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For Peer Review

Determinants of adaptation costs in procurement: an empirical estimation on Italian public works contracts

C. Guccio^{a*}, G. Pignataro^a and I. Rizzo^a

^a*Department of Economics and Quantitative Methods, University of Catania, Corso Italia, 55 C.P. 95121, Catania, Italy*

ABSTRACT

It is widely agreed that rules governing public procurement should be designed to achieve value for money. However, in the public works sector, "... the good being procured is usually complex and hard to be exactly specified *ex ante*, ... [and] alterations to the original project might be needed after the contract is awarded. This may result in considerable discrepancies between the lowest winning bid and the actual costs that are incurred by the buyer" (Bajari *et al.*, 2006). There is now a wide body of literature focusing on cost escalation during the execution of contracts and their estimates reveal that it can be often quite large. The paper is aimed at offering an empirical test of the determinants of adaptation costs in the public works procurement. Using a detailed data set on Italian public works contracts, we run an empirical analysis, grounded on the main conclusions reached in the literature, to test for the main drivers of adaptation costs.

* Corresponding author. E-mail: guccio@unict.it

I. Introduction

Procurement objectives can be stated saying that governments should aim at obtaining “*value for money*”, including the quality dimension in the concept of value. The possibility of fulfilling this objective depends on: the selection of the private contractor, the specification of the contract and the enforcement of the contract. The focus of the economic literature has been, for a long time, on the nature of the procedures for selecting contractors and on the specification of the contract. The issues examined are those related to asymmetric information, both in the form of adverse selection (i.e. the problem of choosing the best private contractor) and of moral hazard (i.e. the problem of preventing opportunistic behaviour in the implementation of the contract). More recently, attention has been paid to the phenomenon of cost escalation occurring during the execution of public works contracts. In this sector, in fact, a relevant feature of procurement is that “... the good being procured is usually complex and hard to be exactly specified *ex ante*, ... [and] alterations to the original project might be needed after the contract is awarded. This may result in considerable discrepancies between the lowest winning bid and the actual costs that are incurred by the buyer” (Bajari *et al.*, 2006).

Indeed, the phenomenon of the increase in planned costs of public projects is a highly debated political as well as economic issue and this paper aims at investigating its determinants on the grounds of the main conclusions reached in the literature.

This paper develops as follows. In section 2, a short economic analysis of the rules on public works in Italy is provided and it is highlighted that the final costs of the works

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4 very often exceed the expected costs. Section 3 offers a survey of the main results of
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6 the literature on the analysis of adaptation costs in public procurement and a
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8 specification of the variables used in the paper to represent the main drivers of
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10 adaptation costs, as emerging from the several studies in the field.
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14 In section 4 we run an empirical analysis of the main determinants of adaptation
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16 costs, using a unique panel data set of public works in Italy; we find support for the
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18 main conclusions reached in the literature and we offer some comments on the policy
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20 implications of the results. Few concluding remarks are presented in section 5.
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24 25 26 **II. Italian Public Works Market: Rules and Performance**

27 28 29 30 *Italian procurement rules*

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33 The Italian procurement system, during the last fifteen years has been subject to
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35 continuous changes.
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39 A reform of public works procurement was initially introduced by the law 11/2/94, n.
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41 109, the so-called *legge Merloni*, “to improve the efficiency, the effectiveness, the
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43 transparency and the quality of public works” (art.1). Since then many changes of this
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45 law have been introduced; recently, new rules have been devised and a law was
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47 passed (*Codice dei contratti pubblici di lavori, servizi, forniture*) which transposes
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4 the EU Directive n. 2004/18/CE on the coordination of procedures for the award of
5 public works, public supply and public service contracts into the Italian legislation¹.
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10 No attempt is made here of analysing the Italian legislation and only a few key
11 general features will be recalled. Italian procurement rules are quite strict in
12 specifying how decisions should be taken (for instance, “award to the lowest
13 bidder”), or what process has to be followed in making a decision (for instance, “do
14 not accept late proposals”, “evaluate proposals only based on the evaluation criteria in
15 the solicitation”). The law tries to reduce bureaucratic discretion as much as
16 possible². On these grounds, preference is given to competition³: procurements
17 should be widely advertised and strictly evaluated on the basis of the criteria
18 announced in advance. Sealed bids are used to prevent collusion among the
19 participants and to ensure transparency. In other words, competition is promoted as
20 much as possible, as a tool to select the most convenient bidder⁴. As far as the
21 specification of the contract is concerned, cost plus contracts are not allowed, so as to
22 prevent opportunistic behaviour of private contractors, and the renegotiation of the
23 contract is severely constrained⁵.
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45 ¹ Italy being a member State of the European Union, its legislation on procurement needs to be
46 designed according with the principles set up in the EU Directive.

47 ² As Kelman (2002) points out, these features strongly characterized the USA procurement before the
48 legislative reforms passed in 1994, 1995 and 1998.

49 ³ Open procedures are the rule and negotiated procedures can be adopted only in well defined
50 circumstances.

51 ⁴ This is in line with the more traditional results of the economic literature on auctions. For an
52 overview of this literature see Klemperer (1999).

53 ⁵ The law specifies under what specific circumstances renegotiation is allowed, as well as the
54 maximum amount, which is permitted, and the authorization procedure required. When a bigger
55 renegotiation is needed, the contract is revoked and a new tender is issued. The project designer is
56 liable for the mistakes in the project, which cause major revisions and, therefore, the revocation of the
57 contract.
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Indeed, the «philosophy» underlying the above mentioned procurement rules does not always seem in line with the economic reality of procurement (though the recent reform of the Italian legislation would seem to introduce some slight changes in this direction, whose effects cannot be assessed yet). However, emphasis is mainly placed on competition as a tool to ensure the selection of the best contractor, on the assumption that it will also provide the minimization of costs for the contracting authority⁶. Indeed, procurement rules aimed at ensuring competition might not be effective in producing the expected final outcome. As Kelman (1990) stresses, the use of sealed bids, i.e. purchasing with anonymous sellers, is in contrast with any purchasing practice in the industrial sector. In fact, customers and suppliers cannot enjoy the value deriving from long term, continuing relationships such as those characterising private sector industrial purchasing⁷, though the undesirable lock-in effect should be not underestimated. Potentially relevant incentives for good performance, such as a promise to award future contracts, are ruled out. These shortcomings might be especially relevant when centralized procurement procedures are used.

A peculiar feature of the Italian procurement is given by the existence of an independent Authority (*Autorità di Vigilanza sui contratti pubblici di lavori, servizi e forniture*) established in 1999, for the legal supervision of public works and

⁶ Expected total costs do not necessarily decrease when the number of bidders increases: the administrative costs as well as the costs for the preparation of the bid should not be undervalued.

⁷ The advantages of such a kind of relationship have been stressed by Williamson (1985).

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4 engineering services and nowadays operating in all the areas of procurement⁸. The
5
6 role of the Authority is to diffuse and to supervise the proper implementation of
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8 effective regulation by the public authorities and the contractors, as well as to collect
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10 data on the procurement sector.
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18 *The performance of the Italian public works market*
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20 As far as public works are concerned, it is useful to point out that such a complex
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22 array of norms is designed to regulate a market of relevant size: in 2006, in Italy, the
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24 demand of public works totally amounted to about 30,721 millions of euros⁹. The
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26 Italian public works market is fragmented both in terms of the tender size and the
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28 number of purchasing authorities¹⁰.
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32 The above mentioned regulation does not seem effective, however, in ensuring the
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34 functioning of the market, i.e. the capability of fulfilling on time the public need
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36 underlying the demand for public works. In fact, table 1 shows that, in the period
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38 2000 – 2005, 101,589 works above 150,000 euros have been awarded and that only
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40 27,529, mainly of small size, were completed.
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50 ⁸ Rizzo (2008) points out that the creation of an independent Authority to supervise and regulate the
51 procurement market is not widespread in other EU countries and offers a tentative political economy
52 explanation.

