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The Effect of Public Support on Senior Manager Attitudes to Innovation

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ABSTRACT

Senior manager innovation-orientated attitudes are key drivers of innovation within micro and smaller firms. Despite this, little guidance exists on the initiatives organisations can utilise to induce and strengthen such desirable attitudes. In this paper, we investigate whether innovation vouchers, an increasingly prevalent form of public innovation support that funds short-term collaborative projects to solve innovation problems for micro and smaller firms, influence senior manager innovation-orientated attitudes. We use a treatment effects approach to examine our question, specifically, propensity score nearest neighbour matching on a U.K. dataset of firms that received an innovation voucher between 2012 and 2015, and a control group of those that did not. Overall, we find that innovation vouchers induce small positive changes in senior manager innovation-orientated attitudes, with the largest change observed for senior manager openness to external knowledge, followed by risk tolerance. Overall, we show innovation vouchers strengthen senior manager innovation-orientated attitudes, thus advancing insights into the determinants of innovation-orientated attitudes and the additional effects of public support programmes. We discuss implications for innovation policy and practice.

Keywords: Public Support; Attitudes; Support for Innovation; Risk Tolerance; Openness to External Knowledge; Behavioural Additionality; Treatment Effects.

INTRODUCTION

This paper examines how public support for innovation influences senior manager innovation-orientated attitudes. Within the context of innovation, attitudes, of employees and senior managers, have received much attention (e.g., Ahn et al, 2017; Antons and Piller, 2015; Kraiczy et al, 2015a; 2015b), given their influence on the intentions, decisions and behaviours of individuals (Bohner and Dickel, 2011), and subsequently on the strategies and activity of organisations. Specifically, senior manager support for innovation and risk tolerance have been found to be important in creating an innovation-orientated climate within firms where innovation is adequately resourced and employees are encouraged to engage in innovation (Kraiczy et al, 2015a; 2015b; Ling et al, 2008). Moreover, given the increasingly important role of external knowledge in the innovation process (Nieto and Santamaria, 2007; Rodriguez et al, 2017), extant work suggests that attitudes to external knowledge are important through their shaping influence on external knowledge activities (Ahn et al, 2017; Antons and Piller, 2015). Collectively, these three individual innovation attitudes – support for innovation, risk tolerance and attitude towards sourcing of external knowledge - comprise senior manager innovation-orientated attitudes.

While existing work has focused on demonstrating the important consequences of innovation-orientated attitudes for organisation's innovation activities, little guidance exists on the initiatives organisations can utilise to induce and strengthen such attitudes, particularly, we know little about the role of public support for innovation. Psychology literature shows that attitudes are *learned* and consist of the array of evaluative information individuals possess about an object, which is integrated and summarised to generate an evaluative judgement stored in their memory (Bohner and Dickel, 2011; Visser and Mirable, 2004). As attitudes are learned, they can be influenced through learning initiatives that provide individuals with new and persuasive evaluative information about an object (Burcharth et al, 2014; Crano and Prislin, 2006). As demonstrated elsewhere, direct public support for innovation induces learning within organisations, namely, experiential learning through the experience of preforming the innovation project and inter-organisational learning through interactions with funded collaborative partners (Autio *et al*, 2008; Clarysse *et al*, 2009). Focusing on innovation vouchers, an increasingly prevalent form of public innovation support that funds short-term collaborative projects to solve innovation problems for micro and smaller firms (Bakhshi et al, 2015; Sala et al, 2016), we argue that the learning processes induced by innovation vouchers provide new and persuasive evaluative information to senior managers that positively influence their support for innovation, risk tolerance and openness to external knowledge.

We believe advancing this understanding is important for several reasons. First, the extremely resource-constrained nature of micro and smaller firms, could limit their ability to themselves fund learning initiatives (Kotey and Folker, 2007), such as employee training, to induce and strengthen innovation-orientated attitudes (Burcharth et al, 2014). As such, innovation vouchers could be a particularly effective initiative as the voucher (helps to) funds the learning initiative and firms can advance their own innovation efforts through innovation vouchers alongside obtaining attitudinal benefits. Thus, innovation vouchers could represent a resource attractive option for micro and smaller firms. Second, from an innovation policy perspective, scholars have argued that a key objective of public support interventions should be to positively change attitudes to innovation, yet little guidance exists concerning how this can be achieved (Afcha, 2011; Buisseret *et al*, 1995; DITRA, 2006).

Redressing this is important as innovation-orientated attitudes significantly influence firm innovation activities, thus, positively changing such attitudes could amplify policymaker efforts to stimulate greater innovation behaviour (Wong and He, 2003) and result in longer-term impacts on firm innovation activities much sought by policymakers (Roper and Hewitt-Dundas, 2016). Thirdly, despite growing attention to individuals within the innovation process (Enkel et al, 2017; Kraiczy et al, 2015a), research has focused on the firm level impacts of public support (Kang and Park, 2012; Radas et al, 2015), thus limiting insight into the impacts on individual organisational members. Finally, despite constituting an increasingly prevalent component of the policy mix targeted to micro and smaller firms throughout Europe, empirical evidence on the effectiveness of innovation vouchers remains limited (Bakhshi *et al*, 2015; Sala *et al*, 2016).

