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SHORT ARTICLE

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More subsidies, more innovation? Evaluating whether a mix of subsidies from regional, national and EU sources crowds out firm-level innovation

Kevin Mulligan [a], Helena Lenihan [b] and Justin Doran [c]

ABSTRACT

Policy-makers at regional, national and European Union (EU) levels of governance use a variety of subsidy programmes to stimulate firm-level innovation. Against this backdrop, this paper investigates three important issues that have not received sufficient attention in the literature: (1) whether evaluating the impact of subsidies from each individual source is biased by ignoring firms that receive a mix of subsidies from different sources at the same point in time; (2) whether receiving a mix of subsidies from regional, national and EU sources crowds out firm-level innovation; and (3) if effective, whether subsidy mix stimulates forms of innovation with higher private or social returns. The findings demonstrate that ignoring subsidy mix significantly biases evaluations of subsidies from individual sources. Moreover, subsidy mix can be a highly effective means of stimulating forms of firm-level innovation with the highest social returns, precisely where market and systemic failures are most acute.

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INTRODUCTION AND LITERATURE REVIEW

The recent European Commission (2017) report entitled *The Economic Rationale for Public Research & Innovation Funding and its Impact* is set to act as a guide for innovation policy in the European Union (EU) for years to come. This report highlights that, although firms are the locus of innovation in EU countries, they do not engage in sufficient innovation activities to drive competitiveness and economic growth. Investing in innovation is an inherently risky activity where, if positive returns on investment are realized, they tend not to be fully appropriable by the firm making the initial investment, but rather are lost through knowledge spillovers to other firms in the wider economy. Such problems are most pronounced in forms of firm-level

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innovation that have the highest social rate of return and play the most important role in sustaining a well-functioning innovation system, as opposed to more incremental forms of innovation that have a higher probability of short-term success but very low spillovers. As the report outlines, market and systemic failures such as the above act as the prime rationales for policy-makers to try to stimulate firm-level innovation through a variety of subsidy programmes, with a particular focus on forms of innovation which are likely to result in high social returns.

In EU countries, subsidies flow to firms from three main sources: regional, national and EU levels of governance (European Commission, 2017). Policy-makers at each level have two interrelated concerns when implementing subsidies (Zúñiga-Vicente, Alonso-Borrego, Forcadell, & Galán, 2014). The first concern is whether subsidies are effective in terms of stimulating *additionality*, where additionality refers to new, additional innovation activities on top of what firms already do. Additionality stands in contrast to *crowding out*, where firms use government subsidies to replace their own private investment. In a review of the empirical literature, Zúñiga-Vicente et al. (2014) demonstrate that subsidies typically do not crowd out firms' private innovation efforts. However, the literature to date almost exclusively focuses on evaluating the impact of subsidies from individual sources. This is not a realistic assumption in the European context; firms are faced with a 'policy mix' and often receive a mix of subsidies from different sources at the same point in time (Czarnitzki & Lopes-Bento, 2014; Flanagan, Uyarra, & Laranja, 2011; Guerzoni & Raiteri, 2015). If firms receive a mix of subsidies from regional, national and EU sources at the same time, and this is ignored when evaluating the impact of subsidies from each individual source on firm-level innovation, this can lead to serious over- or under-estimation of additionality (Czarnitzki & Lopes-Bento, 2014; Guerzoni & Raiteri, 2015). This is an important issue for policy-makers; they use evaluation results to judge the extent to which subsidy programmes achieve policy goals and as a guide for future policy decisions (European Commission, 2017).

The second concern is whether subsidies (1) foster innovation activities with high social returns that strengthen the innovation system by supporting riskier, more long-term forms of radical innovation where spillovers are high, as opposed to (2) only subsidize private returns which are often short-term focused, firm-specific and may have been undertaken without the subsidy (Zúñiga-Vicente et al., 2014). Within the existing literature, radical innovation is typically viewed as having higher social returns, while incremental, organizational and process innovations are viewed as typically having lower spillover potential (Beck, Lopes-Bento, & Schenker-Wicki, 2016).

To address these issues, this paper investigates three specific research problems: (1) whether evaluating the impact of subsidies from regional, local and EU source *individually* is biased by ignoring firms that receive a *mix* of subsidies from different sources at the same point in time; (2) whether receiving a mix of subsidies from regional, national and EU sources leads to additionality or crowding out; and (3) whether subsidies from individual sources and subsidy mixes stimulate forms of innovation with higher private or social returns.