53 ⁹ Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture (2007). The demand is not
54 evenly distributed across the different geographical areas and the different sectors.

55 ¹⁰ In 2006 there were 12,231 public works below 150,000 euros (38.1% of the total) and, at the other
56 extreme, 150 works above 15 millions of euros. 83% of works was below 1 million of euros (Autorità
57 di vigilanza sui contratti pubblici di lavori, servizi e forniture, 2007).
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4 The performance of the Italian public works market is, indeed, a very ‘hot’ and
5 debated issue: it is widely recognised that infrastructures play a strategic role to foster
6 economic growth¹¹ and the improvement of the procurement system is advocated to
7 overcome the present under-provision of infrastructures. Nowadays, a major concern
8 is that not only just a small share of the awarded contracts is completed, but also that
9 the final costs and the duration of the works which are completed very often exceed
10 the expected costs and duration.
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14 In this paper we focus attention upon adaptation costs that is the cost of adapting
15 post-award changes. We are aware that there is no unambiguous way to refer to such
16 a phenomenon¹² but, apart from terminological disputes, in this paper we refer to
17 adaptation costs as the difference between actual, or final costs and the contract costs
18 as a ratio of the contract costs, where the contract costs are those representing the
19 value of the winning bid. More formally, they are expressed as: $AC_h = \frac{FC_h - B_h}{B_h}$,
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47 where FC_h is the final cost and B_h is the value of the winning bid, for a public work
48 h .

47 ¹¹ The effects of infrastructures on economic growth are extensively investigated in the literature (see,
48 Milbourne *et al.*, 2003; Wilhelmsson and Wigren, 2009).

49 ¹² Flyvbjerg *et al.* (2002) provide a similar definition for cost overruns, which is the other term usually
50 encountered in this literature: “actual costs minus estimated costs in percent of estimated costs”, where
51 estimated costs are those forecasted at the time of the decision to realize the project. The authors are
52 well aware, however, of the fact that estimated costs can be computed at different times: project
53 planning, decision to build, tendering, contracting, etc. It also must be noted that the term adaptation
54 costs is sometimes used with a substantially different meaning. Bajari *et al* (2006) define adaptation
55 costs as “any costs that are incurred above and beyond the direct production costs of the project”,
56 whereas they consider the direct production costs as the other source of the cost increases following a
57 modification of the initial plan, that is the direct costs of the additional work.
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4 The Authority's estimates¹³ show that almost two thirds of the public works
5 completed by 2005 experienced adaptation costs and for about a quarter of all works,
6 adaptation costs were higher than 10% of the original cost¹⁴. Therefore, data about
7 Italian public works carried out between 2000 and 2005 seem to suggest that
8 adaptation costs are empirically relevant.
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17 The performance of Italian public works market, measured by the extent of the
18 phenomenon of adaptation costs, therefore, shows interesting economic implications,
19 which need to be investigated empirically. The phenomenon of adaptation costs is not
20 new in the literature and its determinants have been extensively investigated: in the
21 following section, the main contributions offered in this field will be analysed to
22 provide a theoretical framework for the analysis of Section IV.
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33 **III. The determinants of adaptation costs**

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37 There is now quite a wide body of literature on the analysis of adaptation costs in
38 public procurement, attempting to explain the different sources of the increase in
39 planned costs of public projects and to provide supporting and consistent empirical
40 evidence. In this section, we will briefly survey the main results of this literature, to
41 elicit the factors that are widely recognized as main drivers of adaptation costs, and to
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53 ¹³ Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture (2006).

54 ¹⁴ At the same time, in Italian public works delays are very striking: about two thirds of public works
55 completed by 2005 involved delays higher than 20% of the completion time agreed upon in the
56 contract. The determinants of such a phenomenon have been investigated by Guccio *et al.* (2009b).
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4 relate them to the variables we will use to test their empirical relevance in the analysis
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7 for the Italian public works, which will be developed in the next section.
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12 *A brief survey of the literature*
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16 **Complexity, uncertainty and the inescapability of adaptation.** First of all, most
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18 works emphasize that whereas public procurement is not concerned with provision of
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20 standard goods and services, and it regards complex goods, like public works, there
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22 will be an unavoidable degree of uncertainty related to events that may occur during
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24 the execution of the contract, which may cause a difference between what is planned
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26 and what is actually realized, or needs to be realized. One potential explanation of
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28 adaptation costs, then, lies in the inadequate way of dealing with uncertainties in the
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30 planning stage, in terms, for instance, of poor initial design, which requires
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32 substantial changes in the execution stage, or of inaccuracy of costs forecasts¹⁵. This
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34 is what has been termed as technical explanation by Flyvbjerg (2005), for the case of
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36 large infrastructure projects: “Technical explanations account for cost overruns and
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38 benefit shortfalls in terms of imperfect forecasting techniques, inadequate data,
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40 honest mistakes, inherent problems in predicting the future, lack of experience on the
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42 part of forecasters, etc.” Studies of forecasting errors (Flyvbjerg and Skamris, 1997;
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44 Flyvbjerg *et al.*, 2002, 2003a) show that construction costs are generally
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54 ¹⁵ Ganuza (2007) provides a rational explanation for what could be regarded as underinvestment in
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56 project design. A higher investment on a more accurate initial design lowers the probability of
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58 renegotiation and of awarding the project to the most efficient firm, but it increases its rents, when
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60 competition is not perfect.

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4 underestimated, and costs escalation, in general, is more severe for mega projects and
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6 for long time of completion¹⁶. However, over time, “technical error may be reduced
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8 or eliminated by developing better forecasting models, better data, and more
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10 experienced forecasters” (Flyvbjerg, 2005). Even if negligence in dealing with
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12 uncertainty should disappear over time, there may still be contingencies that are really
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14 impossible to be predicted, above all for very complex projects. This observation,
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16 coupled with the pervasiveness of contractual incompleteness, leads to the need of
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18 renegotiation of original contracts and, possibly, to adaptation costs. The issue of
19
20 contractual incompleteness has been extensively investigated in the contract theory
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22 (Hart 1995) and the explanations provided for its existence seem all relevant in the
23
24 case of public works.
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33 **Optimism bias and political incentives to underestimation of costs.** A second
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35 explanation provided for adaptation costs is still related to an “imperfect” project
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37 design, which is not caused by “objective” reasons but by a subjective will to
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39 underestimate costs, when designing the project. Studies using the notion of
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41 “optimism bias” are in this line of thought. This notion has mainly psychological
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43 foundations and it represents a more general explanation of business behavior and
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45 even of individual behavior. According to Lovallo and Kahneman (2003)¹⁷, “when
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47 forecasting the outcomes of risky projects, executives all too easily fall victim to what
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54 ¹⁶ Odeck (2004), however, shows that, in the case of the Norwegian road sector, cost overruns appear
55 to be more severe for smaller projects as compared to larger ones.

56 ¹⁷ See also Kahneman and Tversky (1979) and Flyvbjerg (2005), among the other studies that develop
57 the idea of optimism bias.
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psychologists call the planning fallacy. In its grip, managers make decisions based on delusional optimism rather than on rational weighting of gains, losses, and probabilities. They overestimate benefits and underestimate costs... As a result, managers pursue initiatives that are unlikely to come in on budget or on time”. The psychological nature of this optimism can be tracked down to several cognitive biases suffered by individuals¹⁸. Newby-Clark *et al.* (2000) provide experimental evidence of individuals’ optimistic views about time completion of some tasks, even when they have information about other potential, and more pessimistic scenarios. It is not, however, straightforward to extend the experimental results to the context of public works, to prove the existence of optimism bias and to regard it as a determinant of adaptation costs. Flyvbjerg (2005) noted that: i) the experimental data are drawn from non-expert individuals; ii) if optimism bias has to be considered as an explanation for adaptation costs in public works, it would be able to explain individual cases of inaccuracy, while the phenomenon is widespread and persistent over time. Flyvbjerg *et al.* (2003b) show, for instance, for a sample of transport infrastructure projects covering 20 different countries over 70 years, that nine out of ten projects suffer from cost escalation. Moreover, it is possible to add that, if connected to a psychological basis, optimism bias is difficult to be represented in an empirical test, since the initial underestimation of costs may be representative of different factors. Indeed, optimism bias or, more generally, a “voluntary” underestimation of costs could be considered,

¹⁸ Lovallo and Kahneman (2003) refer to the tendency of individuals to exaggerate their own talents, or the degree of control over events, to anchoring, that is a project plan comes out as an adaptation of an original idea, etc.

