The impact of public sector innovation on Firm Performance

Bianca Buligescu
UNU-MERIT
Maastricht University

Hugo Hollanders
UNU-MERIT
Maastricht University

Maastricht, 31st January, 2012

Draft. Please do not cite or quote.

ABSTRACT

The public sector plays an important role in economically developed countries by contributing to a substantial share of national GDP. By creating a favorable business climate the public sector can also have a profound impact on the economic and innovative performance of firms. Efficient and high quality public services also act as a driver of business performance. The aim of this paper is to estimate the impact of public sector innovation on firm performance. We use a unique business data from the latest 2011 Innobarometer survey covering companies’ perceptions of public sector innovation in thirty-three European countries. We test five hypothesis regarding the impact of innovation in public administration procedures, the impact of innovations in public services for innovation on firm performance. Our results suggest that public administration has a positive impact on company innovation but no impact on sales growth. We also find that innovation in public services have a positive impact on company innovation and sales growth. We find that companies that perceive in general that public services have improved are expected to be 8% more likely to innovate, 4% more likely to experience an increase in their sales and 6% more likely to use services for innovation. We use a bivariate probit with an instrumental variable as an estimation method to control for endogeneity of services for innovation. We use the index of improvements in public sector administration procedures as an instrument to recover causal effects. We find that companies that use services for innovation are 27% more likely to innovate.

JEL Classification: C35, C36, O30, O38, H83

Key words: Nonlinear Model, Instrumental Variables, Innovation, Government Policy, Public Administration

* Corresponding author: Bianca Buligescu, MERIT, School of Business and Economics, Maastricht University, Keizer Karelplein 19, 6211 TC, P.O. Box 616, 6200 MD, Maastricht, The Netherlands, Email: Bianca.buligescu@maastrichtuniversity.nl
1. Introduction

The public sector plays an important role in economically developed countries by contributing to a substantial share of national GDP. By creating a favorable business climate the public sector can also have a profound impact on the economic and innovative performance of firms. Efficient and high quality public services also act as a driver of business performance. The aim of this paper is to estimate the impact of the use of services for innovation on the probability that a firm will innovate. The research question that will be addressed is: What is the impact of public sector innovation on firm performance? We define firm performance as company innovation and positive sales growth. We test four hypotheses which focus on the impact of innovation in public administration procedures, the impact of public services for innovation, and the impact of company innovation and procurement on sales growth.

A detailed analysis of the Innobarometer 2011 firm-level data shows the importance of public sector innovation for business performance. Public sector administration innovations have a positive impact on the probability that a company will innovate but its impact is non significant on increasing sales. Companies that perceive a higher improvement of public administration procedures by 1 unit are expected to have a higher probability to innovate by 8.3%. We also find that companies that perceive an increase of 1 unit in the index of public administration procedures are 13% more likely to use services for innovation.

Public services innovations have a positive impact on the probability that a company will innovate and on increasing sales. Companies that perceive in general that public services have improved are expected to be 8% more likely to innovate, 4% more likely to experience an increase in their sales and 6% more likely to use services
for innovation. We also find that companies that use services for innovation are 27% more likely to innovate. Public services for innovation have a higher positive impact on company innovation among companies that use services for innovation. Among non users of services for innovation, the perception that the information and advice is not easily available has a negative significant impact on the probability that a company innovates. Among users of public services for innovation, working with public research organizations on innovation projects has a significant positive impact on the probability that a company innovates. Companies that innovate are not more likely to experience an increase in sales. We find that if a firm innovates it is 8% more likely to experience increasing sales but we also see that companies that experience increasing sales are 7% more likely to innovate. Our econometric results show that we cannot tell the direction of effects.

The aim of this paper is to estimate the impact of the use of public sector innovation on firm performance. The paper first develops a wide framework for measuring public sector innovations based on government tools. Second the paper evaluates the existing literature and the Innobarometer 2011 with respect to this framework. Third the paper uses the Innobarometer 2011 to evaluate the impact of public sector innovations testing four hypotheses.

2. **Wider framework: findings from the literature**

Public sector innovation is a key contributor to national growth and to the welfare of citizens (Windrum, 2008) yet the literature is scattered across disciplines with respect to the actual measurement of its impact. While traditionally studied in
political science and public administration under the concept of policy reforms and policy changes using public opinion pools, economics recently proposed a new terminology as public sector innovation trying to develop more accurate measurement frameworks for its impact.

There has been an extensive research on the public sector particularly in political science, public administration and in economics however most of the available literature has been concerned with policy reforms and policy changes recently termed as public sector innovation. Political science has been concerned primarily with the mechanisms and factors that determine policies and programmes investigating governance, political systems and political regimes, policy change, reforms and decision making mechanisms (Nelson, 2008; Windrum, 2008). Whereas political science is more concerned with the political organization of the state and political decision making (e.g. the legislative function), public administration is more concerned with the study of the executive function of the government including the functions of the courts in administration of justice and the executive functions of all the civilian and the military agencies in providing police and security public services. On the other hand, public administration also has a regulatory function as it formulates rules, regulations and public policies to implement legislation. The public administration literature is concerned mainly with the organization types and models, the nature of bureaucracies and their effects, reforms in public administration and types of management in public administration. Economics on the other side has been concerned with evaluations of effectiveness and efficiency of implemented or future policies using ex-post and ex-ante evaluation methods and cost-benefit models.

