Innovation induced by public procurement: A firm-level analysis for Italy and Norway

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19 October 2018

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Abstract

In this paper, we focus on public procurement for innovation. We provide a broad characterisation of the firms involved in "innovative public procurement" as opposed to firms participating in "regular" (i.e. non innovative) public procurement, including those firms that perform innovation in an autonomous way (i.e. not related to public procurement). Moreover, we identify the main determinants of the firms' propensity to innovate, when innovative activities are related to a public procurement contract. We carry out this study by using micro-data from two Community Innovation Surveys for Italian and Norwegian firms, which have released information on firms having public procurement contracts. Our main findings highlight important differences between firms engaged in regular or innovative public procurement, in particular regarding the role of firm size and sectors, the presence of in-house R&D activities and the educational level of employees.

JEL classification: O31, O33, O38, H57

Key words: public procurement, firms' innovation, Italy, Norway

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1. Introduction

Public procurement is the purchase of goods and services by governments and state-owned companies. During the last fifteen years, both at the European and national levels, public procurement has been intensely revitalised as a demand-side policy instrument to foster innovation.

Such a renewed attention can be found in many documents and initiatives of the European Commission. Among other reports, we can recall the guide on public procurement as a driver of innovation in Small and Medium-sized Enterprises (SMEs) and in public services (European Commission, 2014). Furthermore, relevant EC initiatives have been directed to closely monitoring national policy frameworks and spending on innovation procurement across Europe, as well as to quantifying its impact compared to other procurement approaches (cf. EC, 2016a). Finally, increasing evidence that public procurement for innovation is still underexploited, especially in supporting innovative start-ups and SMEs, has led the Commission to express the need for a new guidance document (EC, 2016b). Then, on May 2018 the Commission has published a "Guidance on innovation procurement" to encourage public buyers of goods and services to use public procurement as a means to stimulate innovations (EC, 2018).

The growing interest in the use of public procurement as innovation policy tool is mainly due the fact that supply-side innovation policies (such as R&D public subsidies and tax incentives) are deemed to be insufficient to meet the current challenges in promoting competitiveness (Edler and Georghiou, 2007), also because of increasing budgetary constraints.

As stressed by Appelt and Galindo-Rueda (2016, p. 6), in spite of the increasing policy interest, "there is very limited statistical evidence on the link between public procurement and innovation". In the early 2000s, the empirical literature on public procurement for innovation was rather fragmented and mostly limited to case studies (e.g. Edquist et al., 2000; Edler et al., 2005). Only recently, some studies based on sound statistical and/or econometric evidence have been published (Aschhoff and Sofka, 2009; Slavtchev and Wiederhold, 2011; Guerzoni and Raiteri, 2014; Ghisetti, 2017; Florio et al., 2018).

In this paper, we carry out a micro-econometric analysis with the aim of contributing to this relatively under-researched topic: first, by providing a broad characterisation of the firms involved in "innovative public procurement" (IPP, henceforth), as opposed to firms participating in "usual" (i.e. non innovative) public procurement (PP), including those that perform innovation in an autonomous way (i.e. not related to PP contracts)*;* then, by identifying the main determinants of the firms' propensity to innovate, when innovative activities are related to a PP contract.

As already mentioned, there are some studies on IPP based on quantitative analysis, most of them aimed at examining the contribution of PP to firms' innovation success in terms of increased

innovation inputs and outputs. By far less attention has been paid to the question of what strategies or firms' characteristics increase the probability that firms will introduce innovations as part of a public procurement contract.

We carry out this study by using micro-data from two Community Innovation Surveys for Italian and Norwegian firms, which have released information on firms having public procurement contracts. In the appendix we also consider the case of Portugal for which, due to the low number of firms with IPP, it is unlikely that an analysis similar to that done for the former countries will give rise to equally reliable results.

As for Italy, the dataset has been provided by the Italian National Institute of Statistics (ISTAT) and it is concerned with the year 2012. With regard to Norway, the analysis is based on most recent micro-data provided by Eurostat, which refer to 2014[2]. Therefore, another original aspect of this study is that, by comparing Italy and Norway, we examine whether the key determinants of firms' innovation induced by PP are the same or not in two very different institutional and economic context.