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4 instead, as connected with political incentives to behave in such a way¹⁹. An
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6 optimistic design of a work may represent an instrument for changing priorities
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8 across different projects, for creating a commitment to the realization of a work,
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10 facilitating its start up, or for producing short term political benefits, as arising from
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12 the possibility of increasing the number of works to be started, even if, in the
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14 medium-long term they will be delayed or even not completed, because of financial
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16 problems. There are a few studies trying to prove that political behavior is at work,
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18 behind the existence of adaptation costs, with the help of anecdotal evidence (Wachs,
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20 1989; Wachs, 1990; Flyvbjerg *et al.*, 2002). It turns out that the behavior of political
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22 decisionmakers, in overestimating the net benefits of projects, is interpreted in terms
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24 of lying, something that cannot be represented by observed data. Therefore, the
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26 authors of these studies need to turn to interviews to people that have played a role in
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28 the design and approval of public works, to check whether political pressure has led
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30 to overstate benefits and underestimate costs.
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40 **Opportunistic behavior.** A third relevant driver of adaptation costs, widely
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42 discussed in the literature, is related to the potential opportunistic motivation of
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44 rinegotiation of contracts for public works, especially on the side of firms: when a
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46 contract for a public work has been awarded, the firm can exploit the unavoidable
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50 ¹⁹ Flyvbjerg (2005) regards political incentives to overestimation of benefits and underestimation of
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52 costs as a separate explanation of cost overruns. However, Lovallo and Kahneman (2003) consider
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54 also organizational pressure as a source of optimism bias: "Every company has only a limited amount
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56 of money and time to devote to new projects. Competition for this time and money is intense, as
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58 individuals and unit jockey to present their own proposals as being the most attractive for investment.
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60 Because forecasts are critical weapons in these battles, individuals and units have big incentives to
accentuate the positive in laying out prospective outcomes". In general, therefore, optimism bias can
also have a rational foundation.

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4 contract incompleteness, to gain additional money over and above what has been
5 agreed upon in the contract²⁰. In other words, the modification of the initial plans may
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7 be driven by the incentive of the firm to exploit its bargaining power in bilateral
8 negotiations with procurers, who may suffer by being “locked” into the contract with
9 the firm. The relevant contributions here are especially those examining some
10 procurement features that may affect the strength of the incentives to behave
11 opportunistically during renegotiation, mainly connected with the nature of the
12 contract and with the contract awarding procedure. These studies re-examine, then,
13 the efficiency properties of mechanisms, like fixed price contracts and auctions,
14 considering how ex-ante incentives may affect ex-post renegotiation and bargaining
15 and, consequently, adaptation costs. As for the first issue, the nature of the contract,
16 several studies have compared fixed price with cost plus contracts. Bajari and Tadelis
17 (2001), in particular, show that procurers may face a trade-off between providing *ex*
18 *ante* incentives and avoiding *ex post* transaction costs due to costly renegotiation: “FP
19 contracts provide the strongest incentives for cost reduction. On the other hand, if the
20 design is left incomplete, then the cost of renegotiating FP contracts is high. When
21 C+ contracts are used the cost-reducing incentives disappear, but the process of
22 adaptation is far smoother because the reimbursement process is simple, well defined,
23 and leaves little room for haggling.” The costs arising from fixed-price contract,
24 related to adaptation of projects, tend to be higher as the complexity of projects
25 increases, since the potential for adaptation increases with complexity. Therefore,
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56 ²⁰ Within the context of concession contracts, Guasch (2004) has examined the potential incentive of
57 governments in renegotiating contracts.
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4 “cost-plus contracts are preferable to fixed-payment contracts when a project is
5 highly complex and the cost of ex ante contract preparation and specification is large”
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7 (Estache *et al.*, 2009). With respect to the issue of the impact of procurement
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9 awarding procedures on adaptation costs, the analysis is part of the research that
10
11 compares auctions with negotiations. A first line of argument holds that negotiations
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13 transmit more information to the firm than auctions, and, for this reason, may help
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15 preventing the need and scope of renegotiation. Bajari *et al.* (2009) argue that the
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17 only piece of information the bidders receive in auctions is the bid, while in
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19 negotiation the parties have usually the opportunity to discuss the details of the
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21 project. This is the reason why negotiations should help to attenuate the need for
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23 adaptation and, therefore, the impact on adaptation costs when procurement regards
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25 complex projects. A second relevant issue raised about the relationship between
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27 awarding procedures and adaptation costs is that, with incomplete contracts, the
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29 winning bidders in auctions may have an incentive to behave opportunistically,
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31 during the execution of the contract, and to push for revising the bid that allowed
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33 them to win the award of the work (Guasch, 2004). This may be part of a situation of
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35 adverse selection, whereas a bidder that is ready to act opportunistically, at the
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37 execution stage, will bid a very low price (what is usually referred to as
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39 underbidding), so as to secure the win of the bid and, then, to exploit the opportunity
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41 of a renegotiation (Bajari *et al.*, 2009; Chong *et al.* 2009, Guccio *et al.*, 2009a)²¹.
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55 ²¹ Ware *et al.* (2007) present this behavior, also known as lowballing, as part of a colluding agreement
56 with procurers, who would guarantee the winner a convenient renegotiation, sharing the gains, which
57 will arise.
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4 **Corruption.** Finally, adaptation costs are surely influenced by corruption. Guasch
5 (2004) shows that the likelihood of renegotiation increases with the level of
6 corruption of a country, while Auriol (2006) estimates the cost of corruption to be
7 between 4 and 10 percent of procurement spending.
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16 *The variables used to represent the determinants of adaptation costs*
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20 **Complexity.** Complexity of projects, then, may be associated to a negligent or
21 “objective” overlooking of contingencies, which requires renegotiation of the original
22 agreement between the procurer and the firm, because of contractual incompleteness.
23 Complexity is, in fact, related to several characteristics of works, which are uneasily
24 expressed by just one dimension. We will try to capture the impact of complexity on
25 adaptation costs, considering different variables. The expected time duration of the
26 work (*ED*), as fixed at the time of signing the contract, is the first of these variables:
27 the longer the time needed to complete a work, the higher the risk of occurrence of
28 contingencies not foreseen in the original contract. Another variable is represented by
29 the estimated total value of the work (*ETV*) by the contracting authority, since it
30 seems reasonable to assume that a “larger” work presents a higher degree of
31 complexity and a higher risk of not considering every contingency at the planning
32 stage. Finally, exploiting the Italian classification of public works and the fact that,
33 for each public work, there is a record of all the categories in which it can be
34 decomposed, a weighted composition index of the work (*WCI*) is computed,
35 calculated on the different sub-categories involved in the work, weighted for their
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4 relative amount²². We will also make an attempt to measure the impact on adaptation
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6 costs of the problems related to the execution of the work, which may also include
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8 errors or poor design. One of the variables we will use is the existence of legal
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10 disputes (*DIS*) between the firm and the purchasing authority. It is representative of
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12 problems with the execution of the work, which are not solved by an agreement
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14 between the parties, and it may be partially connected with the quality of the initial
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16 design. A poor design can be contested by the firm, because it cannot be executed or
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18 it is too costly to be executed. It can also be executed in a different way, which is
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20 considered as more efficient by the firm, but it is however contested by the
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22 contracting authority. We are well aware that the existence of legal disputes is
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24 connected to several other reasons, first of all defects of execution of the work by the
25
26 firm, and that its impact on adaptation costs will also measure the legal costs
27
28 connected with the dispute itself. We will, therefore, be cautious in the interpretation
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30 of the results. We will also consider that the Italian law admits the possibility, for the
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32 contracting authority, to procure not only the work, but also the final design of the
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34 project. We will use a dummy variable to capture whether the contract includes the
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36 final design of the project or not (*PROJ*). The effects of this variable, however, are
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38 not unambiguous: on one hand, the lack of an executive project and therefore, the
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40 possibility for the firm to intervene on the project could allow for the adoption of
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42 technical solutions consistent with its productive capacities and know-how and,
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54 ²² Public works are articulated in sub-categories, i.e. the different components of the overall work,
55 which contribute, according with their relative relevance for the specific work, to the estimated total
56 value. It is plausible to assume that the more complex is a public work the higher is the number of
57 sub-categories involved in its implementation.
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4 therefore, could reduce the pressure on the renegotiation and adaptation cost during
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6 the implementation. On the other hand, however, the separation of the activities of
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8 project and implementation introduces a conflict of interests between the project
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10 designer and the firm implementing the work and, therefore, may limit the firm's
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12 opportunistic behaviour. Finally, we control for the presence of subcontractors in the
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14 execution of the work (*SUB*), since it may negatively affect the implementation of the
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16 original design, even when the latter does not present serious limitations.
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23 **Political incentives.** Since our empirical analysis is based on data on public works
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25 carried out by very different authorities, we will try to capture the effect of political
26
27 incentives to underestimate costs, considering the different governance models of the
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29 contracting authorities²³. To grasp the relation between the *governance* and the
30
31 *performance* of the contract, contracting authorities have been grouped in the
32
33 following categories: central government (State administrations even with
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35 autonomous organization – *C_GOV*), local governments (regions, provinces,
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37 municipalities – *L_GOV*), institutions (Public institutions, Health Authorities, which
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39 enjoy budget autonomy - *INST*), public ownership companies (ANAS, FS, Poste
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41 s.p.a. – *P_ENT*) and private companies (e.g. concessionaires – *PRIV_COM*)²⁴. Our
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47 hypothesis is that central government on one side and private companies, on the
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54 ²³ Different models of governance refer to appointment methods, soft or hard budget constraints, etc. It
55 must be noted that a different governance model may also impinge on incentives to monitoring the
56 implementation of the work.