The rationale for government intervention is to realize activities with high social returns that due to certain market failures do not have private returns (Arrow,
Innovation policies and innovations in public sector activities are oriented to address market failures and in particular (Alvarez et al., 2012): “mitigate the “imperfect private appropriability” that characterize the production of scientific and technical knowledge (Nelson, 1959; Arrow, 1962); correct information asymmetries affecting investment in innovation, which leads to problems in accessing external finance or to slowing down technology diffusion; and facilitate the coordination of investments in and access to complementary assets by the different actors involved in the innovation process.”

The main difficulty in measuring the impact of public sector innovation is the diversity of public sector services and policies, diversity of agencies and bodies responsible for the implementation and the diversity of beneficiaries and outcomes. The multitude of governmental policies and services that have diverse outputs makes it difficult to measure its outcome in a uniformly manner. The government can use a multitude of tools, to solve market and systemic failures, such as: 1) organization and provision of collective/individual goods and services that have high social returns but which due to market failures do not have private returns (OECD, 2009); 2) organization and/or financing private provision of collective/individual goods and services that have high social returns but which due to market failures do not have private returns (via incentives to organize and coordinate privately, procurement); 3) collective/individual support via financial cash transfers, subsidies or tax credits, or counselling and advice provision for particular groups of individuals or firms (OECD, 2009); 4) revenue generation and collection (tax system, public enterprises); 5) regulations; 6) policies; and 7) information provision.

These tools can be grouped in government tasks: public demand, public supply, stimulating private demand, public financing, public information, public
administration, public order and safety and state defence. These tools have behavioural effects since they provide behavioural incentives and the targeted groups can endorse or block certain reforms. Public administration offers the state the bureaucratic apparatus that enables the provision of goods and services and the organization and implementation of policies. In addition to public administration, there are other agencies, organizations, courts and police establishments, in charge of service provision.

Public sector innovation can occur at different levels: innovations in public administration and organization of public sector establishments, policy and regulations innovations (reforms), innovations in public campaigns and public information dissemination, innovations in revenue collection and generation (tax system, public enterprises), innovations in service and goods delivery (such as education, public knowledge/R&D developed by universities), public services or goods innovations (ex: infrastructure), financial support innovations (introducing new programmes such as innovation subsidies), innovations in behavioural incentives provided, systemic innovations and conceptual innovations (adapted from Windrum, 2008).

So far there is a wide literature in economics analyzing the impact of procurement, regulations, knowledge spillovers from universities, R&D subsidies and tax credits on business innovation, employment, sales growth, export, business survival and productivity (Aschhof and Sofka, 2009, Crespi et al., 2011, Paraskevopoulos, 2012, Wren and Storey, 2002). The economic literature is supplemented by political science studies looking at the impact of ICT or e-government on societal outcomes (Andersen et al., 2010). The economic studies look in general at a particular policy, programme or regulation in a particular country and
use treatment evaluation methods to assess its impact on businesses. The key research question in studies such as these is: what would the performance of firms which participated in the programme have been, if they had not participated (counterfactual). Actual implementation of public policy and public programmes could easily have unintended consequences, e.g., public support could lead to either crowding in or crowding out of private funding. Mistakes in targeting the programme could lead to displacement or substitution effects. Substitution effects happen when the types of projects funded by innovation agencies are very similar to the types of projects funded by firms (Crespi et al., 2011). This induces perverse effects on companies to substitute between projects and carry them on with public funding. Displacement effects happen when firms which do not participate in public programmes do not survive on the market or are worse off due to the public programme. Moreover the programme can have a deadweight effect if the change observed among direct beneficiaries would have occurred even in the absence of the programme, therefore public spending did not create any value added.

Regulations are demand side instruments whose primary goal is to change private actors’ behaviour (Aschhof and Sofka, 2009). Paraskevopoulou (2012) distinguishes between regulatory policies that explicitly include the innovation process in their objectives such as IPR regulations, competition regulations and industry-university links and others whose primary aim does not refer to innovation but nevertheless carry significant repercussions for it such as regulations concerning environment, health and safety, employment conditions etc. Aschhof and Sofka (2009) following the OECD (1997) classify regulations as: economic (e.g. anti-trust policy, price control), social (e.g. environmental or safety regulations) or administrative (e.g. product liability).
Regulations can have both a direct and an indirect effect on innovation. By establishing new regulations the government modifies the framework conditions in which firms operate and innovate while at the same time new regulations can force firms to adopt new standards for their products and processes (Aschhof and Sofka, 2009). Regulations can have consequences for both technological innovations, by modifying for example environmental and human safety regulations and for non-technological innovations, through the management of innovation within and across organizations, regulations can influence the structure of industries, the demand patterns and the institutional context in which firms operate (Paraskevopoulou, 2012). Therefore regulations can be seen as an inducement mechanism for technical change influencing the direction of technological innovation (Paraskevopoulou, 2012). The relationship between regulation and innovation is dynamic in the sense that regulations influence innovations which create new conditions to be regulated (Paraskevopoulou, 2012).