Starting from Italy, it is well known the "bias" of the industrial system towards SMEs, which mainly operate in traditional, low-skilled and non R&D-intensive sectors. In addition, the Italian research and innovation system scores low on several specific aspects relevant to foster R&D and innovation, such as the share of public and private R&D investments, the endowment and employment of highly-skilled human resources and the cooperation between academia and business.

In Norway, the manufacturing sector, traditionally characterised by a predominance of small firms and industries involved in the basic processing of raw materials, has experienced, since the late 1970s, significant structural changes brought, on the one hand, by the development of the oil, gas and service industries, on the other, by the substantial decline of many labour-intensive industries. Moreover, the Norwegian national innovation system is characterised by high R&D expenditures and developed public and private research infrastructures.

Interestingly enough, the main features of the current Italian model of public procurement dates back to 2000. With the Dlgs. 50/2016, Italy has continued the reform of public procurement in line with the 2014 European directives (23/EU, 24/EU and 25/EU). Norway's original legislation

[2] Eurostat provided us with a CD-ROM containing micro-data from CIS 2014 only for some European countries (Italy excluded). Among the North European countries that could be opposed to Italy, only for Norway we found a complete and consistent set of information related to PP and IPP. Although the Italian and Norwegian micro-data do not refer to the same year, we are not too worried about the meaningfulness of our comparison. Indeed, it is likely that the structural and behavioural characteristics of the firms with PP contracts did not change very much from 2012 to 2014: first, because the two years are very close; secondly, because PP is usually based on multi-year contracts.

implementing public procurement has been in force since 1994. However, the Norwegian legislation on public procurement is now, to a large extent, also based on the EU 2014 directives, in accordance with Norway's obligations under the European Economic Area (EEA) Agreement. These new directives have been implemented during 2016, and have thus entered into force on 1st January 2017.

2. Innovation induced by public procurement

2.1 Conceptual framework

In its most general definition, IPP occurs when "a public agency places an order for a product or a system which does not exist at the time, but which could probably be developed within a reasonable period" (see Edquist and Hommen, 2000; Edquist and Zabala-Iturriagagoitia, 2012). As such, this is usually opposed to the "usual" or "regular" PP, which takes place when a public body buys goods and services that already exist. A more precise definition is provided by the European Commission which distinguishes between "Pre-commercial Procurement" and "Public Procurement of Innovative Solutions". In the first case, public buyers purchase the R&D services that are likely to give rise to entirely new goods or services. In the second one, instead, "the contracting authorities act as launch customer for innovative goods and services that are not yet available on a large-scale commercial basis" (EC, 2014, p. 12). Hence, the major advantage of IPP lies in a substantial reduction of the market risk for the firms delivering innovative solutions. In the present paper, IPP mainly corresponds to the second definition.

From a theoretical point of view, the discussion on IPP is intrinsically linked with the debate on the role of demand as a driver of innovation. Scholars embracing the demand-pull approach have always emphasized the importance of demand dynamics as a crucial factor influencing both the decision of firms to innovate and the direction of the firms' innovative efforts. The intuition regarding the role of demand for innovation has been sparked by the seminal contribution of Schmookler (1966), who claims that demand conditions crucially influence the desirability and realization of innovations: indeed, the existence of an expected profitability through market expansion represents the key stimulus to which innovative firms actually react. However, since the 1980's, the focus of the innovation literature has shifted in favour of supply-side factors. Only more recently, in particular with the work by Edler and Georghiou (2007), the long debate between the supply-push versus demand-pull sources of innovation has settled for a more balanced view, which sees demand as a complementary factor driving innovation.

According to Guerzoni (2010), this recent wave of studies is characterised by the mixture of two

elements. On the one hand, the extent of the demand, possibly measured by the size of the market, can be considered as a major incentive for firms to invest in R&D, as long as it determines the expected innovation profits. On the other, demand can also be considered as a relevant source of information from users which, by providing producers with more accurate knowledge about the market needs, may substantially contribute to reduce the inherent uncertainty associated with the development of new products.

2.2 Key assumptions

Despite the existing evidence points to the effectiveness of PP in stimulating innovation, such a positive effect cannot be taken for granted. Most importantly for the scope of this study, a number of barriers can prevent firms from even entering the PP market, especially when innovation represents the specific object of the PP contract.