57 ²⁴ A somewhat similar differentiation of contracting authorities can be found in Bandiera *et al.* (2009),
58 a work analyzing the behaviour of Italian procurers in the purchase of standardized goods.
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4 other, are the ‘polar’ cases as far as incentives are concerned. Moving from the
5 former extreme to the latter we would expect lower adaptation costs²⁵.
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12 **Opportunistic behaviour.** Since the Italian procurement of public works is mainly
13 ruled by the criterion of fixed price, in this work, we cannot test the different impact
14 of the nature of the contract on adaptation costs. We will check, instead, for the
15 relation between the type of awarding procedure and adaptation costs, using a dummy
16 variable, according to whether it is an auction or a negotiation (*OPEN*). We will also
17 check whether underbidding and its intensity affect the extent of renegotiation and its
18 adaptation costs. The variable used to capture underbidding is the ratio of the value of
19 the winning bid to the value of the work (*R_WBID_ETV*), as estimated by the
20 contracting authority. We are aware of the fact that, behind this variable, other
21 phenomena may be hidden. However, the variables related to the governance of
22 contracting authorities help us in controlling for potential incentives to
23 underestimation of costs (the denominator of our variable). It must also be considered
24 that what we would regard as underbidding could be, instead, the natural outcome of
25 competition in the market for public works. More generally, the value of the winning
26 bid is affected by the nature of the market. We try to control for different market
27 features. To control for the effects of competition on the bid, we will use the number
28 of potential bidders – *P_BID* - (i.e. the number of firms qualified for the specific
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54 ²⁵ The relations of causality between the difference of cost and the procurement procedure for each
55 contracting authority need to be explored. A lower difference of cost for a category of contracting
56 authority might not be determined necessarily by a more careful behaviour but by a larger use of
57 negotiated procedures (which reduce the risk of contractual revisions).
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4 public work category -e.g. roads, railways, etc.- and for the specific contract value at
5 national level). It is also important to evaluate the position of the winning bidder
6 within the market. We will, therefore, use a variable, measuring the number of
7 contracts awarded to each firm by all the contracting authorities included in the data
8 set in the period under consideration (*LEAD*): in a market in which tendering is
9 effective in selecting the best bidder, and assuming that quality is homogeneous
10 across firms for the works of the same category and size, the greater this number, the
11 higher the probability that the firm is more efficient than others, so being able to offer
12 lower prices, without increasing adaptation costs. Finally, we will consider a proxy
13 for the potential existence of long-term relationships between the firm and the
14 purchasing authority, represented by the number of contracts awarded to each firm by
15 the same purchasing authority (*INT*). The expected sign for this variable is negative,
16 since the interaction is likely to prevent opportunistic behaviour and, therefore, the
17 greater the interaction, the lower the likelihood of contractual revisions and
18 adaptation costs.
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43 **Corruption.** We will use a proxy for corruption proposed by Golden and Picci
44 (2005), based on the difference between a measure of the physical quantities of public
45 infrastructure and the cumulative price government pays for public capital stocks
46 (*GP_INDEX*).
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4 **Control factors.** We will consider the ratio between the actual duration of the work
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6 and the expected duration (*EX_T*) to control for the relative delay of the different
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8 works. We will also control for year of award, through dummies for each year (2000,
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10 2001, 2002, 2003 and 2004) and compare estimates, where public works sectors are
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12 pooled to others, where we also control for sectors.
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18 **IV. Empirical analysis**

19 *Data and descriptive statistics*

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26 The data used in the following analysis are those collected by *Osservatorio per i*
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28 *lavori Pubblici* of the *Autorità di Vigilanza sui contratti pubblici di lavori, servizi e*
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30 *forniture*. The observation unit is given by the single public work and very detailed
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32 information are available on the various steps of the procurement procedure – project,
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34 selection of the contractor, execution and completion of the work. The sample refers
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36 to 9,888 public works, whose costs range from 150,000 euros to 5 million euros,
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38 awarded in the period 2000-2004 and completed by 2005²⁶. Table 2 provides
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40 summary statistics for the number of contracts awarded per year, the total amount and
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42 the mean value of contracts.
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48 << TABLE 2 around here >>
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53 ²⁶ The sample was also selected on the basis of the completeness of the records included in the data
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55 base. To limit the heterogeneity, the public works above 5 million euros were not included in the
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57 sample because of the longer time lag required to complete complex works. Moreover, public works
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59 with a final cost lower than the contract cost were not taken into account because of the lack of
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adequate information.

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Altogether, the sample is representative of the composition of public works in Italy, both in terms of sectors and of contracting authorities. Tables 3 and 4, respectively show the composition of the sample in terms of the sectors covered and of the type of contracting authorities, grouped in five categories, according to their different governance structure. With respect to the value of the works, the data show a high variability across sectors and contracting authorities. Table 3 indicates that public works in the sample are mainly referable to roads and highways, social and school buildings and protection of environment, which account for about 60% of the entire sample, in terms of both the number of works and their value. Table 4 reveals that most of the works represented in the sample are carried out by local governments.

<< TABLE 3 around here >>

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Econometric framework

The aim of this section is to provide a test of the empirical relevance of the different factors discussed in section III, in the explanation of adaptation costs. For this purpose, we employ a panel data of Italian public works for 16 sectors awarded in the period 2000-2004 and completed by 2005. The dependent variable is the adaptation cost (AC) for project i in sector j , as defined in section II.