The Fraunhofer Institute for Systems and Innovation Research (2004) analyzed the effect of regulation on innovation using a survey applied to 250 European companies. Their findings suggest that the most important regulations for product and services innovations were related to health and safety aspects, the quality of products and services and the question of liability. Moreover their findings emphasized that regulations had both positive effects on liability claims or increased acceptance of new products by consumers and users and negative effects such as increasing labour and development costs.

The government is both a major producer of public services and a consumer in certain industries such as defence, education or health care services. As a consumer governments can act as an early-state or lead user of innovations enabling companies
to learn and refine their products and experience cost reductions quickly (Aschhof and Sofka, 2009). Wide dissemination can lead to reduced prices and newly created or extended markets for private demand. Therefore public demand can drive private demand.

Governments foster innovation in the scientific and technological infrastructure by direct support for basic research and applied research within Universities. Fundamental research expands the capability of the economy to generate new inventions and innovations (Aschhof and Sofka, 2009). Public knowledge creation can be used by firms to complement internal R&D or awareness of emerging technologies however there is also the risk of creation of new knowledge that cannot be explored yet on the market (Aschhof and Sofka, 2009). Therefore the European Commission developed collaborative programmes attempting to link businesses with universities.

University-industry interactions take several forms such as joint research, contract research, personnel mobility and training. Most studies show that firms profit from this type of collaboration such as: R&D collaboration with universities and research institutions increases a firms ‘sale attributable to market novelties, collaboration with universities has a positive impact on a manufacturing firm’s probability of applying for a patent and it has a positive impact on increasing the firm’s innovative sales (Aschhof and Sofka, 2009). However several authors warn that these positive effects are primarily limited to certain high technology industries and large firms with high R&D intensities and related absorptive capacities (Aschhof and Sofka, 2009).

At an aggregate level, the relationship between public sector innovation and private sector innovation is bidirectional. Innovations in the private system can affect
and influence public sector innovations in a positive or a negative way. The example
of the recent financial innovations that brought a global financial crisis had a negative
impact on public sector finances resulting in budget cuts and slowing growth in public
sector employment. An example of a positive impact is the adoption of improved
information and communication technologies resulting in the introduction and
improvement of e-government services. Innovations in the public sector can also
influence innovation in the private sector in a positive or negative way. A positive
example is the introduction of simplified procedures to apply for permits, or the recent
adoption of the common European patent which will significantly reduce the costs of
applying for a patent. A negative example is fostering corruption and informal
payments to bypass failures in regulations or administration.

3. Data description

The Innobarometer 2011 survey on the “Impact and perception of public
sector innovation among companies” was carried out by TNS opinion between 16
February and 7 March 2012 and collected responses from 10,112 companies of which
8,699 in EU27 Member States. The main objective of the Innobarometer 2011 survey
was to identify the introduction of improved public services for businesses, their
impact on business performance, if these improvements were due to public sector
innovation and the importance of innovation versus low cost in winning public
tenders. Aggregate results at the country level have been reported in the

Section 3.1 presents an overview of how the Innobarometer 2011 measures
public sector innovation and our construction of new variables. Section 3.2 presents
descriptive statistics of public sector innovation measures by firm performance outcomes.

### 3.1 Innobarometer 2011 measurement of public sector innovation

Innovation in public sector is measured in the Innobarometer 2011 indirectly via the companies’ perception regarding improvements in public administration, public services, policies and regulations. The 2011 Innobarometer measures the perception of companies regarding innovations in public administration procedures (Q5), general improvement in public services (Q4), whether public services should improve to match the business needs (Q12) and the general perception with regards to the impact and functioning of public services for innovation (Q10 and Q11). The Innobarometer 2011 asks firms the following questions about the impact and the functioning of public services for innovation: whether the fiscal and regulatory system promotes innovation, the creation of public knowledge helps companies to innovate, the innovation programmes are well targeted and also whether service delivery is easily accessible. In addition to these questions the Innobarometer 2011 asks companies whether they use certain public services such as: training programmes for employees, applying for business support via research or innovation subsidies, applying for starting a business and legal advice, obtaining work permits for foreign workers, health and safety issues, and environmental permits and obligations (Q3) and their use of procurement contracts which is a governmental measure to stimulate private demand (Q13).

We create two new variables based on existing data: the index of improved public administration procedures and the use of services for innovation. Our aim is to measure the impact of public sector innovation on firm performance defined as firm
innovation and increase in sales. The quality of public administration procedures is measured using six questions (Q5), in which companies are asked if they observed the introduction of any of the following: `option to complete government forms over the internet’, `reduction in the time and effort for filling forms’, `access to information on government services over the internet’, `reduction in the time required for permits and licenses’, `faster response time for other government services’, `reduction in financial costs to your company’. By aggregating these questions an index has been constructed. The index of improved public administration procedures measures the degree of the introduction of new administration for businesses by taking the average of the number of ‘Yes’ responses to all 6 before-mentioned public services (Question Q5 in the IB2011 survey) excluding those items for which the firm responded with a [Don’t know/No answer]. The indicator will take on a value from 0 to 1. Figure 2 shows the frequency distribution for the in total 13 possible values for the index. About 13% of companies have not experienced any introduction of improved public administration procedures and almost 11% of companies have experienced the introduction of all 6 types of improved public administration.