Important barriers can be related, on the one hand, to the firms' awareness of innovation opportunities and their capabilities to seize them and, on the other, to the inherent risk aversion of the public sector (see Uyarra et al., 2014).

Hence, first of all, in comparison with the procurement of already existing goods and services for the lowest possible price, the IPP requires a high degree of firms' in-house competence. It follows that, compared to firms with usual PP contracts, firms dealing with innovations related to PP, especially when innovation is specifically required as part of the contract, are likely to be more active on innovation, namely with internal R&D facilities and a high level of human capital. Furthermore, risk aversion of public agencies might lead to use selection criteria privileging firms with larger size and longer experience or belonging to R&D-intensive industries. Accordingly, it can be assumed that large companies and firms in high-tech industries are more likely to participate in IPP instead of being involved in "regular" PP or introducing innovations in an autonomous way.

Finally, the importance of information coming from sources external to the firms cannot be neglected. First, external knowledge might substantially contribute to increase the general information and awareness of firms about the availability of this particular form of public support and its potential advantages. Second, as already mentioned, external networking, especially with potential public procurers, might be considered as a relevant source of information from potential users, which would contribute to further reduce firms' uncertainty related to the development of new products. Finally, firms with better access to multiple sources of external knowledge should also be in a better position to offer innovative solutions. This should diminish the risk aversion of contracting authorities and create an environment of trust which, in turn, could increase the firms' ability to enter into the IPP market. Therefore, a further hypothesis that can be introduced is that the

more firms are open to frequent interaction with different external actors and sources of knowledge (especially with potential public procurers), the higher the likelihood they will come up with innovations induced by public procurement contracts.

3. Empirical analysis

3.1 Variables and econometric method

By using the CIS micro-data at our disposal, in a first step, we provide a broader characterisation of the Italian and Norwegian firms carrying out innovation within a PP contract compared to firms participating only in usual (i.e. non innovative) PP and to those autonomously performing innovation (i.e. not related to PP contracts). Next, in a second step, we aim at identifying the key determinants of the firms' propensity to innovate when innovative activities are undertaken as part of a PP contract.

Table 1. CIS 2012 and 2014 questionnaires: section on public procurement

10.1 During the three years 2010 to 2012 (or 2012 to 2014) did your enterprise have any procurement contracts to provide goods or services for:	
(a) Domestic public sector organisations (b) Foreign public sector organisations	Firms with PP (innovative or not)
10.2 Did your enterprise undertake any innovation activities as part of a procurement contract to provide goods or services to a public sector organisation?	
- Yes and innovation required as part of the contract - Yes but innovation not required as part of the contract	Firms with innovations related to PP (required and/or not required)
- No	Non innovative firms or firms with innovations not related to PP

Source: adapted from Eurostat.

As Table 1 illustrates, drawing on the firms' answers to the CIS questionnaires, we are able to construct three different indicators. The first one, *Public Procurement*, is a binary indicator equal to 1 if a firm has declared to have any PP contract (i.e. in general, without specifying whether involving innovation or not) with domestic and/or foreign public sector organisations, and 0 otherwise. Then, in order to identify firms carrying out innovation within a PP contract, we have built a second binary indicator, *Innovation related to PP*, equal to 1 if a firm has declared to have undertaken innovation as part of a PP contract (i.e. in general, thus with innovation required and/or not required), and 0 otherwise. Next, a third binary indicator, *Innovation required*, is used to distinguish and keep separated firms developing innovations that are specifically required by PP contracts.

Table 2. Basic descriptive statistics on public procurement and innovation (percentages on total firms in round brackets; percentages on firm with PP in squared brackets).

	Italy (CIS 2012)	Norway (CIS 2014)
Total number of firms	18697	4974
Firms with Public Procurement (PP)	5137 (27.47)	1691 (34.00)
Firms with PP and innovations (both related and not related to PP)	3039 [59.16]	1178 [69.66]
Firms with innovations not related to PP	2205 [42.92]	752 [44.47]
Firms with innovations related to PP (both required and not required by PP)	834 [16.24]	426 [25.19]
Firms with innovations specifically required by PP contracts	499 [9.71]	205 [12.12]

Source: own computations on CIS 2012 Italian and CIS 2014 Norwegian data.