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4 Because of the censoring of these data at zero²⁷, ordinary least squares (OLS)
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6 regression techniques are not applicable, as least squares estimates are not consistent
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8 when the residuals are not normally distributed. A natural approach is to use a Tobit
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10 model²⁸, with the following empirical specification:
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$$13 \quad AC_{ij} = \beta_0 + \beta EV_{ij} + \varepsilon_{ij} \quad [1]$$

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15 where EV is a vector of independent variables, already identified and described in
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17 section III, and ε an i.i.d. and normally distributed error term. The notation for
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19 identifying each independent variable is explained in Table 5, and their descriptive
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21 statistics are shown in Table 6.
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32 << TABLE 5 around here >>

33 << TABLE 6 around here >>

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35 To better account for the heterogeneity across sectors, the regressions draw on panel
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37 Tobit random effect²⁹, where the error term takes the form:
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$$42 \quad \varepsilon_{ij} = \nu_i + \mu_{ij} \quad [2]$$

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52 ²⁷ The range of the variable in the sample is between 0.0000 and 1.8037.

53 ²⁸ To control for sample selection we also considered a Tobit II estimate (Amemiya, 1984) achieving
54 comparable results. Estimation can be obtained by the authors upon request.

55 ²⁹ A standard Tobit fixed effect model would be inconsistent, since the fixed effects cannot be treated
56 as incidental parameters in non-linear models without biasing the other model coefficients
57 (Wooldridge, 2002).
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4 where ν is an unobservable individual effect including a random term with $\sim N(0, \sigma^2)$,
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7 and μ is an independent random disturbance term assuming normal distribution \sim
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10 $N(0, \sigma^2)$.

11 We estimate these models using maximum likelihood methods, assuming robust
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14 standard errors³⁰.

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16 The results of the regression described in [1] are displayed in Table 7: the first
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19 column summarizes the estimation results of Tobit model and the second the
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22 estimation results of random-effects Tobit model³¹. According to the likelihood ratio
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25 tests, the random-effects Tobit estimates are more reliable than the standard Tobit
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28 estimates. Thus the following comments are based on the random-effects Tobit
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31 estimates.

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<< TABLE 7 around here >>

34 Altogether, the results of the empirical analysis seem to confirm the relevance of the
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37 factors, outlined in section III, for the explanation of adaptation costs in the
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40 procurement of public works.

41 Complexity, as measured by the different variables used in our analysis, is a
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44 significant factor in the explanation of adaptation costs. As expected, higher levels of
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47 complexity increase adaptation costs, for the plausible reason that they may be
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50 associated to greater uncertainty and to a higher likelihood of negligent or

54 ³⁰ For panel Tobit with random effects, we use bootstrap with 50 interactions (Cameron and Trivedi,
55 2005).

56 ³¹ We employ this model because of the bias in standard Tobit estimates if an unobservable sector
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60 effect is included.

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4 unavoidable deficiencies in the original design, thus raising the need for
5 renegotiation, in the presence of contractual incompleteness.
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9 The existence of legal disputes is associated to higher adaptation costs. Reminding
10 the cautious comments on the interpretation of this variable, as expressed in section
11 III, this result may be also representative of the fact that some of the adaptation costs
12 are originated by problems with the design of the project. The involvement of the
13 firm in the project design seems to increase the adaptation costs and, therefore, there
14 is no positive effect in the sharing of information and knowledge between the firm
15 and the contracting authority. At least, it is more than compensated by the potential
16 negative impact (in terms of increasing adaptation costs) of the reduction of the
17 conflict of interest between the project designer and the firm. The existence of sub
18 contractors seems to have no significant effect on adaptation costs.
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33 As far as the relevance of political incentives is concerned, our analysis shows that all
34 the models of governance different from central government (with the exception of
35 local governments) have a significant effect on adaptation costs, more precisely they
36 tend to be associated to lower adaptation costs. Strangely enough, the effect is
37 stronger for public enterprises than for private companies. This implies that the nature
38 of this effect needs further investigation.
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47 With respect to the relevance of the opportunistic behaviour of the firm, as connected
48 with some features of the awarding procedure, the results show that higher adaptation
49 costs tend to be associated with auctions as well as underbidding. The results are
50 robust, since both variables used in the analysis (the dummy for open tendering
51 procedures and the ratio between the winning bid and the estimated total value) are
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4 significant, with the expected sign. The variables controlling for market conditions do
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6 not play a significant role. The number of potential bidders and the number of
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8 contracts awarded to the winning bidder are not always significant, and when they are
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10 so, the size of their effect is negligible. It needs to be stressed that these results do not
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12 imply any conclusive judgment on the overall efficiency of the different procurement
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14 procedures, since it is not possible to conclude which procedure produces the best
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16 outcome for the contracting authority, in terms of minimization of the total cost of
17
18 construction. However, it makes clear that this outcome may not be completely
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20 guaranteed by the competitiveness of the award procedure, but it is also related to the
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22 monitoring in the works' implementation stage. Moreover, even if, in principle, there
23
24 are rules, in the Italian law, that should prevent the opportunistic behaviour of firms,
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26 excluding the "too" low or "too" high bids, they seem to be not so much effective in
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28 terms of preventing renegotiations³².
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35 Furthermore, higher levels of corruption, as measured by the indicator proposed by
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37 Golden and Picci (2005) are associated to higher adaptation costs.
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39 Finally, the relative delay in the completion of the work exerts a positive and
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41 significant effect on the adaptation costs.
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46 47 *Robustness checks*

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55 ³² A system for evaluating the bids, based on the notion of standard costs, might be more effective in
56 preventing underbidding because it might reduce the asymmetrical information of the contracting
57 authority.
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4 In order to check for the robustness of our findings, we performed a number of
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6 alternative tests that we thought to be relevant.
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9 To test the marginal effect of each variable included in the general specification, a
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11 separate regression is carried out for each additional regressor, controlling for year of
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13 award, through dummies for each year (2000, 2001, 2002, 2003 and 2004), and for
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15 sectors, with panel Tobit random effect³³.
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19 Our estimates show that the sign and the significance of the coefficients of our
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21 variables are not affected by changes in the specification of the model³⁴.
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25 Similar results are also obtained when the model is estimated on two sub-samples:
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27 one with roads and highways only, which represent almost a third of all our
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29 observations, and the other one with the remaining works. With respect to the latter
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31 sub-sample, according to the likelihood ratio tests, the random-effects Tobit estimates
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33 are more reliable than the standard Tobit estimates³⁵. The results we get, when we
34
35 estimate the model in this sub-sample, made of 6,667 observations for 15 sectors, are
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37 substantially identical to the ones for the entire sample. The only exceptions are the
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39 coefficient for the variable *L_GOV*, which is still negative but significant, the one for
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41 the variable *OPEN*, which is not significant, and, finally, the estimate for the Golden
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43 and Picci (2005) index, which is not significant too. This latter result is not
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45 surprising, since the index is computed on the infrastructure endowment, at the
46
47 provincial level. The estimates relative to the road and highways sub-sample are also
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53 ³³ Table A.2 in the appendix

54 ³⁴ The only exception is the coefficient of the variable *INT*, which has a negative and significant
55 effect, differently from the general model. The reason is probably the very modest value of the
56 coefficient.

57 ³⁵ Table A.3 in the appendix.
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4 consistent with the results for the entire sample, even if there are differences in the
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6 significance of the coefficients of some variables³⁶.
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10 These further tests allow for some other comments. First of all, the factors that may
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12 affect adaptation costs can be differentiated, in terms of their impact, across the
13
14 different sectors. At the sector level, moreover, a particular relevance is attributable to
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16 the type of contracting authorities and to the structure of the market which might have
17
18 different degrees of specialization. The main implication is that should the analysis on
19
20 adaptation costs be carried out at the sector level, it must take into account these
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22 specific factors.
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26 Secondly, our analysis shows that there are some factors, whose impact is pervasive
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28 across the different sectors. This is particularly true for the variable measuring the
29
30 impact of underbidding and for the variable representing the relative delay. This latter
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32 effect is not surprising since in the Italian public works market delays in the
33
34 completion of the public works are relevant and widespread across all the works³⁷.
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39 **V. Concluding remarks**

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42 The focus of this paper is on the determinants of adaptation costs in the Italian public
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44 works market. The main findings of the literature have been discussed and the relevant
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46 factors behind adaptation costs, as emerging in such a literature, have been
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48 investigated and tested using an extensive data base of Italian public works.
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56 ³⁶ Table A.4 in the appendix.