**Figure 1 Frequency distribution for the index of improved public administration procedures**

Notes: own calculation based on Innobarometer 2011

We further create a new variable measuring the use of public services for innovation by companies. This indicator is constructed as a dummy variable which takes a value of 1 if the company has used at least one of the following public services: ‘applying for research or innovation subsidies’, ‘applying for patents or trademarks’,

‘conformity certifications for new products’, ‘other (such as starting a business, obtaining legal advice or obtaining subsidies for research or innovation activities)’

The rationale for grouping different services is that all these services provided by the government aim to increase firm innovation. In total 2,814 companies have used at least one service for innovation compared to 5,462 companies who did not use any of such services.

3.2 Descriptive statistics

Our aim is to measure the impact of public sector innovation on firm performance defined as firm innovation and increase in sales. Before discussing the econometric results, we first discuss the findings of the descriptive statistics for two of the key variables: innovating company and positive sales growth in Table 1. We include also the use of services in Table 1 for innovation as this variable could be endogenous.

Companies that innovate are more likely to use services for innovation compared to companies that do not innovate (Table 1 shows that 50.3% of innovators have used at least one service for innovation as compared to 21.3% of non-innovators). Innovating companies are more likely to observe the introduction of improved services by public administration, in particular for the option to complete government forms over the internet and access to information on government services over the internet. Innovating companies are more likely to observe a general improvement in public services. There is no difference between innovators and non-innovators in their perception that public services must become more innovative to better match business needs. Innovating companies are more likely to experience increasing sales whereas

---

1 Note that some of these services such as applying for patents and trademarks and conformity certification for new products could be provided by intermediary private businesses. However, in the end even the intermediary private business has to finalize these applications using public sector services.
non-innovators are more likely to experience stable or decreasing sales. A higher share of innovators have won at least one public procurement contract.

Companies with increasing sales are more likely to be an innovator and use services for innovation (in particular applying for patents or trademarks). Companies with increasing sales are also more likely to have experienced the introduction of improved services by public administration, in particular the option to complete government forms over the internet and faster response time for other government services.

Companies using services for innovation are more likely to be an innovator. Companies using services for innovation are more likely to have experienced the introduction of improved services by public administration, in particular access to information on government services over the internet and reduction in the time required for permits or licenses. These companies are also more likely to share a more positive perception that public services have improved in general. Companies using services for innovation are more likely to experience an increase in sales and to have won a public procurement contract.

Table 1 Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>Company is an innovator</th>
<th>Company has increasing sales</th>
<th>Company uses services for innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Company is an innovator</td>
<td>--</td>
<td>--</td>
<td>52.5%</td>
</tr>
<tr>
<td>Use of services for innovation</td>
<td>--</td>
<td>--</td>
<td>52.5%</td>
</tr>
<tr>
<td>Applying for research or innovation subsidies</td>
<td>23.4%</td>
<td>5.9%</td>
<td>17.5%</td>
</tr>
<tr>
<td>Applying for patents or trademarks</td>
<td>20.2%</td>
<td>6.0%</td>
<td>16.5%</td>
</tr>
<tr>
<td>Conformity certification for new products</td>
<td>24.0%</td>
<td>8.6%</td>
<td>18.8%</td>
</tr>
<tr>
<td>Other (such as starting a new business)</td>
<td>22.3%</td>
<td>9.0%</td>
<td>18.8%</td>
</tr>
<tr>
<td>Training programs for employees</td>
<td>42.5%</td>
<td>30.9%</td>
<td>38.1%</td>
</tr>
<tr>
<td>Obtaining work permits for foreign workers</td>
<td>14.2%</td>
<td>8.0%</td>
<td>12.6%</td>
</tr>
<tr>
<td>Health and safety issues</td>
<td>48.4%</td>
<td>36.8%</td>
<td>43.8%</td>
</tr>
<tr>
<td>Environment related permits and obligations</td>
<td>44.9%</td>
<td>27.9%</td>
<td>40.2%</td>
</tr>
<tr>
<td>Index of improved public administration procedures</td>
<td>50.6%</td>
<td>45.7%</td>
<td>49.9%</td>
</tr>
<tr>
<td>Option to complete government forms over the internet</td>
<td>80.8%</td>
<td>72.9%</td>
<td>79.0%</td>
</tr>
<tr>
<td>Reduction in the time and effort for filling forms</td>
<td>48.3%</td>
<td>44.8%</td>
<td>47.5%</td>
</tr>
<tr>
<td>Access to information on government services over the internet</td>
<td>78.1%</td>
<td>71.7%</td>
<td>76.5%</td>
</tr>
<tr>
<td>Reduction in the time required for permits or licenses</td>
<td>30.5%</td>
<td>27.1%</td>
<td>26.9%</td>
</tr>
<tr>
<td>Company is an innovator</td>
<td>Company has increasing sales</td>
<td>Company uses services for innovation</td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Yes 36.2%</td>
<td>Yes 36.4%</td>
<td>Yes 38.5%</td>
<td></td>
</tr>
<tr>
<td>No 31.8%</td>
<td>No 31.9%</td>
<td>No 31.3%</td>
<td></td>
</tr>
<tr>
<td>Faster response time for other government services</td>
<td>Reduction in financial costs to your company</td>
<td>General perception public services have improved</td>
<td></td>
</tr>
<tr>
<td>Public services must be more innovative to match business needs</td>
<td>Sales of company have increased</td>
<td>Sales of company have decreased</td>
<td></td>
</tr>
<tr>
<td>Company exports abroad</td>
<td>High share of employees with a university degree</td>
<td>Low share of employees with a university degree</td>
<td></td>
</tr>
<tr>
<td>Company has been taken over or merged with another company</td>
<td>Company won at least one procurement contract</td>
<td>Company is less than 6 years old</td>
<td></td>
</tr>
<tr>
<td>Very small firm: less than 10 employees</td>
<td>Small firm: between 10 and 50 employees</td>
<td>Medium-sized firm: between 50 and 250 employees</td>
<td></td>
</tr>
<tr>
<td>Large firm: more than 250 employees</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. **Methodology**