Table 2 shows that Norwegian firms participate in PP more frequently (34%) than firms in Italy (27.5%). Moreover, firms with PP in Norway are more innovative than their Italian counterparts. This difference is mainly due to the shares of firms with innovations related to PP (25% in Norway, 16% in Italy). However, in Italy there are relatively more firms with innovations specifically required by PP contracts while the opposite occurs in Norway.

According to a recent OECD study (Appelt and Galindo-Rueda, 2016) mostly based on CIS data (at least for European countries), between 9% and 34% of firms operating in countries for which data are available have delivered goods or services to public authorities during the three-year period of reference 2010-2012. Not surprisingly, public procurement turns out to be more common in large firms than in SMEs.

Table 3. Firms involved in public procurement: percentage by size class

	Italy (CIS 2012)			Norway (CIS 2014)		
	SMEs	Large firms	Total	SMEs	Large firms	Total
Percentage of firms with PP (on total firms)	27.06	31.29	27.47	32.86	46.21	34.00
Percentage of firms with innovations related to PP (on firms with PP)	14.01	34.15	16.24	24.53	30.26	25.19

Source: own computations on CIS 2012 Italian and CIS 2014 Norwegian micro-data.
Note: SMEs are firms with less than 250 employees; Large firms are with more than 249 employees.

CIS micro-data for Italy and Norway confirms the aforementioned finding (cf. Table 3). Indeed, as for firms participating in PP, the share is bigger for large firms than for SMEs in both surveys

(accounting for 31% and 46%, respectively). Turning to firms with innovation related to PP, it is interesting to note that, though only for Italy, the share for large firms become even higher (34%).

Table 4. Firms involved in public procurement: number and percentage by industry

	High-tech industry	Low-tech industry	KIBS	Transports	Public utilities	Construction	Trade and other services	Total
Italy (CIS 2012)								
Firms with PP	236	436	740	234	444	1959	1088	5137
Firms with innovations related to PP	73	76	230	39	87	189	140	834
Percentage of firms with PP (on total firms)	20.42	14.16	30.71	17.53	47.54	45.06	20.02	27.47
Percentage of firms with innovations related to PP (on firms with PP)	30.93	17.43	31.08	16.67	19.59	9.65	12.87	16.24
Norway (CIS 2014)								
Firms with PP	122	255	549	93	103	248	321	1691
Firms with innovations related to PP	41	60	195	11	21	39	59	426
Percentage of firms with PP (on total firms)	26.35	20.21	42.46	29.15	44.98	51.35	34.70	34.00
Percentage of firms with innovations related to PP (on firms with PP)	33.61	23.53	35.52	11.83	20.39	15.73	18.38	25.19

Source: own computations on CIS 2012 Italian and CIS 2014 Norwegian micro-data.

Table 4 reports the firms' distribution across seven aggregate sectors. Sectorial aggregations are based on the two-digit NACE (Statistical Classification of Economic Activities). With respect to high- and low-tech industry, we have followed the OECD ISIC Rev. 3 technology intensity definition of manufacturing industries (OECD, 2011). In particular, we have grouped together firms in high and medium-high technology sectors into the unique category of *High-tech industry;* likewise, firms in low- and medium-low technology sectors have been grouped together in *Low-tech industry*. In order to identify firms in knowledge intensive business services (KIBS) and keep them separated from those in other, traditional or less knowledge intensive services, we have referred to the Eurostat classification[3]. The other sectors are Public utilities, Transports, Construction, Trade and other services (which plays the role of reference category)[4].

According to Table 4, firms involved in PP are mostly in construction, public utilities and knowledge intensive business services KIBS, either in Italy or in Norway. As for firms with innovations related to PP, in Italy high-tech industries and KIBS are largely predominant, with a share equal to 31% of firms with PP contracts, whilst in all the other sectors the percentage of firms is much lower (with a partial exception of public utilities). In Norway, firms with innovations

[3] See http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf.
[4] To get more meaningful information from our estimates, we prefer to employ few aggregate sectors rather than a very high number of two-digit industries.

related to PP are also very concentrated in high-tech industries and knowledge intensive business services (34% and 36%, respectively); however, also in low-tech industry and public utilities we can observe a significant presence, since they account for more than 20% of firms with PP contracts.