57 ³⁷ See footnote 14 in section II:
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4 Our results suggest that the main drivers of adaptation costs, as recognized in the
5 literature, seem to be relevant also to explain this phenomenon in the Italian public
6 works market.
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11 Complexity is a significant factor in the explanation of adaptation costs. Unlike other
12 studies in the field, however, in our analysis the size of the work, as a measure of
13 complexity, is not a significant factor while the complexity effect is better captured
14 by the expected duration and by the weighted composition index of the work.
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21 As far as political incentives are concerned, our analysis shows that all the models of
22 governance different from central government (with the exception of local
23 governments) tend to be associated to lower adaptation costs.
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29 The opportunistic behaviour of the firm is confirmed as very relevant determinant of
30 adaptation costs, both in terms of the type of procurement procedure adopted and of
31 underbidding. The results are robust and hold also when the analysis is carried out
32 taking into account the sector effects.
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39 Summing up, our analysis far from being conclusive on the determinants of
40 adaptation costs in the Italian public works market offers, however, some tentative
41 policy implications. The fact that the opportunistic behaviour of the firm turns out as
42 a very relevant driver would suggest to enhance the role of reputation in the awarding
43 of the contract. This may counterbalance the “compensation” role that renegotiation
44 can assume, as a way to recover the “losses” from underbidding in competitive
45 procedures. In this case, however, great attention should be paid to the design of
46 proper incentive schemes for the contracting authority.
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TABLES AND FIGURES

Table 1 – Public works awarded and completed between 2000 and 2005 – public works over 150,000 euros (value at current prices)

Years	Public works awarded			Public works completed				
	Number	Total amount (million euros)	Average amount (euros)	Number	% of public works awarded	Total amount (million euros)	% of total amount of public works awarded	Average amount (euros)
2000	15,829	13,874	876,470	7,183	45.38	3,911	28.19	544,535
2001	18,550	14,297	770,726	7,734	41.69	3,833	26.81	495,617
2002	19,822	16,472	831,014	6,426	32.42	2,763	16.78	430,010
2003	18,709	16,983	907,723	4,355	23.28	1,644	9.68	377,527
2004	16,899	18,677	1,105,192	1,686	9.98	546	2.92	323,952
2005	11,780	14,349	1,218,067	145	1.23	37	0.26	257,066
Total	101,589	94,651	931,706	27,529	27.10	12,735	13.46	462,615

Source: Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture (2007)

Table 2 – Distribution and summary statistics of contracts by year of award – public works above 150,000 euros (value at current prices)

Year	Number of obs.	Total amount (million euros)	Mean (euros)	St. Dev. (euros)	Maximum amount (euros)	Minimum amount (euros)
2000	2,344	1,083	462,170	508,013	4,482,703	150,024
2001	3,117	1,246	399,754	417,029	4,815,961	150,047
2002	2,511	979	389,710	384,392	4,965,733	150,000
2003	1,485	524	353,077	314,363	4,340,000	150,000
2004	431	138	319,792	264,867	3,212,078	150,000
Total	9,888	3,970	401,504	415,902	4,965,733	150,000

Source: our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture

Table 3– Composition of the sample by sector – public works above 150,000 euros (value at current prices)

Sector	Number of obs.	Total Amount (million euros)	Mean (euros)	St. Dev. (euros)	Maximum amount (euros)	Minimum amount (euros)
Roads and highways	3,221	1,189	369,163	365,879	4,760,063	150,000
Railways	63	33	527,551	459,139	2,263,251	153,100
Other transport infrastructures	153	88	574,308	618,239	4,214,288	151,000
Works of protection of the environment, of defence of the soil, water resources.	1,313	535	407,720	407,657	4,482,703	150,001
Urbanization works	738	302	408,776	446,595	4,965,733	150,055
Infrastructures of the energy sector	57	24	428,221	382,748	2,325,757	151,910
Telecommunications and data processing technologies	36	11	303,896	169,394	791,551	157,089
Infrastructures for the agriculture and the fishing sector	73	31	426,938	519,342	4,389,133	153,702
Infrastructures for industrial activities, commerce and handicrafts sector	150	83	554,142	578,835	3,293,275	156,204
Social and school building	1,248	514	411,800	409,399	4,597,925	150,000
House building	275	143	518,765	547,303	4,374,389	150,000
Cultural Heritage	456	166	364,678	302,000	2,685,411	150,997
Infrastructures for sport, show and tourism	453	170	374,526	385,980	4,564,473	150,097
Building for health care sector	355	150	422,599	397,920	3,253,678	150,237
Other public building	1,125	446	396,001	447,230	4,777,537	150,024
Other transport infrastructures	172	85	495,216	597,161	4,815,961	150,180
Total	9,888	3,970	401,504	415,902	4,965,733	150,000

Source: our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture

Table 4 – Composition of the sample by purchasing authorities – public works above 150,000 euros (value at current prices)

Purchasing authorities	Number of obs.	Mean Amount (euros)	St. Dev. (euros)	Maximum amount (euros)	Minimum amount (euros)
Central government	545	364,155	429,264	4,441,529	150,135
Local government	6,987	376,435	359,715	4,777,537	150,000
Public agencies with special budget autonomy	1,216	509,189	569,304	4,815,961	150,000
Public ownership companies	606	321,276	285,910	3,436,940	150,082
Private concessionaires	534	613,454	636,289	4,965,733	150,024
Total	545	364,155	429,264	4,441,529	150,135

Source: our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture

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60**Table 5 – Description of variables employed**

VARIABLE	DEFINITION
DEPENDENT VARIABLE	
<i>AC</i>	Adaptation costs
INDEPENDENT VARIABLES	
<i>Complexity of works</i>	
<i>ED</i>	Expected duration
<i>ETV</i>	Estimated total value (thousand euros)
<i>WCI</i>	Weighted public work composition index
<i>DIS</i>	Dummy for legal disputes
<i>PROJ</i>	Dummy for contracts including the final project design
<i>SUB</i>	Dummy for subcontracting
<i>Political incentives</i>	
<i>C_GOV</i>	Central Government
<i>L_GOV</i>	Sub-Central Governments
<i>INST</i>	Institutions
<i>P_ENT</i>	Public Enterprises
<i>PRIV_COM</i>	Private Companies
<i>Opportunistic behavior</i>	
<i>OPEN</i>	Dummy for auctions
<i>R_WBID_ETV</i>	Ratio between the winning bid and the estimated total value
<i>P_BID</i>	Number of firms qualified for the work category and value
<i>LEAD</i>	Number of contracts awarded to a firm in the market
<i>INT</i>	Number of contracts awarded to a firm by the same contracting authority
<i>Corruption</i>	
<i>G&P_INDEX</i>	Golden and Picci (2005) infrastructure corruption index at provincial level
<i>Other covariates</i>	
<i>EX_T</i>	Ratio between actual duration and estimated duration
<i>YEAR_AWARD</i>	Dummies for: 2000, 2001, 2002, 2003, 2004