Our aim is to test the following four hypotheses regarding public sector innovation using data from the Innobarometer 2011:

1. Public sector administration innovations are expected to have a positive impact on company innovation and on increasing sales.

2. Public services innovations are expected to have a positive impact on company innovation and on increasing sales.

3. Public services for innovation are expected to have a higher positive impact on company innovation among companies that use services for innovation.

4. Companies that innovate are more likely to experience an increase in sales.

5. Procurement is expected to have a positive impact on increasing sales.
Section 4.1 first explains the methodology used in our regressions, section 5 presents the econometric results for the impact of public sector innovation on the probability that a firm will innovate, that a firm will use public services for innovation and that a firm will have grown. Section 6 summarizes the evidence for each of the four hypotheses.

4.1. Methodology

We use a linear probability model, probit and instrumental variables to investigate the impact of public sector innovation on firm performance. The five hypothesis investigated use different techniques and an indication of the estimation method is provided. We further present a discussion of the instrumental variable methodology used.

In a cross-sectional data, in the presence of endogeneity, only the use of instrumental variable estimation can recover the causal effect provided that one has good instruments. Estimation of instrumental variable models for binary variables and with binary endogenous regressors seems to be problematic. Imbens and Woodridge (2007) emphasize that both IV and control functions are more difficult to apply to nonlinear models and there are few if any methods that apply for the cases with discrete endogenous variables. The estimation methods used in cases with endogenous binary variables are based on Maximum Likelihood Estimation methods and linear probability models using the two stage least squares.

In order to test for exogeneity we use the Rivers-Vuong approach as indicated by Wooldridge (2010, p.597). Normally the Rivers-Vuong (1988) approach is used as an instrumental variable estimation procedure in cases where the endogenous variable is continuous. Wooldridge (2010, p.597) indicated the Rivers-Vuong approach as a
test for exogeneity in cases of binary endogenous variables. The Rivers-Vuong approach is relatively simple and it implies introducing the residuals from an ordinary least squares where the endogenous variable is predicted based on additional exclusion restrictions\(^1\) into a probit equation as an additional independent variable.

The additional exclusion restrictions are: the index of improved public services which we use as an exclusion restriction for the use of services for innovation and a young company less than 6 years old which we use as an exclusion restriction for sales growth. If the estimated residuals are significant then the hypothesis that the variables are exogenous is rejected and a maximum likelihood method estimation is necessary.

The linear instrumental variables approach is estimated using a two stage least squares (2SLS) model which is written in the following way:

\[
\begin{align*}
y_1 &= \alpha_1 + \beta_1 y_2 + \beta_2 y_3 + \delta_1 x_j + \varepsilon_1 \\
y_2 &= \alpha_2 + \delta_2 x_j + \delta_3 z_1 + \nu_1 \\
y_3 &= \alpha_3 + \delta_3 x_j + \delta_4 z_1 + \nu_2 
\end{align*}
\]

where \(y_1\) is company innovation, \(y_2\) is use of services for innovation and \(y_3\) is sales growth, \(x_j\) is a vector of exogenous variables and \(z_1\) and \(z_2\) are instrumental variables.

The first estimation strategy has been advocated by Angrist (2001) and Angrist and Pischke (2009). This estimation strategy has proven to provide good estimates of the average treatment effect in many applications and partial effects using a non-linear form seem to be similar to the partial effects from a linear probability model (Imbens and Wooldridge, 2007; Angrist, 2001). The 2SLS model has the advantage of easily interpretable coefficients measuring the effect in probability metric (Nichols, 2011). If responses to use of services for innovation and sales growth vary across individuals, then using linear instrumental variables gives the average effect of treatment on the
treated (ATT) for “compliers” (i.e. those who use services for innovation because of the improvement in public sector innovation) (Abadie, 2003). For an instrumental variable estimation two requirements need to be fulfilled: 1) that the instruments are partially correlated with the endogenous variable (Cov(Z,Y2,3)≠0) (the inclusion restriction) and 2) that the instruments are exogenous to the dependent variable meaning that the effect of the instrument on the dependent variable goes through its correlation with the endogenous regressor (Cov(Z,ε1) =0) (the exclusion restriction).