Moving to the econometric method, our analysis is based upon a Heckman probit model with sample selection. Such a model is composed of two probit equations: an outcome equation for the probability of introducing innovations related to PP (IPP), and a selection equation for the probability of being involved in PP. Formally:

$$IPP_i = 1(\boldsymbol{X}_i'\square + \epsilon_i > 0) \;\; if \; PP_i = 1, \; missing \; otherwise \qquad [1]$$

$$PP_i = 1(\boldsymbol{Z}_i'\alpha + u_i > 0) \qquad [2]$$

where the suffix *i* identifies firms.

Thus, the firm characteristics that increase the PP participation are used to correct the estimation of the probability of being involved in IPP. Despite the parameters of the model are identified even when the same set of regressors enters the selection and outcome equations (i.e. $\boldsymbol{X_i}$ and $\boldsymbol{Z_i}$ include the same variables), to improve identification it is a standard practice to use different covariates in the second equation (selection), which must be unrelated to the innovation probability (outcome). Then, the model can be estimated with Maximum Likelihood (ML) either simultaneously (one-step) or with a two-step procedure.

Among the control variables that are used in both the selection and innovation equations we consider the *Firm size,* measured by the log of turnover recorded in 2012 (for Italian firms) and 2014 (for Norwegian firms), and seven dummy variables accounting for the firms' sectors (see above).

Then, there is a set of variables affecting only the probability to innovate. Among these, we have included two variables routinely used in empirical studies on innovation: *Human capital*, measured by a categorical indicator taking values from 0 to 6 according to the percentage of employees with an university degree[5]; and *R&D performing firms,* which is a dummy variable equal to 1 if a firm has carried out R&D intra-muros. Further regressors account for the use of external knowledge sources: *Cooperation with universities* and *Cooperation with government,* are binary indicators of whether a firm has cooperated with universities and with government or public research institutes; *Overall importance of cooperation*, which should detect the overall importance of external cooperation for innovation (i.e. regardless the type of partner), is equal to 1 if a firm has declared to

[5] The classes are the following: 0 stands for none graduated employee; 1 for less than 5%, 2 for 5 to 9%, 3 for10-24%, 4 for 25-49%, 5 for 50-74% and 6 for 75% and more.

have cooperation linkages with all types of partners among those listed in the CIS[6], 0 otherwise; *Acquisition of external knowledge* indicates whether a firm has invested for the acquisition of external knowledge, thus outside any formal cooperation agreement.

Finally, another set of variables affects only the probability of being involved in PP. *Firms belonging to a group* is a dummy variable which takes value 1 if a firm belongs to an enterprise group, 0 otherwise. *Firms operating in domestic market only* is equal to 1 if a firm has declared to sell its products only in the domestic market, 0 otherwise. *New ways of organising external relations* is also a binary indicator used to identify firms having introduced organisational innovations facilitating their external relations. By capturing the firm attitude and efforts to undertake alliances or collaborations with other enterprises, this variable should exert a positive impact on PP. In fact, especially for SMEs, to participate in public tenders involving big amounts of money and/or different competencies it is necessary to set up a temporary association of companies.

3.2 Results

The following tables report the results of the described econometric analysis for Italy and Norway. Table 5 shows the results of the Heckman probit estimation for the probability of being engaged in IPP, when innovation is related to PP (i.e. regardless of whether it is required or not), conditional on the probability of being included in the sample, namely of being involved in PP. Next, in Table 6, we present the results for the probability of being engaged in IPP, when innovation is specifically required by PP. In both cases, the outcome and selection equations are estimated simultaneously.

Table 5. Heckman probit model with sample selection: one step simultaneous estimation

	ITALY (CIS 2012)		NORWAY (CIS 2014)	
Variables	Innovation related to PP (outcome equation)	PP (selection eq.)	Innovation related to PP (outcome equation)	PP (selection eq.)
Constant	1.2690***	-1.7164***	1.1559**	-1.8469***
	(0.1718)	(0.1115)	(0.4984)	(0.1977)
Firm size (log of turnover)	-0.0421***	0.0492***	-0.0636***	0.0903***
	(0.0089)	(0.0070)	(0.0197)	(0.0121)
High-tech industries	0.0816	-0.0932*	0.2070*	-0.3101***
	(0.0675)	(0.0483)	(0.1140)	(0.0781)
Low-tech industries	0.2215***	-0.2274***	0.3260***	-0.4638***
	(0.0517)	(0.0350)	(0.1036)	(0.0589)

[6] These are: other firms in the same business group, suppliers, clients or costumers (both public and private), competitors, consultants, universities, government and research institutes.