Table 6 - Summary statistics of variables employed

Variable	Number of obs.	Mean	St. Dev.	Minimum	Maximum
DEPENDENT VARIABLE					
<i>AC</i>	9,888	0.09	0.14	0.00	1.80
INDEPENDENT VARIABLES					
<i>Complexity of works</i>					
<i>ED</i>	9,888	212.96	139.24	3.00	1,327.00
<i>ETV</i>	9,888	401.50	415.92	150.00	4,965.73
<i>WCI</i>	9,888	1.24	0.44	0.00	3.93
<i>DIS</i>	9,888	0.02	0.14	0.00	1.00
<i>PROJ</i>	9,888	0.20	0.40	0.00	1.00
<i>SUB</i>	9,888	0.78	0.42	0.00	1.00
<i>Political incentives</i>					
<i>C_GOV</i>	9,888	0.06	0.23	0.00	1.00
<i>L_GOV</i>	9,888	0.71	0.46	0.00	1.00
<i>INST</i>	9,888	0.12	0.33	0.00	1.00
<i>P_ENT</i>	9,888	0.06	0.24	0.00	1.00
<i>PRIV_COM</i>	9,888	0.05	0.23	0.00	1.00
<i>Opportunistic behavior</i>					
<i>OPEN</i>	9,888	0.81	0.39	0.00	1.00
<i>R_WBID_ETV</i>	9,888	0.87	0.09	0.43	1.00
<i>P_BID</i>	9,888	2,249.49	1,396.36	1.00	5,707.00
<i>LEAD</i>	9,888	17.88	37.91	1.00	436.00
<i>INT</i>	9,888	2.42	3.38	1.00	60.00
<i>Corruption</i>					
<i>GP_INDEX</i>	9,888	1.15	1.02	0.41	6.44
<i>Other covariates</i>					
<i>EX_T</i>	9,888	1.77	1.91	0.01	128
<i>D_2000</i>	9,888	0.24	0.43	0.00	1.00
<i>D_2001</i>	9,888	0.32	0.46	0.00	1.00
<i>D_2002</i>	9,888	0.25	0.44	0.00	1.00
<i>D_2003</i>	9,888	0.15	0.36	0.00	1.00
<i>D_2004</i>	9,888	0.04	0.20	0.00	1.00

Source: our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture and Golden and Picci (2005)

Table 7 – Tobit estimation results for adaptation costs

INDEPENDENT VARIABLE: AC (ADAPTATION COSTS)		
DATA SAMPLE: UNBALANCED PANEL OF 9,888 OBSERVATIONS, RELATIVE TO 16 SECTORS		
Explanatory variable	Tobit	Tobit random effects (1)
<i>CONSTANT</i>	0.451*** (0.023)	0.456*** (0.024)
<i>Complexity of works</i>		
<i>ED</i>	0.000*** (0.000)	0.000*** (0.000)
<i>ETV</i>	0.000 (0.000)	0.000 (0.000)
<i>WCI</i>	0.018*** (0.004)	0.016*** (0.004)
<i>DIS</i>	0.031** (0.012)	0.030** (0.012)
<i>PROJ</i>	0.012*** (0.004)	0.012*** (0.004)
<i>SUB</i>	0.003 (0.004)	0.003 (0.004)
<i>Political incentives</i>		
<i>L_GOV</i>	-0.001 (0.009)	-0.000 (0.010)
<i>INST</i>	-0.024*** (0.007)	-0.019** (0.008)
<i>P_ENT</i>	-0.097*** (0.010)	-0.093*** (0.011)
<i>PRIV_COM</i>	-0.032*** (0.010)	-0.025** (0.011)
<i>Opportunistic behaviour</i>		
<i>OPEN</i>	0.011** (0.005)	0.010** (0.005)
<i>R_WBID_ETV</i>	-0.490*** (0.021)	-0.494*** (0.022)
<i>P_BID</i>	0.000* (0.000)	0.000* (0.000)
<i>LEAD</i>	0.000** (0.000)	0.000** (0.000)
<i>INT</i>	0.000 (0.001)	0.000 (0.001)
<i>Corruption</i>		
<i>GP_INDEX</i>	0.004** (0.002)	0.004* (0.002)
<i>Other covariates</i>		
<i>EX_T</i>	0.006*** (0.001)	0.006*** (0.001)
<i>Controlling for year of award</i>	yes	Yes
<i>Controlling for sector</i>	pooling	Yes
<i>Observations</i>	9,888	9,888
<i>Uncensored</i>	7,571	7,571
<i>Number of sectors</i>	16	16
<i>Rho</i>	--	0.01418
<i>Pseudo R²</i>	0.7611	--
<i>Log likelihood</i>	1237.523	1292.209
<i>LR χ^2</i>	$\chi^2 (21) = 1232.78***$	--
<i>Wald</i>	--	$\chi^2 (21) = 1049.51***$
<i>(2) LR test (p-value)</i>	--	0.0000

Notes: (1) Bootstrap standard errors are reported in parentheses. (2) The LR test is used to compare the Tobit and random-effects Tobit models. Robust standard errors are reported in parentheses

***, ** and * denote significance at 1, 5 and 10 per cent levels, respectively

Appendix

Table A.1 - Correlation between independent variables

	OPEN	R_WBID_ETV	SUB	PROJ	EX_T	DIS	ETV	WCI	ED	INT	P_BID	LEAD	C_GOV	L_GOV	INST	P_ENT	PRIV_COM	GP_INDEX
OPEN	1.000																	
R_WBID_ETV	-0.278	1.000																
SUB	0.134	0.148	1.000															
PROJ	-0.028	-0.015	-0.030	1.000														
EX_T	-0.014	0.038	0.006	-0.044	1.000													
DIS	0.034	-0.033	0.021	-0.033	0.009	1.000												
ETV	0.106	-0.082	0.107	-0.028	-0.020	0.111	1.000											
WCI	0.013	0.087	0.125	-0.033	-0.006	0.046	0.161	1.000										
ED	0.139	-0.080	0.063	0.034	-0.186	0.050	0.386	0.114	1.000									
INT	-0.134	0.032	-0.012	0.158	-0.048	-0.024	0.046	-0.026	-0.028	1.000								
P_BID	0.157	0.074	0.069	-0.028	-0.009	-0.012	-0.062	0.096	0.066	-0.050	1.000							
LEAD	-0.005	0.100	0.087	0.015	-0.019	0.000	0.129	0.048	0.036	0.208	-0.010	1.000						
C_GOV	-0.122	-0.004	-0.083	0.140	-0.059	-0.008	-0.022	-0.058	0.037	-0.016	-0.097	-0.036	1.000					
L_GOV	0.076	0.049	0.063	-0.181	0.070	-0.010	-0.094	-0.015	-0.039	-0.084	0.105	-0.007	-0.375	1.000				
INST	-0.001	0.029	0.036	-0.003	-0.003	-0.009	0.097	0.071	0.139	-0.071	0.029	0.006	-0.090	-0.581	1.000			
P_ENT	-0.006	-0.143	-0.106	0.172	-0.057	0.017	-0.049	-0.032	-0.183	0.251	-0.084	-0.013	-0.062	-0.397	-0.096	1.000		
PRIV_COM	-0.021	0.015	0.018	0.044	-0.017	0.023	0.122	0.020	0.032	0.022	-0.067	0.056	-0.058	-0.371	-0.090	-0.061	1.000	
GP_INDEX	0.062	-0.377	-0.232	0.037	-0.040	0.010	0.035	-0.028	0.090	-0.038	0.000	-0.095	0.114	-0.096	0.031	0.028	0.004	1.000