The relevance of the instrument partly depends on how large the probability of compliers is, and partly on its policy relevance. If the correlation between Corr(Z,Y2,3) is small, that is Z is a weak instrument then even a small correlation between Z and ε can produce a larger bias than ordinary least squares (OLS). That is instrumental variable estimation in the presence of weak instruments is even worse than an ordinary regression as it introduces a lot of bias.

Non-linear estimation techniques with instrumental variables use a bivariate probit as the estimation strategy (Wooldridge 2010, p.595-596; Imbens and Wooldridge, 2007). This type of estimation has several advantages. First it based on maximum likelihood and second the likelihood function is constructed from f(γ1|y2,xj)f2(γ2|zj) and so it does not change if xj includes y2. Third, some authors argue that the non-linearity can drive the results in some cases to a larger extent than the exclusion restriction. The bivariate probit model with endogenous y2 is written in the following way:

\[ y_1 = 1[β_1 y_2 + δ_1 x_j + ε_1 > 0] \]
\[ y_2 = 1[δ_2 x_j + δ_3 z_1 + ν_1 > 0] \]
Where \((\varepsilon_1, v_1)\) is independent of \(z_1\) and \(x_j\) and distributed as bivariate normal with mean zero, each has unit variance, and \(\rho_1 = \text{Corr}(\varepsilon_1, v_1)\). If \(\rho_1 \neq 0\) then \(\varepsilon_1\) and \(v_1\) are correlated, and a probit estimation is inconsistent for \(\beta_1\) and \(\delta_1\).

According to Angrist and Pischke (2009, p.202), the difference between bivariate probit and 2SLS is that where bivariate probit estimates the unconditional average causal effect or effect on the treated, the 2SLS estimation gives only local average causal effects.

5. Results

This section investigates the four hypotheses and groups the answers in three sections: section 5.1 investigates the impact of innovation in public administration, section 5.2 investigates the impact of innovations in public services, section 5.3 investigates the impact of company innovation and procurement on sales growth.

5.1. The impact of innovation in public administration

From the first column in Table 1 we see that: the option to complete government forms over the internet, access to government services over the internet and reduction in financial costs to the company are positively associated with the probability that a company will innovate in the European Union. The majority of countries introduced the option to complete government forms over the internet. Although the introduction of the option to complete government forms over the internet is positively associated with company innovation, this innovation did not lead to a reduction in time and effort to complete government forms. Overall in the European Union the time required for obtaining permits and licenses did not reduce. Although the individual impact of each of these measures is estimated to be around 2-
3% on company innovation we think that the cumulative effect of introducing more innovations in public administration procedures will be higher. Indeed Model 2 in Table 1 uses the index of improved public administration procedures to test the cumulative impact of the six measures and the results show that companies that perceive a higher improvement public administration procedures by 1 unit are expected to have a higher probability to innovate by 8.3%. The six items included in the index for improved services by public administration (Model 1, rows 2-7) are moderately correlated to one another and using the index instead provides better estimation results for company innovation however on the other hand the aggregation can create artificial effects as for example in the case of sales growth. None of the innovations in public administration has an impact on sales growth. Therefore we hypothesize that the effect of innovations in public administration on sales growth goes indirectly through company innovation.

We further test whether improvements in public administration have an impact on the use of services for innovation and find that the option to complete government forms over the internet, access to information on government services over the internet and a reduction in the time required for permits and licenses have a significant impact on the use of public services for innovation. Considering the cumulative impact of innovations in public administration, companies that perceive an increase of 1 unit in the index of public administration are 13% more likely to use services for innovation.
Table 2. The impact of innovations in public administration procedures

<table>
<thead>
<tr>
<th></th>
<th>Company innovation</th>
<th>Positive Sales Growth</th>
<th>Use of services for innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
<td>Model 1</td>
</tr>
<tr>
<td>1 Index of improved public administration procedures</td>
<td></td>
<td>0.083</td>
<td>0.049</td>
</tr>
<tr>
<td>2 Option to complete government forms over the internet</td>
<td>0.039</td>
<td></td>
<td>0.026</td>
</tr>
<tr>
<td>3 Reduction in the time and effort for filling forms</td>
<td>-0.009</td>
<td></td>
<td>-0.008</td>
</tr>
<tr>
<td>4 Access to information on government services over the internet</td>
<td>0.030</td>
<td></td>
<td>0.011</td>
</tr>
<tr>
<td>5 Reduction in the time required for permits or licenses</td>
<td>0.008</td>
<td></td>
<td>-0.006</td>
</tr>
<tr>
<td>6 Faster response time for other government services</td>
<td>0.027</td>
<td></td>
<td>0.015</td>
</tr>
<tr>
<td>7 Reduction in financial costs to your company</td>
<td>0.027</td>
<td></td>
<td>0.025</td>
</tr>
</tbody>
</table>

Notes: The table provides estimates from a linear probability model also known as linear regression. Significant results highlighted in bold, significance at 95% confidence interval. Control variables include: export, merger, human capital skills, firm size, sectors and country dummies. Using a multinomial logit with three outcomes instead of linear regression for sales does not modify the results.