Table 5 (continues)

Knowledge intensive business services	-0.1273**	0.2729***	-0.0501	0.1877***
	(0.0496)	(0.0337)	(0.0893)	(0.0550)
Public utilities	-0.4724***	0.7390***	-0.1593	0.2287**
	(0.0602)	(0.0461)	(0.1209)	(0.0949)
Transports	0.1777***	-0.0867*	-0.0171	-0.1943**
	(0.0627)	(0.0453)	(0.1463)	(0.0854)
Construction	-0.6639***	0.7757***	-0.2893***	0.4566***
	(0.0410)	(0.0285)	(0.0983)	(0.0722)
Cooperation with universities	0.0461		0.2914***	
	(0.0689)		(0.0944)	
Cooperation with government	0.3116***		0.0769	
	(0.0894)		(0.0965)	
Overall importance of cooperation	0.0501		0.0610	
	(0.1710)		(0.1502)	
Acquisition of external knowledge	0.1787***		0.2062***	
	(0.0410)		(0.0697)	
Human capital (ordinal var. 0 to 6)	0.0237***		0.0165	
	(0.0074)		(0.0193)	
R&D performing firms	0.2652***		0.3256***	
	(0.0399)		(0.1007)	
Firms belonging to a group		0.0449**		-0.0056
		(0.0195)		(0.0406)
Firms operating in domestic market only		0.0308		-0.0673*
		(0.0197)		(0.0351)
New ways of organising external relations		0.4290***		0.2818***
		(0.0296)		(0.0571)
Wald test of independent equations (rho=0)	133.02***		10.47***	
athrho	-1.8133***		-1.4522***	
Observations	18,697		4,974	
Censored obs. (firms without PP contracts)	13,560		3,283	
Uncensored obs. (firms with PP contracts)	5,137		1,691	

Robust standard errors in brackets. Trade and other services, among industry dummies, used as reference category. *** p<0.01, ** p<0.05, * p<0.10

First of all, as the bottom lines of the tables show, the hypothesis of independent equations is refused by the Wald test, which confirms that, in both estimations, the outcome and the selection equations should not be estimated separately. Moreover, the negative and significant athrho (i.e. the negative correlation of the residuals of equations 1 and 2) suggests that there are some un-observables firm characteristics that increase the probability of PP participation while reducing the likelihood of innovation.

Regarding the specific determinants of PP, only the variable accounting for the implementation of organisational innovations impacting firm external relations seems to play a pervasive role, being positive and highly significant in both countries. This finding confirms that, especially SMEs, in order to smooth and speed-up procurement procedures, might need to set-up not only an early interaction in procurement to get a close and early engagement with the public buyer, but also a broad range of external relations, which would be useful to gain access to information and knowledge not available in-house. This could further be supported by the positive and significant coefficient also emerged for group membership, though in this case only for Italy.

Moving to the innovation equation, the first thing to stress is that, in both countries, the firm size is still significant but negatively associated with the dependent variable. Hence, for firms with innovations related to PP, compared to firms with regular PP contracts, size does not matter. Contrary to our expectations, belonging to low-tech industries increases the probability to innovate via PP in both estimates. Transports is also proved to be a high innovative sector, though only for Italy. In both countries, the impact of construction is negative and significant as expected. As for Norway, knowledge intensive business services are no more significant, while being in these sectors or in public utilities decrease the likelihood of achieving innovation related to PP in Italy.

Next, compared to firms involved in general PP contracts, it is confirmed that, for firms with innovations related to PP, to perform R&D activities and have a high level of human capital do play a significant role. As for the use of external sources of knowledge, cooperation with government and research labs shows an important effect, though only in Italy; by contrast, in Norway, universities seems to be most important as partners of cooperative projects for innovation. In both countries, firms' engagement in acquisition of external knowledge (i.e. outside any formal cooperation) is also positive and highly significant.

Turning to Table 6, it can be noticed that, overall, we have found almost consistent results. Hence, also when innovation is specifically required as part of the PP contract, the selected firms are confirmed to be very different from those with usual (i.e. non innovative) PP.