It is important to highlight that subsidy recipients and non-recipients often differ systematically in several important characteristics. For example, actual recipients may have had more past innovation success, higher levels of human capital and operate in more innovation intensive sectors (Guerzoni & Raiteri, 2015). These firms may be more likely to apply for and receive subsidies. Even in the absence of any subsidies, these firms may be more innovation active than other firms due to their inherent characteristics. Therefore, simply comparing the innovation activity of subsidy recipients and non-recipients is not a robust methodology. Instead, in line with significant existing research (e.g., Czarnitzki & Lopes-Bento, 2014; Beck et al., 2016) this paper employs a propensity score matching (PSM) methodology. PSM matches subsidy recipients with non-recipients that are identical in all key characteristics, and thus provides the basis for a fair comparison and a robust evaluation of the impact of subsidies on firm-level innovation. As discussed at length by Beck et al. (2016), the PSM methodology also

overcomes the two main problems associated with evaluating subsidies: endogeneity and sample selection bias.

METHODOLOGY AND DATA

In order to compare firms that have received subsidies from different sources (i.e., regional, national and EU levels of governance), it is necessary to use a methodology that allows for a fair comparison between treated firms (firms which receive a subsidy) and untreated firms (firms which do not receive a subsidy). As highlighted in the previous section, there are significant problems with directly comparing treated and untreated firms and, therefore, this paper employs PSM techniques to overcome such issues. These techniques, in essence, compare firms that are similar in all characteristics (e.g., firm size, sector, etc.) with the only difference being that one received a subsidy and the other did not. The specific PSM methodology used in this paper is discussed below.

PSM models facilitate estimating the *treatment effects* of subsidies from different sources:

$$\mathrm{E(aTT)} = \mathrm{E(YT|S} = 1) - \mathrm{E(YC|S} = 1) \tag{1}$$

where firms that receive subsidies are termed *treated* while non-recipients are *untreated*. Therefore, aTT represents the average treatment effect on treated firms; YT is the outcome variable; S = 1 denotes the receipt of a subsidy; and YC is the counterfactual 'potential' outcome if the treated firm had not been treated (S = 0). While YT is directly observable, YC is unobservable and must be estimated.

PSM's main advantage is that it allows the creation of an experimental setting in which treatment effects can be tested using non-experimental data. Due to the likely endogeneity and selection bias of subsidies (Czarnitzki & Lopes-Bento, 2014), a straightforward comparison of average treatment effects for treated and untreated firms does not capture the counterfactual outcome:

$$\mathrm{E(YC|S} = 1) \neq \mathrm{E(YC|S} = 0) \tag{2}$$

As discussed by Mitze (2014), re-establishing the conditions of an experiment overcomes the issue highlighted in equation (2) by matching treated firms that have a set of exogenous characteristics, X, with a control group of untreated firms that are statistically identical to the treated firm in all characteristics except for the receipt of a subsidy:

$$\mathrm{E(YC|S} = 1, \mathrm{X}) = \mathrm{E(YC|S} = 0, \mathrm{X}) \tag{3}$$

If, after matching, there is a significant difference in innovation outcomes between treated and untreated firms, this difference can be attributed to the subsidy. Therefore, we estimate equation (4) to gauge the treatment effect:

$$\mathrm{E(aTT)} = \mathrm{E(YT|S} = 1, \mathrm{X} = \mathrm{x}) - \mathrm{E(YC|S} = 0, \mathrm{X} = \mathrm{x}) \tag{4}$$

All matching criteria are compiled into a single index known as the *propensity score*, indicating the probability of receiving a subsidy (Mitze, 2014). This is achieved by estimating probit models on a dummy variable representing whether or not a firm received subsidies.[1] We employ the 'nearest neighbour' PSM method, which matches treated firms with the three closest untreated firms in terms of their propensity score.[2]

The data used for this study stem from the 2005 Business Environment and Enterprise Performance Survey (BEEPS). BEEPS surveys use stratified random sampling to ensure samples are representative of the relevant population of firms, where the sectoral composition of the sample is determined by their relative contribution to gross domestic product (GDP). The 2005 BEEPS

captures whether firms in Germany, Greece, Ireland, Portugal and Spain received subsidies from regional, national or EU sources, providing a pooled sample of 3342 firms across the five countries. The BEEPS captures detailed information on firms' radical and incremental product/service innovation, process and organizational innovation, and firm-specific characteristics used to calculate the propensity score.[3] Recent empirical work by Crowley (2017), using BEEPS data for Central and Eastern Europe and Central Asia, emphasizes the importance of the regional dimension of subsidies for firms' innovation performance, identifying an urban bias in subsidy distribution across countries. However, although panel data are available for later series of the BEEPS and for other countries, 2005 is the only year for which data on whether firms received subsidies from regional, national and EU sources are available. These data are the key information required to test for subsidy mix effects.