Our analysis is based on a dataset of firms that received an innovation voucher between 2012 and 2015, and a control group of those that did not. Following others (Radas *et al*, 2015) we employ propensity score nearest neighbour matching to estimate our results. The matching estimator controls for the non-random self-selection process involved in obtaining an innovation voucher (Caliendo and Kopeinig, 2008). We also estimate several checks to assess robustness of our results to the influence of unobserved characteristics, different matching estimators, and different attitudinal measurement scales. Overall, the analysis contributes to the literature on innovation orientation by providing new insights into the external determinants of innovation-orientated attitudes and to the innovation policy literature by providing novel insights into the impacts of public support on attitudes to innovation and knowledge, the micro-level impacts of public support, and the efficacy of innovation vouchers.

This paper proceeds as follows. First, we discuss the conceptual background to our study and develop our hypotheses. Next, the dataset used and methodology employed is outlined. Following this, our results and robustness checks are presented, before discussing the findings, outlining our contributions and highlighting managerial and policy implications.

1. ATTITUDES TO INNOVATION AND KNOWLEDGE

1.1 What are attitudes and how are they changed?

Attitudes are one of the main determinants of human behaviour (Bohner and Dickel, 2011; Chen et al, 2013). Attitudes refer to individuals learned evaluative judgements that predispose them to consistently respond to an object with some degree of (un)favourableness (Antons and Piller, 2015; Ajzen, 2001). They consist of the array of evaluative information individuals possess about an object, which is integrated and summarised to generate an evaluative judgement stored in their memory (Visser and Mirable, 2004). More important and relevant information, and information gained through direct experience of the object is often more salient in constructing an attitude (Bohner and Dickel, 2011; Crano and Prislin, 2006). Alongside beliefs and emotions, attitudes shape “what people see, hear, think and do” (Burcharth et al, 2014; 151). Attitudes guide information processing and search by limiting the field of vision (i.e. where individuals search), selectively filtering the information to which attention is paid and influencing interpretations of information encountered (e.g. perceived information quality) (Bohner and Dickel, 2011; Bohner and Wanke, 2002). Specifically, attitudes bias search and processing toward

attitude congruent information (i.e. confirms or aligns with the existing attitude), with more attention, higher importance and positive understandings attached to congruent than incongruent information (Bohner and Dickel, 2011). Through biasing information search and processing, attitudes also guide intentions, decisions and behaviours toward an attitude object (Ajzen, 2001; Glasman and Albarracin, 2006). The guiding influence of attitudes on individual intentions, decisions and behaviours illustrates the importance of attitudes for organisations (Antons and Piller, 2015; Damanpour and Schneider, 2006). As noted by Burcharth et al (2014; 151), if organisations seek to perform innovation projects, attitudes could “play a dominant role either legitimizing or hindering such new initiatives in being adopted and implemented”.

The importance of attitudes has drawn attention to how they can be changed (Bohner and Dickel, 2011). For example, if negative attitudes to innovation, risk and external knowledge existed, how could firms change attitudes to facilitate innovation? As noted above, attitudes refer to *learned* predispositions and consist of an array of evaluative information possessed about an object (Visser and Mirabile, 2004). As attitudes are learned, attitudes can be “influenced or re-shaped as an effect of learning effects” (Burcharth et al, 2014; 151). Prior research cites learning initiatives as providing new and persuasive evaluative information about an attitude object to an individual, induces change in the array of evaluative information the individual possesses about the object, and through this, attitudinal change (Bohner and Dickel, 2011; Crano and Prislin, 2006). Persuasiveness is critical for attitude change and is largely determined by the content and source (Petty and Wegener, 1998). Content perceived to be relevant, important, favourable and convincing (e.g., causally linking an object with a favourable and likely consequence) is more likely to receive the attention and cognitive effort required to comprehend and evaluate the new information relative to the existing array of attitude information, to induce attitudinal change (Bohner and Dickel, 2011; Petty and Brinol, 2010). Moreover, information from sources perceived to be credible can further increase the persuasiveness of evaluative information and its potential for attitudinal change (Petty and Brinol, 2010). For organisations and policymakers this highlights that attitudes can be influenced and strengthened by initiating learning efforts that expose individuals to new evaluative information, with change more likely if the information is relevant, important, favourable, convincing and from a credible source.

2.2 Senior Manager Innovation-Orientated Attitudes

Senior managers (e.g., founders, CEO and COO) are key drivers of innovation within organisations (Huang et al, 2012; Kraiczy et al, 2015a), particularly within micro and smaller firms where they possess significant power and discretion over strategic choices (Ahn et al, 2017; Marcati *et al*, 2008). Operating under bounded rationality, attitudes shape senior manager interpretation of the available strategic choices by guiding information search, processing and retention (Bohner and Dickel, 2011; Hambrick and Mason, 1984). By shaping interpretation, attitudes significantly influence firm innovation strategy, behaviour and performance (Hambrick and Mason, 1984; Kraiczy *et al*, 2015a; 2015b).

