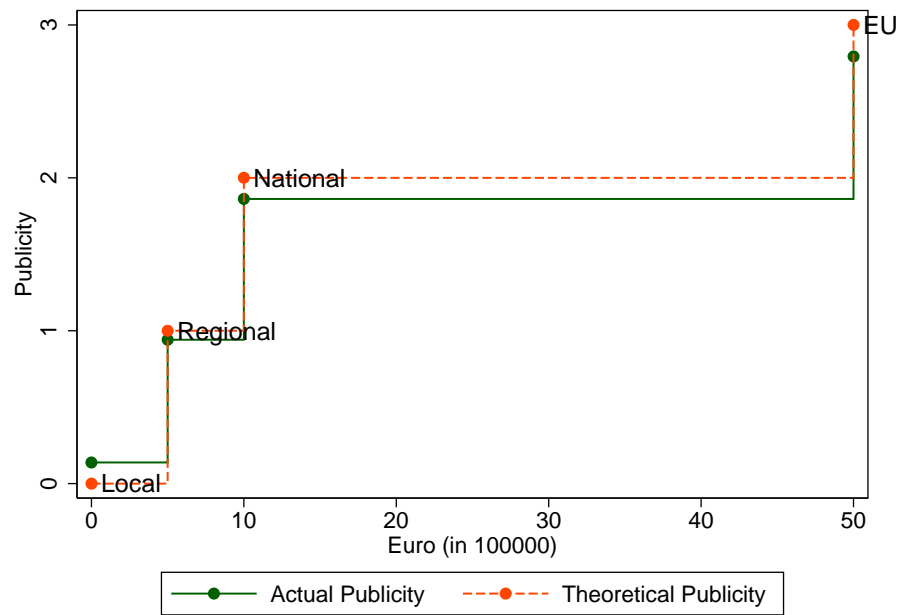


figure 2 - The publicity function

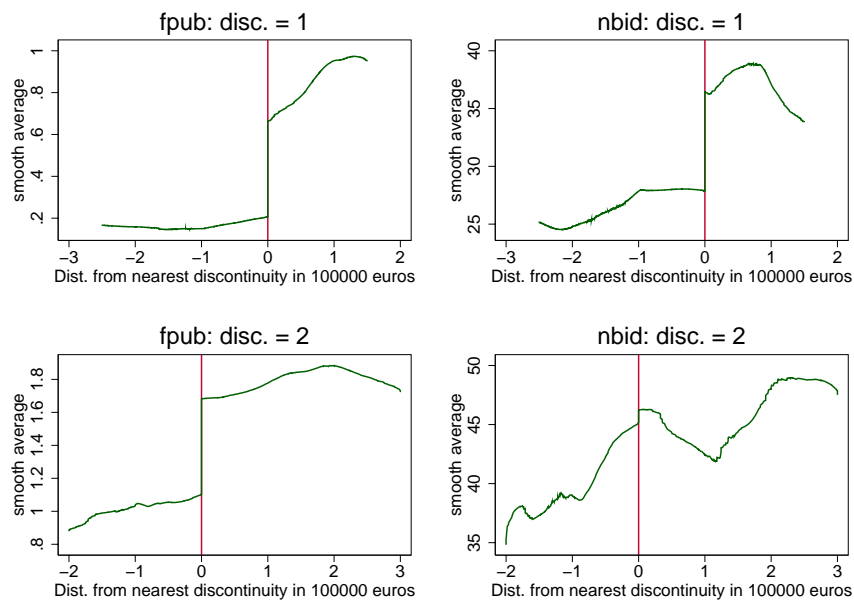


figure 3 - Intention-to-treat effects

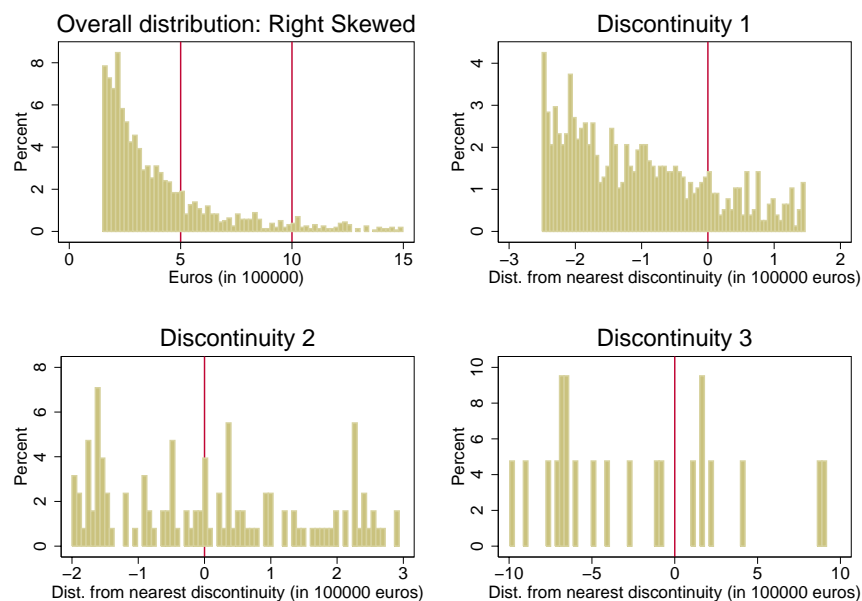


figure 4 - The distribution of the starting values for roads' contracts

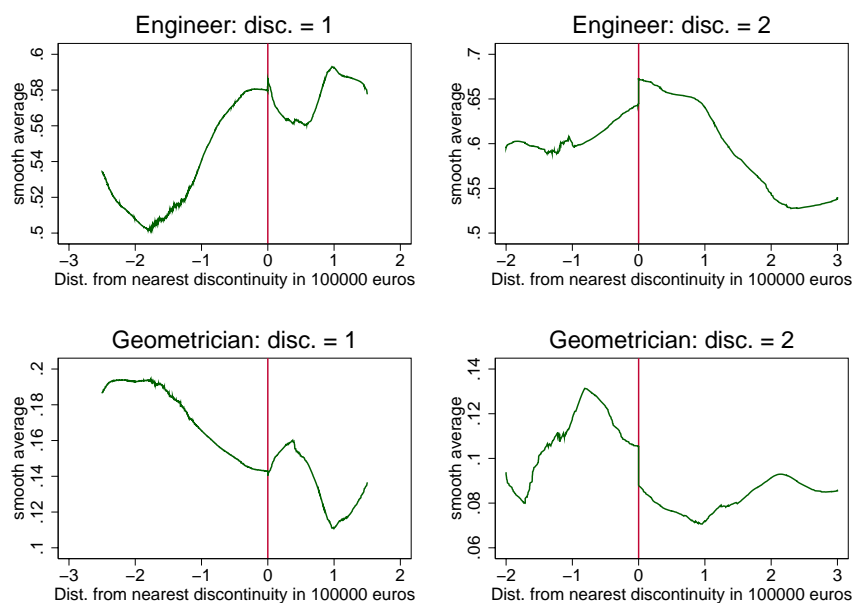


figure 5 - Continuity conditions and sorting: the profession of the person in charge

Method	OLS-ITT	OLS-ITT	OLS	IV-LATE	OLS-ITT	OLS	IV-LATE
Outcome	Publicity	Number of Bidders	Number of Bidders	Number of Bidders	Winning Rebate	Winning Rebate	Winning Rebate
Treatment			Publicity	Publicity		Publicity	Publicity
Instrument	Theo.Publ.	Theo.Publ.		Theo.Publ.	Theo.Publ.		Theo.Publ.
Mean-Out.	.62	.	30	.	.	13	.
(sd)	.86	.	30	.	.	5.9	.
SMALL	.86	9	6.8	11	1.5	1.6	1.8
(se)	.01	.54	.5	.65	.1	.1	.12
MEDIUM	.81	13	6.7	17	.94	1.1	1.3
(se)	.01	.78	.66	1	.17	.13	.22
LARGE	.74	6	2.3	8.3	1	1	1.5
(se)	.02	1.1	.68	1.6	.22	.14	.3
N	5500	5734	5500	5500	5734	5500	5500

table 3 - Regression discontinuity estimates of the effect of publicity on competition