Table A.2 - Tobit estimation results for adaptation costs

INDEPENDENT VARIABLE: AC (ADAPTATION COSTS)
 DATA SAMPLE: UNBALANCED PANEL OF 9,888 OBSERVATIONS RELATIVE TO 16 SECTORS

Explanatory variables	Tobit random effects (1)													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) #	(9)	(10)	(11)	(12)	(13)	(14)
CONSTANT	0.043*** (0.010)	0.069*** (0.010)	0.066*** (0.011)	0.081*** (0.010)	0.079*** (0.010)	0.086*** (0.011)	0.077*** (0.010)	0.100*** (0.013)	0.057*** (0.011)	0.495*** (0.020)	0.084*** (0.010)	0.078*** (0.011)	0.081*** (0.010)	0.080*** (0.011)
<i>Complexity of work</i>														
ED	0.000*** (0.000)	--	--	--	--	--	--	--	--	--	--	--	--	--
ETV	--	0.000*** (0.000)	--	--	--	--	--	--	--	--	--	--	--	--
WCI	--	--	0.013*** (0.004)	--	--	--	--	--	--	--	--	--	--	--
DIS	--	--	--	0.047*** (0.013)	--	--	--	--	--	--	--	--	--	--
PROJ	--	--	--	--	0.009** (0.005)	--	--	--	--	--	--	--	--	--
SUB	--	--	--	--	--	0.007* (0.004)	--	--	--	--	--	--	--	--
<i>Political incentives</i>														
L_GOV	--	--	--	--	--	--	-0.001 (0.010)	--	--	--	--	--	--	--
INST	--	--	--	--	--	--	-0.024*** (0.008)	--	--	--	--	--	--	--
P_ENT	--	--	--	--	--	--	-0.087*** (0.011)	--	--	--	--	--	--	--
PRIV_COM	--	--	--	--	--	--	-0.024** (0.011)	--	--	--	--	--	--	--
<i>Opportunistic behaviour</i>														
OPEN	--	--	--	--	--	--	--	0.031*** (0.005)	--	--	--	--	--	--
R_WBID_ETV	--	--	--	--	--	--	--	--	-0.479*** (0.020)	--	--	--	--	--
P_BID	--	--	--	--	--	--	--	--	--	0.000* (0.000)	--	--	--	--
LEAD	--	--	--	--	--	--	--	--	--	--	0.000* (0.000)	--	--	--
INT	--	--	--	--	--	--	--	--	--	--	--	-0.001** (0.001)	--	--
<i>Corruption</i>														
GP_INDEX	--	--	--	--	--	--	--	--	--	--	--	--	0.020*** (0.002)	--
<i>Other covariates</i>														
EX_T	--	--	--	--	--	--	--	--	--	--	--	--	--	0.003*** (0.001)
<i>Controlling for year of award</i>	yes	yes	yes	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes	Yes
<i>Controlling for sector</i>	yes	yes	yes	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes	Yes
<i>Observations</i>	9,888	9,888	9,888	9,888	9,888	9,888	9,888	9,888	9,888	9,888	9,888	9,888	9,888	9,888
<i>Uncensored</i>	7,571	7,571	7,571	7,571	7,571	7,571	7,571	7,571	7,571	7,571	7,571	7,571	7,571	7,571
<i>Number of sector</i>	16	16	16	16	16	16	16	16	16	16	16	16	16	16
<i>Log likelihood</i>	869.8914	770.3344	739.5762	741.5705	736.63889	735.69725	781.0727	757.3792	1022.4845	737.2951	736.1421	737.1671	802.8068	741.9462
<i>Wald</i>	$\chi^2(5)=279.32***$	$\chi^2(5)=77.05***$	$\chi^2(5)=15.35***$	$\chi^2(5)=19.36***$	$\chi^2(5)=9.48*$	$\chi^2(5)=8.96*$	$\chi^2(8)=98.48***$	$\chi^2(5)=50.90***$	$\chi^2(5)=595.82***$	$\chi^2(5)=9.78*$	$\chi^2(5)=7.37*$	$\chi^2(5)=10.52*$	$\chi^2(5)=143.31***$	$\chi^2(5)=20.12***$

(1) Bootstrap standard errors in parentheses
 * significant at 10%; ** significant at 5%; *** significant at 1%
 # The coefficients of the variables representing the different governance structures are estimated with respect to C_GOV

Table A.3 - Tobit estimation results for adaptation costs (excluding roads and highways)

INDEPENDENT VARIABLE: AC (ADAPTATION COSTS)		
DATA SAMPLE: 6,667 OBSERVATIONS RELATIVE TO 15 SECTORS EXCLUDING "ROADS AND HIGHWAYS"		
Explanatory variable	Tobit	Tobit random effects (1)
<i>CONSTANT</i>	0.450*** (0.029)	0.452*** (0.031)
<i>Complexity of works</i>		
<i>ED</i>	0.000*** (0.000)	0.000*** (0.000)
<i>ETV</i>	0.000 (0.000)	0.000 (0.000)
<i>WCI</i>	0.013*** (0.003)	0.013*** (0.004)
<i>DIS</i>	0.033** (0.013)	0.033** (0.014)
<i>PROJ</i>	0.012** (0.005)	0.013** (0.006)
<i>SUB</i>	0.000 (0.005)	0.000 (0.005)
<i>Political incentives</i>		
<i>L_GOV</i>	-0.021*** (0.008)	-0.017** (0.009)
<i>INST</i>	-0.000 (0.009)	0.000 (0.011)
<i>P_ENT</i>	-0.085*** (0.014)	-0.086*** (0.015)
<i>PRIV_COM</i>	-0.041*** (0.012)	-0.035*** (0.012)
<i>Opportunistic behaviour</i>		
<i>OPEN</i>	-0.007 (0.006)	-0.006 (0.006)
<i>R_WBID_ETV</i>	-0.475*** (0.028)	-0.477*** (0.029)
<i>P_BID</i>	0.000* (0.000)	0.000* (0.000)
<i>LEAD</i>	0.000** (0.000)	0.000** (0.000)
<i>INT</i>	-0.000 (0.001)	-0.000 (0.001)
<i>Corruption</i>		
<i>GP_INDEX</i>	0.001 (0.002)	0.001 (0.002)
<i>Other covariates</i>		
<i>EX_T</i>	0.005*** (0.001)	0.005*** (0.001)
<i>Controlling for year of award</i>	yes	Yes
<i>Controlling for sector</i>	pooling	Yes
<i>Observations</i>	6,667	6,667
<i>Uncensored</i>	5,249	5,249
<i>Number of sector</i>	15	15
<i>Rho</i>	--	0.01035
<i>Pseudo R²</i>	0.4867	--
<i>Log likelihood</i>	946.9754	939.57
<i>LR χ^2</i>	$\chi^2(21)= 620.00$ ***	--
<i>Wald</i>	--	586.74***
<i>(2) LR test (p-value)</i>	--	0.0000

Notes: (1) Bootstrap standard errors are reported in parentheses. (2) The LR test is used to compare the Tobit and random-effects Tobit models. Robust standard errors are reported in parentheses

***, ** and * denote significance at 1, 5 and 10 per cent levels, respectively.

Table A.4 - Tobit estimation results for adaptation costs (roads and highways only)

INDEPENDENT VARIABLE: AC (ADAPTATION COSTS) DATA SAMPLE: 3,221 OBSERVATIONS RELATIVE TO "ROADS AND HIGHWAYS" ONLY	
Explanatory variable	Tobit
<i>CONSTANT</i>	0.483*** (0.056)
<i>Complexity of works</i>	
<i>ED</i>	0.000*** (0.000)
<i>ETV</i>	-0.000 (0.000)
<i>WCI</i>	0.027*** (0.008)
<i>DIS</i>	0.023 (0.022)
<i>PROJ</i>	0.011 (0.008)
<i>SUB</i>	0.010 (0.007)
<i>Political incentives</i>	
<i>L_GOV</i>	-0.062 (0.041)
<i>INST</i>	-0.036 (0.046)
<i>P_ENT</i>	-0.134*** (0.042)
<i>PRIV_COM</i>	-0.046 (0.042)
<i>Opportunistic behaviour</i>	
<i>OPEN</i>	0.019** (0.009)
<i>R_WBID_ETV</i>	-0.525*** (0.037)
<i>P_BID</i>	0.000 (0.000)
<i>LEAD</i>	0.000 (0.000)
<i>INT</i>	0.001 (0.001)
<i>Corruption</i>	
<i>GP_INDEX</i>	0.011*** (0.004)
<i>Other covariates</i>	
<i>EX_T</i>	0.012*** (0.002)
<i>Controlling for year of award</i>	Yes
<i>Sector</i>	Only Roads and highways
<i>Observations</i>	3,221
<i>Uncensored</i>	2,322
<i>Number of sector</i>	1
<i>Pseudo R²</i>	0.1896
<i>LR χ^2</i>	$\chi^2 (21) = 448.25***$
<i>Log likelihood</i>	304,7079

Robust standard errors are reported in parentheses

***, ** and * denote significance at 1, 5 and 10 per cent levels, respectively.