To address the paper's first research problem, two separate PSM models are estimated. The first PSM model analyzes the additionality of subsidies from regional, national and EU sources *individually*, while ignoring whether firms receiving subsidies from these individual sources also received subsidies from other sources. The second PSM model performs the same estimation, except we exclude any firm that received subsidies from any other source than the one under investigation. If there is a significant difference in the results from these first two sets of estimations then this indicates potential bias may exist in estimations that ignore subsidy mix effects.

To address the paper's second and third research problems, we estimate a third PSM model that focuses on the additionality of all potential combinations of subsidies from different sources. This estimation is to gauge directly the effects of the following specific subsidy mixes: (1) regional and national; (2) regional and EU; (3) national and EU; and (4) regional, national and EU. Results from this estimation demonstrate whether receiving subsidies from a mix of sources crowds out firm-level innovation or, if additionality is achieved, whether it has high social returns.

RESULTS

Table 1 presents the results of the empirical estimations. These results indicate that not controlling for subsidy mix does lead to bias when estimating the impact of subsidies from individual sources. In addition, firms receiving a mix of subsidies from national and EU sources are 25% more likely to engage in radical product/services innovation, indicating that subsidy mix can lead to forms of additionality with a high social impact.

Testing for bias

Regarding the first research problem, it is clear that subsidies from each different individual source have a positive impact on all forms of firm-level innovation. This is evident in column (1) of Table 1, which shows the almost universal positive sign and significance of the treatment effects. However, there is clear evidence of bias in the PSM model that does not control for whether firms receive a mix of subsidies from different sources. This is evident in columns (5) and (6), which show the comparison of the results controlling for subsidy mix and not controlling for subsidy mix. The significance of the mean comparison tests highlight the bias introduced by not controlling for subsidy mix in the empirical analysis.

This bias can be demonstrated by an illustrative example. The first row of Table 1 shows that firms receiving subsides from regional sources are 10.91% more likely to engage in radical product/service innovation when compared with matched firms that did not receive regional subsidies. The second row of Table 1 excludes all firms that received subsidies from any other source except the regional source (i.e., national, EU). For those firms receiving subsidies from regional sources only, the average treatment effect is 13.80%. Therefore, in this case, not accounting for subsidy mix leads to an under-estimation of additionality by almost 3%. This means that subsidies from national and EU sources act as confounding factors when evaluating the impact of

Table 1. Innovation output additionality of subsidy variables and test for hidden treatment effects.

		Propensity score matching (PSM)				Mean comparison based on PSM	
Subsidy variables	**Innovation output**	**(1) Treated firms**	**(2) Control group**	**(3) Treatment Effect**	**(4) Standard Error**	**(5) *t*-test for difference**	**(6) *p*-value for difference**
Regional	Radical	243	3099	0.11***	0.04	−6.04	0
Regional only	Radical	166	3176	0.13***	0.04		
Regional	Incremental	243	3099	0.17***	0.04	−4.27	0
Regional only	Incremental	166	3176	0.19***	0.04		
Regional	Process	243	3099	0.15***	0.04	6.13	0
Regional only	Process	166	3176	0.13***	0.05		
Regional	Organizational	243	3099	0.05*	0.03	−22.1	0
Regional only	Organizational	166	3176	0.07*	0.04		
National	Radical	226	3116	0.14***	0.04	2.97	0
National only	Radical	128	3214	0.13**	0.05		
National	Incremental	226	3116	0.11***	0.04	−6.96	0
National only	Incremental	128	3214	0.15***	0.05		
National	Process	226	3116	0.15***	0.04	−6.49	0
National only	Process	128	3214	0.18***	0.05		
National	Organizational	226	3116	0.15***	0.03	2.37	0.02
National only	Organizational	128	3214	0.14***	0.05		
European Union (EU)	Radical	134	3205	0.12**	0.05	−4.1	0
EU only	Radical	67	3275	0.16**	0.07		
EU	Incremental	134	3205	0.076	0.05	−10.3	0
EU only	Incremental	67	3275	0.18**	0.07		
EU	Process	134	3205	0.07	0.05	1.653	0.10
EU only	Process	67	3275	0.06	0.08		
EU	Organizational	134	3205	0.06	0.05	4.514	0
EU only	Organizational	67	3275	0.02	0.07		
Regional and national	Radical	40	3302	0.08	0.08		
	Incremental	40	3302	0.13	0.09		
	Process	40	3302	0.08	0.09		
	Organizational	40	3302	0.13*	0.07		

Regional and EU	Radical	11	2327	0.15	0.18
	Incremental	11	2327	0.36**	0.15
	Process	11	2327	0.30	0.18
	Organizational	11	2327	−0.03	0.14
National and EU	Radical	32	3309	0.25**	0.10
	Incremental	32	3309	−0.02	0.10
	Process	32	3309	0.13	0.10
	Organizational	32	3309	0.28***	0.10
Regional and national and EU	Radical	25	2818	0.01	0.11
	Incremental	25	2818	0.05	0.12
	Process	25	2818	0.07	0.12
	Organizational	25	2818	−0.07	0.09

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

subsidies from regional sources, making regional subsidies appear less effective at stimulating firm-level innovation.