Table 6. Heckman probit model with sample selection: one step simultaneous estimation

	ITALY (CIS 2012)		NORWAY (CIS 2014)	
	Innovation required by PP (outcome eq.)	PP (selection eq.)	Innovation required by PP (outcome eq.)	PP (selection eq.)
Constant	0.7462***	-1.7542***	0.3549	-1.8655***
	(0.2333)	(0.1147)	(0.9458)	(0.1994)
Firm size (log of turnover)	-0.0344***	0.0515***	-0.0553*	0.0912***
	(0.0109)	(0.0072)	(0.0283)	(0.0122)
High-tech industries	0.1965**	-0.0935*	0.3591***	-0.3122***
	(0.0796)	(0.0484)	(0.1341)	(0.0781)
Low-tech industries	0.3076***	-0.2277***	0.4085***	-0.4678***
	(0.0642)	(0.0351)	(0.1249)	(0.0590)
Knowledge intensive business services	-0.0305	0.2749***	-0.0255	0.1896***
	(0.0645)	(0.0340)	(0.1285)	(0.0554)
Public utilities	-0.3845***	0.7378***	-0.1622	0.2235**
	(0.0765)	(0.0463)	(0.1690)	(0.0951)
Transports	0.3001***	-0.0851*	0.2236	-0.1989**
	(0.0786)	(0.0453)	(0.1612)	(0.0853)
Construction	-0.6148***	0.7766***	-0.3142**	0.4510***
	(0.0548)	(0.0287)	(0.1449)	(0.0726)
Cooperation with universities	0.1607**		0.3838***	
	(0.0793)		(0.1407)	
Cooperation with government	0.2162**		0.0743	
	(0.0939)		(0.1062)	
Overall importance of cooperation	-0.0399		0.0021	
	(0.1528)		(0.1541)	
Acquisition of external knowledge	0.1704***		0.2134**	
	(0.0509)		(0.0926)	
Human capital (ordinal var. 0 to 6)	0.0228**		0.0448	
	(0.0103)		(0.0302)	
R&D performing firms	0.2076***		0.2685**	
	(0.0478)		(0.1243)	
Firms belonging to a group		0.0310		-0.0027
		(0.0222)		(0.0446)
Firms operating in domestic market only		0.0400*		-0.0597
		(0.0220)		(0.0393)
New ways of organising external relations		0.4373***		0.2783***
		(0.0283)		(0.0641)
Wald test of independent equations (rho=0)	107.82***		4.84**	
athrho	-1.4101***		-1.1404**	
Observations	18,697		4,974	
Censored obs. (firms without PP contracts)	13,560		3,283	
Uncensored obs. (firms with PP contracts)	5,137		1,691	

Robust standard errors in brackets. Trade and other services, among industry dummies, used as reference category. *** p<0.01, ** p<0.05, * p<0.10

Compared to firms with innovation related to PP (i.e. regardless of whether it is specifically required or not by the contract, cf. Table 5), the most striking differences are that being in high-tech industries significantly increase the probability of achieving innovation required by PP in both countries; moreover, cooperating with universities in this case play a significant role not only in Norway but also in Italy. These findings could suggest that the innovations specifically required by PP contracts, at least in part, might be more relevant and complex.

4. Concluding remarks

The empirical analysis carried out in this paper has shown that there are important differences between the firms that are engaged in regular or innovative public procurement. Both in Italy and Norway the firm size affects positively the probability of being involved in PP but, then, its impact on the likelihood of introducing innovations related to PP is negative. Equally relevant differences emerge looking at the firms' sectors while innovations related to or required by PP contracts also depend on the presence of in-house R&D activities and the educational level of employees.

Of course, these results are preliminary and should be considered in the light of some limitations pertaining the generalizability of the findings. First, they are based on cross-sectional datasets that do not allow us interpret the results in terms of causality. Secondly, the evidence provided should be validated by more empirical work, for instance extending the analysis to other European countries.

Moreover, in order to compare the Italian and Norwegian cases, we have been compelled to work with a limited number of potential determinants affecting both the probability to be involved in PP and that of innovating due to PP contracts. In fact, for the purposes of our analysis, the CIS 2014 questionnaire (employed for Norway) provides less detailed information than that of CIS 2012 (used for Italy). So, it will be interesting to inspect whether for the Italian case the present findings will be confirmed by including in the regression analyses a wider set of explanatory variables.