5.2 The impact of innovations in public services

We further test the impact of innovations in public services on company innovation, positive sales growth and the use of services for innovation (Table 3). We find that companies that perceive in general that public services have improved are expected to be 8% more likely to innovate. Companies that perceive public services have deteriorated are 3% more likely to innovate compared to companies that perceive the status quo was maintained, however in this case the probability value is very close to the 0.05 threshold suggesting that results could change if we would control for more variables. Companies that perceive public services have improved in general are 4% more likely to experience an increase their sales and 6% more likely to use services for innovation.

Table 3. The impact of innovations in public services

<table>
<thead>
<tr>
<th></th>
<th>Company innovation</th>
<th>Positive sales growth</th>
<th>Use of services for innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Public services have improved (ref: Public services remained the same)</td>
<td>0.087</td>
<td>0.044</td>
<td>0.063</td>
</tr>
<tr>
<td>2 Public services have deteriorated (ref: Public services remained the same)</td>
<td>0.029</td>
<td>-0.052</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Notes: The table provides estimates from a linear probability model also known as linear regression. Significant results highlighted in bold, significance at 95% confidence interval. Control variables include: export, merger, human capital skills, firm size, sectors and country dummies.

We further test the hypothesis that companies that use public services for innovation are more likely to innovate (Table 4). We find that companies that use services for innovation are 27% more likely to innovate (Column 4). If endogeneity
would not be taken into account the effect of public services for innovation would be underestimated by 7% as seen in column 1 where we estimate a linear regression and find an effect of 21% (Column 1). When we control for endogeneity we exclude the possibility that more innovative companies could be applying and using more services for innovation therefore the effect can be interpreted as a causal effect.

Table 4. The impact of using public services for innovation on company innovation

<table>
<thead>
<tr>
<th>Company innovation</th>
<th>Not controlling for endogeneity</th>
<th>Controlling for endogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LPM OLS</td>
<td>Probit MLE</td>
</tr>
<tr>
<td></td>
<td>LPM 2SLS</td>
<td>Bivariate probit MLE IV</td>
</tr>
<tr>
<td></td>
<td>Bivariate probit MLE: no IV</td>
<td></td>
</tr>
<tr>
<td>Coefficient</td>
<td>0.21</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>0.66</td>
<td>0.76</td>
</tr>
<tr>
<td>Marginal effect of the use of services for innovation</td>
<td>0.21</td>
<td>0.19</td>
</tr>
<tr>
<td>Rho</td>
<td>-0.10</td>
<td>0.40</td>
</tr>
<tr>
<td>Number of observations</td>
<td>8276</td>
<td>8276</td>
</tr>
<tr>
<td></td>
<td>8276</td>
<td>8276</td>
</tr>
</tbody>
</table>
| Notes: Significant results highlighted in bold. 2SLS is estimated using ivreg2. Average marginal effects are calculated using the margins option in Stata. We use the index of improved public administration procedures as an instrument. Control variables include: export, merger, human capital skills, firm size, sectors and country dummies.

We further hypothesized that public services for innovation are expected to have a higher positive impact on company innovation among companies that use services for innovation. In table 5 we find that there is no difference in the overall perception of innovations in public services on company innovation between companies that use services for innovation and companies and companies that don’t. Using questions Q10 and Q11 from the Innobarometer we also test the impact and functioning of different public services for innovation. We find that among non users of services for innovation, the perception that the information and advice is not easily available has a negative significant impact on the probability that a company innovates. Among users of public services for innovation, working with public research organizations on innovation projects has a significant positive impact on the probability that a company innovates.
Table 5. Testing for differences in the perception of the impact and functioning of public services for innovation on company innovation between companies that use services for innovation and companies that don’t.

<table>
<thead>
<tr>
<th>Probability that a company will innovate</th>
<th>No use of services for innovation</th>
<th>Use of services for innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public services have improved (ref: Public services remained the same)</td>
<td>0.098</td>
<td>0.087</td>
</tr>
<tr>
<td>Public services have deteriorated (ref: Public services remained the same)</td>
<td>0.005</td>
<td>0.032</td>
</tr>
<tr>
<td>Public services providers are doing a good job in creating the right conditions for companies to innovate</td>
<td>0.019</td>
<td>-0.012</td>
</tr>
<tr>
<td>The regulatory and fiscal system promotes the ability for companies to innovate</td>
<td>0.016</td>
<td>0.016</td>
</tr>
<tr>
<td>Companies can work closely with public research organisations on innovation projects</td>
<td>0.012</td>
<td>0.061</td>
</tr>
<tr>
<td>The public education and training system has equipped companies’ staff with the knowledge and skills needed to innovate</td>
<td>-0.012</td>
<td>-0.036</td>
</tr>
<tr>
<td>The provision of information and advice helping companies to innovate is of a high quality</td>
<td>-0.016</td>
<td>-0.011</td>
</tr>
<tr>
<td>The information and advice available to companies is easily available</td>
<td>-0.076</td>
<td>-0.051</td>
</tr>
<tr>
<td>The procedures to obtain financial support for companies to innovate (e.g. grants, tax reliefs) are simple-to-use</td>
<td>-0.044</td>
<td>-0.008</td>
</tr>
<tr>
<td>Government’s programmes are well targeted to support innovation in companies</td>
<td>0.023</td>
<td>0.043</td>
</tr>
<tr>
<td>Number of observations</td>
<td>2679</td>
<td>1842</td>
</tr>
<tr>
<td>R2</td>
<td>0.120</td>
<td>0.145</td>
</tr>
</tbody>
</table>