Method	OLS-ITT	OLS-ITT	OLS	OLS	IV-LATE	IV-LATE
Treatment			Publicity	Publicity	Publicity	Publicity
Instrument	Theo.Publ.	Theo.Publ.			Theo.Publ.	Theo.Publ.
Info. Set	MEDIUM	LARGE	MEDIUM	LARGE	MEDIUM	LARGE
Prof. type	-.024	.053	.09	.11	-.0021	.09
(sd)	.034	.056	.029	.034	.042	.076
Male	-.0042	-.018	-.011	-.015	-.0045	-.023
(se)	.0081	.013	.0066	.0076	.01	.018
Age	.45	.26	.76	.6	.68	.4
(se)	.2	.31	.16	.19	.25	.43
Sec.Let.Name	.15	-.15	.21	.049	.19	-.27
(se)	.14	.21	.11	.13	.17	.29
Last Num.Year of Born	-.094	.083	-.017	.11	-.14	.13
(se)	.074	.12	.06	.071	.093	.16

table 4 - Tests for the presence of sorting and for the continuity conditions

Method	OLS	IV-LATE	OLS	IV-LATE	OLS	IV-LATE
Outcome	Winner	Winner	Winner	Winner	Winner	Winner
	Outside	Outside	Public	Public	Member	Member
	Region	Region	Company	Company	of a Group	of a Group
Treatment	Publicity	Publicity	Publicity	Publicity	Publicity	Publicity
Instrument		Theo.Publ.		Theo.Publ.		Theo.Publ.
Mean-Outcome	.48	.	.099	.	.21	.
(sd)	.5	.	.3	.	.41	.
SMALL	.1	.23	.054	.094	.076	.16
(se)	.0091	.015	.0074	.01	.0087	.013
MEDIUM	.046	.3	.01	.019	.033	.2
(se)	.012	.034	.0084	.02	.011	.028
LARGE	.0041	.25	.011	.045	.0048	.16
(se)	.012	.052	.0088	.032	.012	.042
N	4881	4881	5350	5350	5350	5350

table 5 - Regression discontinuity estimates of the effect of publicity on the nature of the winner

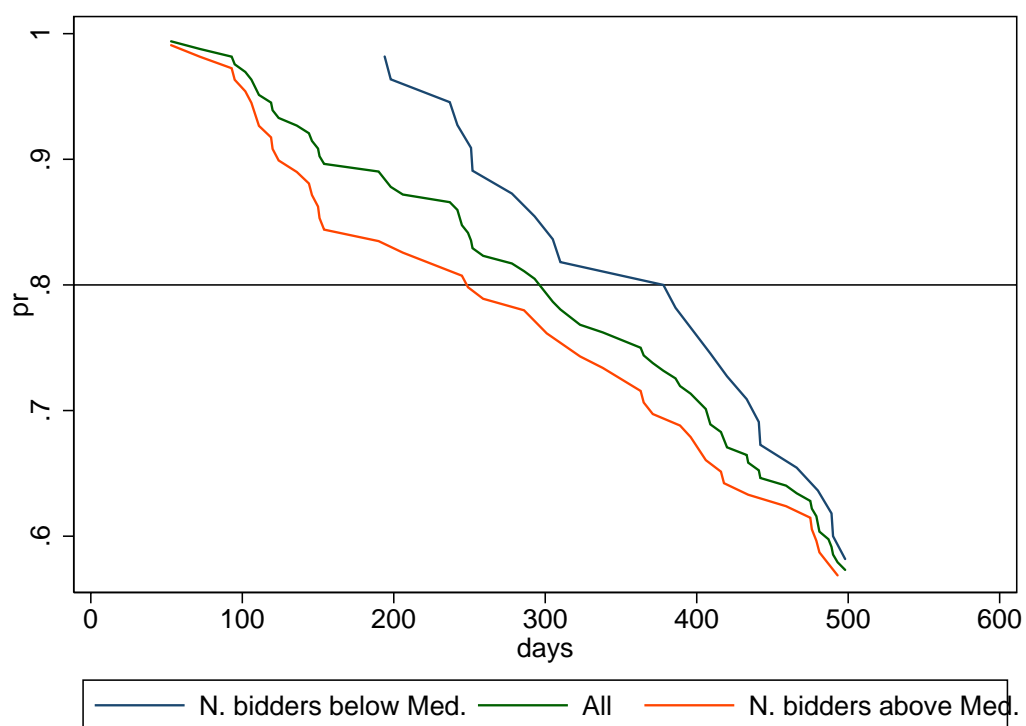


figure 6 - Competition and duration: kaplain-meier estimates, roads in year 2000

	Number of bidders above median	Winning rebate above median	Winner outside region	Winner Public Company	Winner Member of a Group
Info. Set					
MEDIUM	.31	-.026	-.082	.1	.29
(se)	.04	.041	.042	.068	.044
LARGE	.19	.02	-.034	.051	.31
(se)	.044	.044	.043	.07	.045
N	5723	5723	5209	5723	5723

table 6 - Works' duration, estimated hazard ratios from cox-PH models

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