Appendix: the case of Portugal

The following tables show additional results based on CIS 2014 data for Portugal. As Table A1 reports, in this case firms participating in PP are much less (19.7%) than those in Italy (27.5%) and Norway (34%) (cf. Table 2). Moreover, compared to the former countries, the most striking difference is that in Portugal there are few firms (47 only) that have been involved in innovation activities specifically required by PP.

Table A1. Basic descriptive statistics on public procurement and innovation
(percentages on total firms in round brackets; percentages on firm with PP in squared brackets).

	Portugal (CIS 2014)
Total number of firms	5321
Firms with PP	1046 (19.66)
Firms with PP and innovations (both related and not related to PP)	712 [68.07]
Firms with innovations related to PP (both required and not required by PP)	207 [19.79]
Firms with innovations specifically required by PP	47 [4.49]

Source: own computations on CIS 2014 Portuguese micro-data.

Table A2. Firms involved in public procurement: number and percentage by industry

	High-tech industry	Low-tech industry	KIBS	Transports	Public utilities	Construction	Trade and other services	Total
Portugal (CIS 2014)								
Firms with PP	75	281	217	82	27	18	346	1046
Firms with innovations related to PP	18	49	58	11	6	6	59	207
Percentage of firms with PP (on total firms)	14.26	12.6	30.26	17.01	23.48	62.07	28.31	19.66
Percentage of firms with innovations related to PP (on firms with PP)	24.00	17.44	26.73	13.41	22.22	33.33	17.05	19.79

Source: own computations on CIS 2014 Portuguese micro-data.

Table A2 shows that in Portugal the sectoral distribution of firms with PP contracts is remarkably skewed in favour of two sectors: low-tech industries and knowledge intensive business services. Most importantly, the very low presence of firms in the construction sector makes Portugal hardly comparable with Italy and Norway.

According to the above features, it is not surprising that the results of the Heckman probit estimation, illustrated in Table A3 are not only different but also less satisfactory than those achieved for Italy and Norway. In particular, the probability of being engaged in IPP when innovation is related to PP is significantly affected by two dummy variables only (R&D presence and cooperation with government). Moreover, both in the selection and outcome equation the firm size does not exert any significant impact.

Due to the very low number of Portuguese firms with innovations specifically required by PP contracts, we did not perform an additional estimation as for Italy and Norway.

Table A3. Heckman probit model with sample selection: one step simultaneous estimation

	PORTUGAL (CIS 2014)	
	Innovation related to PP (outcome eq.)	PP (selection eq.)
Constant	0.5477 (0.4998)	-0.8223*** (0.2268)
Firm size (log of turnover)	-0.0276 (0.0251)	0.0118 (0.0147)
High-tech industries	0.2694 (0.1723)	-0.5564*** (0.0797)
Low-tech industries	0.2154 (0.1344)	-0.5710*** (0.0530)
Knowledge intensive business services	0.1599 (0.1192)	0.0173 (0.0654)
Public utilities	-0.0654 (0.2359)	-0.1698 (0.1371)
Transports	0.0140 (0.1724)	-0.4022*** (0.0783)
Construction	-0.1220 (0.3161)	0.7944*** (0.2405)
Cooperation with universities	0.1627 (0.1517)	
Cooperation with government	0.4582** (0.1852)	
Overall importance of cooperation	0.1294 (0.4469)	
Acquisition of external knowledge	0.0161 (0.1184)	
Human capital (ordinal var. 0 to 6)	-0.0337 (0.0260)	
R&D performing firms	0.2209** (0.1008)	
Firms belonging to a group		0.0948* (0.0507)
Firms operating in domestic market only		-0.0495 (0.0510)
New ways of organising external relations		0.4154*** (0.0514)
Wald test of independent equations (rho=0)	8.81***	
athrho	-0.8791***	
Observations	5,321	
Censored obs. (firms without PP contracts)	4,275	
Uncensored obs. (firms with PP contracts)	1,046	

Robust standard errors in brackets. Trade and other services, among industry dummies, used as reference category. *** p<0.01, ** p<0.05, * p<0.10.

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