Columns (5) and (6) of Table 1 use the statistical output from the PSM model to perform a mean comparison test between these two results. This comparison shows that the almost 3% difference between these two results is statistically significant. This form of bias is detected, and significant, in all statistically significant results. Therefore, when evaluating the impact of subsidies on firm-level innovation, it clearly demonstrates the importance of accounting for potential subsidy mix effects.

The impact of subsidy mix

The final portion of Table 1 focuses on our second and third research problems, presenting the results for specific mixes of subsidies from regional, national and EU sources. Results indicate that no subsidy mix leads to crowding out. However, in the majority of cases, subsidy mix does not stimulate firms' innovation output.

As noted, the most important exception to this finding is that, compared with matched firms that received no subsidy, firms receiving a mix of subsidies from national and EU sources are 25% more likely to engage in radical product/services innovation. This compares with a treatment effect from only national sources of 12.76% and from only EU sources of 16.41%.

Regarding the impact of subsidies on innovation with a higher social rate of return, EU subsidies have the highest impact on the likelihood of firms engaging in radical innovation (relative to regional and national subsidies). Regional and national subsidies, although stimulating radical innovation, appear to have stronger effects on incremental or organizational innovation. When considering subsidy mix, firms receiving a mix of subsidies from national and EU sources (in contrast to the other subsidy mixes) have the potential for a very high social rate of return, especially given that radical innovation is the most risky form of innovation with the highest spillover potential (Beck et al., 2016).

CONCLUSIONS

This paper evaluates whether receiving a mix of subsidies from regional, national and EU sources crowds out firm-level innovation or leads to forms of innovation with a lower social rate of return. To date, the literature has focused on evaluating the additionality of subsidies from individual sources (Zúñiga-Vicente et al., 2014). We find that subsidies from each individual source are effective at stimulating firm-level innovation. This is particularly the case for regional and national subsidies, which have a positive impact on (1) radical and incremental product/service innovation and (2) process and organizational innovation.

However, drawing on policy mix theory (Flanagan et al., 2011), we argue that evaluations of subsidies from individual sources may be biased because they ignore whether firms receive subsidies from other sources at the same point in time and, therefore, may over- or under-estimate additionality. Our results suggest that ignoring this form of subsidy mix effect in evaluations of subsidies from individual sources results in a significant source of bias. This finding has important implications for policy-makers, who rely on the results of evaluations to gauge the effectiveness of policy and help guide future policy decisions, as well as policy analysts and academics who conduct such evaluations.

Turning to the direct effects of the subsidy mix, the results indicate that receiving a mix of subsidies from regional, national and EU sources does not crowd out firms' innovation activities. While most subsidy mixes are less effective at stimulating firm-level innovation than subsidies from individual sources, firms that receive a mix of subsidies from national and EU sources are 25% more likely to engage in radical product/service innovation. This very high level of additionality, in a form of innovation that has the highest social returns in terms of the spillovers

produced (Beck et al., 2016), provides clear evidence that the subsidy mix can be a highly effective means of stimulating firm-level innovation precisely where market and systemic failures are most acute.

This paper applied a robust empirical methodology to ensure, in so far as is possible, that the results reflect the 'true' impact of subsidies on firm-level innovation. Though the dataset used is large and contains rich information on firms' innovation performance, one limitation of this research is that we only had access to cross-sectional data from 2005. Though this was the most recent edition of the BEEPS dataset that captured information on subsidies from different sources, future research would benefit from more recent survey data. Moreover, an avenue worthy of future exploration could be to apply the framework developed in this paper to data from the harmonized Community Innovation Survey. However, it should be noted that data on regional, national and EU funding for innovation are not universally included in this survey. Therefore, this paper's findings suggest that future editions of the BEEPS, and other firm-level surveys more broadly, could provide important analytical resources if they were to capture consistently the mix of subsidies from different sources available to firms.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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NOTES

[1] The main concern of this paper is to evaluate the impact of subsidies from different sources on firms' innovative performance (not the factors that determine which firms receive subsidies). The probit models are estimated as a necessary step to conduct PSM, not as end results. Therefore, for brevity, the probit models are not presented but are available from the authors upon request.

[2] As robustness tests we also employ two different matching procedures: (1) using only one neighbour in the nearest neighbour approach; and (2) Kernel density matching. All the main results are confirmed in the robustness tests. These results are available from the authors upon request.

[3] Descriptions as well as mean and standard deviation statistics on all variables used are available from the authors upon request.

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