Notes: The table provides estimates from a linear probability model also known as linear regression. Significant results highlighted in bold, significance at 95% confidence interval. Control variables include: export, merger, human capital skills, firm size, sectors and country dummies.

5.3. The impact of company innovation and procurement on sales growth

Ideally one would like to ask whether company innovation has a positive impact on positive sales growth or whether firms that grow faster are more likely to innovate. Results in the literature are not clear cut concerning this question. Table 6 reveals endogeneity between positive sales growth and company innovation, we see that if a firm innovates is 8% more likely expected to experience positive sales growth but on the other hand we also see that companies that experience a positive sales growth are 7% more likely expected to innovate. Therefore, we cannot tell the direction of effects. We need an instrumental variable to be able to establish causality.

Table 6. Revealing endogeneity

<table>
<thead>
<tr>
<th>Use of services for innovation</th>
<th>Positive sales growth</th>
<th>Company innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of services for innovation</td>
<td>0.04</td>
<td>0.20</td>
</tr>
<tr>
<td>Firm innovates</td>
<td>0.18</td>
<td>0.08</td>
</tr>
<tr>
<td>Positive sales growth</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Index of improved public administration procedures</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>Environment related permits and obligations</td>
<td>0.04</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Notes: The table provides average marginal effects estimates from a probit model. Significant results highlighted in bold, significance at 95% confidence interval. Control variables include: export, merger, human capital skills, firm size, sectors and country dummies.
We further use the index of improved public administration as an instrument to establish a causal impact of innovation on growth sales (Table 7). We find that company innovation does not have a significant impact on positive sales growth.

Table 7. The causal effect of company innovation on positive sales growth

<table>
<thead>
<tr>
<th>Probability for a company to have increasing sales</th>
<th>Not controlling for endogeneity</th>
<th>Controlling for endogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LPM OLS</td>
<td>Bivariate Probit MLE IV</td>
</tr>
<tr>
<td>Company is an innovator</td>
<td>0.085</td>
<td>0.012</td>
</tr>
<tr>
<td>Public services have improved</td>
<td>0.035</td>
<td>0.057</td>
</tr>
<tr>
<td>Public services have deteriorated</td>
<td>-0.055</td>
<td>-0.013</td>
</tr>
<tr>
<td>Index of improved public administration procedures</td>
<td>0.010</td>
<td>0.10</td>
</tr>
<tr>
<td>Rho</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
<td>7285</td>
<td>7285</td>
</tr>
</tbody>
</table>

Notes: Significant results highlighted in bold, significant at 95% confidence interval. Average marginal effects are calculated using the margins option in Stata. We use the index of improved public administration procedures as an instrument. Control variables include: export, merger, human capital skills, firm size, sectors and country dummies. Reference category is public services remained the same.

6. Conclusions

We formulated four hypotheses on the impact on public sector innovations on company performance. We used the Innobarometer 2011 to test the impact of public sector innovation in administration, public services on company innovation and sales growth.

The first hypothesis tested whether public sector administration innovations has a positive impact on company innovation and on increasing sales. We find that public sector administration innovations have a positive impact on company innovation but its impact is non significant on increasing sales. Companies that perceive a higher improvement of public administration procedures by 1 unit are expected to have a higher probability to innovate by 8.3%. We also find that companies that perceive an increase of 1 unit in the index of public administration procedures are 13% more likely to use services for innovation.
The second hypothesis tested whether public services innovations have a positive impact on company innovation and on increasing sales. We find that companies that perceive in general that public services have improved are expected to be 8% more likely to innovate, 4% more likely to experience an increase in their sales and 6% more likely to use services for innovation. We also find that companies that use services for innovation are 27% more likely to innovate.

The third hypothesis tested whether public services for innovation have a higher positive impact on company innovation among companies that use services for innovation. We find that among non users of services for innovation, the perception that the information and advice is not easily available has a negative significant impact on the probability that a company innovates. Among users of public services for innovation, working with public research organizations on innovation projects has a significant positive impact on the probability that a company innovates.

The fourth hypothesis tested whether companies that innovate are more likely to experience an increase in sales. We find that if a firm innovates it is 8% more likely to experience increasing sales but we also see that companies that experience increasing sales are 7% more likely to innovate. Therefore, we cannot tell the direction of effects without using an instrument. Using an instrument we show that company innovation does not have a significant impact increasing sales.
References


OECD (2009), Measuring Government Activity.


http://www2.unpan.org/egovkb/global_reports/12report.htm