In the context of innovation, three individual attitudes that collectively comprise senior manager innovation-orientated attitudes, have been found to be important determinants of innovation. First, senior manager *support for innovation*, reflected in encouragement for innovative behaviour, assistance in developing new ideas, and the provision of adequate resources to innovation activities (Felekoglu and Moultrie, 2014; Gomes et al, 2001; Green,

1995). This is because support for innovation helps to create a climate of innovation within the firm by providing clear signals to employees about the importance of innovation to the firm and the support for innovative behaviour (Cooper and Kleinschmidt, 1996; Damanpour and Schneider, 2006; Rhee et al, 2010; Scott and Bruce, 1994). These signals can guide employee motivation and behaviour toward greater innovativeness (Mumford, 2000; Yuan and Woodman, 2010). Moreover, support for innovation can enhance the provision of adequate resources, such as time, human capital and finance, to firm innovation activities, which facilitates the development, implementation and adoption of innovations (Cooper and Kleinschmidt, 1996; Hegarty and Hoffman, 1990; Hurley and Hult, 1998).

The second innovation-orientated attitude is senior managers' *risk tolerance*, which reflects their ability and willingness to engage in and encourage behaviours and activities with uncertain outcomes (Gilley et al, 2002; Kraiczy et al, 2015b; Ling et al, 2008). This is because innovation is a risky process with an uncertain distribution of potential outcomes, both negative (e.g., high failure rates) and positive (e.g., successful introduction of new products) (Latham and Braun, 2009). While risk management strategies can mitigate some risk (Kim and Vonortas, 2014), senior managers must still commit finite firm resources ex-ante before the distribution of outcomes is known. Senior managers with lower risk tolerances are likely to focus more on the potential 'negative' outcomes of the distribution, while those with higher risk tolerances focus more on the 'positive' (Ling et al, 2008; Sitkin and Weingart, 1995). Consequently, senior managers with higher risk tolerances are more likely to perform, encourage and allocate resources to innovation activities (Knight et al, 2001; Kraiczy et al, 2015b; Ling et al, 2008). Moreover, senior managers' risk tolerance conveys signals to employees influencing their innovative behaviour (Scott and Bruce, 1994).

Finally, senior manager *openness to external knowledge* reflects their tendency to regularly utilise external knowledge for innovation and objectively value its contribution vis-a-vis internal knowledge. As transferring and utilising external knowledge drives innovation (Nieto and Santamaría, 2007; Rodriguez et al, 2017), senior manager openness to external knowledge drives innovation by shaping external knowledge activities (Antons and Piller, 2015; Burcharth et al, 2014). For example, when attitudes to external knowledge are negatively biased (i.e. not-invented here), firms may not search (optimally) for external knowledge due to a belief that sufficient internal knowledge exists, and when encountered, interpret external knowledge with a negative bias and reject it, regardless of its potential utility (Antons and Piller, 2015; Lichtenthaler and Ernst, 2006; Mehrwald, 1999). In micro and smaller firms, senior manager openness to external knowledge is particularly important given their direct involvement in external search activities (Ahn et al, 2017), as well as their key role in allocating resources and support for employee external search (Ahn et al, 2017; Scott and Bruce, 1994). However, while evidence increasingly demonstrates the importance of innovation-orientated attitudes, less guidance exists on the specific learning initiatives firms can utilise to induce and strengthen such desirable attitudes, particularly, we know little about the receipt of public support for innovation (Ahn et al, 2017; Antons and Piller, 2015; Kraiczy et al, 2015a).

2.3 Public Support for innovation through Innovation Vouchers

Government provides significant amounts of public support (e.g., subsidies) to organisations to stimulate innovation (e.g., Herrera and Nieto, 2008; Hsu et al, 2009; Kang and Park, 2012; Radas et al, 2015). Here we focus on a specific type of public support, namely innovation vouchers. While traditionally most public support focused on larger firms, increasingly micro and smaller firms are targeted, with innovation vouchers a prevalent component of the policy mix for micro and smaller firms throughout Europe. Innovation vouchers aim to incentivise firms to collaborate with a public or private organisation to address an innovation problem the firm is encountering (Bakhshi *et al*, 2015; Cornet *et al*, 2006; Sala *et al*, 2016). Hence, they build on the understanding that external collaboration drives innovation (Nieto and Santamaria, 2007; Rodriguez et al, 2017). Through funding the collaboration, innovation vouchers aim to induce a range of attitudinal, intentional and behavioural changes that increase their future collaboration and innovation propensity (Bakhshi et al, 2015; SQW, 2014). In the U.K., innovation voucher programmes provide organisations with a voucher that has a small monetary value (i.e. £5,000), which is then exchanged with a university or private sector company, in return for short-term collaborative assistance (i.e. 6 months) with their innovation project. Other variations of innovation vouchers exist throughout Europe, with programmes typically varying in the duration of support, partner types and value offered (see Schade and Grigore (2009) for an overview).

It is well established that public support induces learning processes (Autio et al, 2008; Clarysse et al, 2009; Radas et al, 2015; Wong and He, 2003). Specifically, undertaking an innovation voucher project could result in two types of learning, namely, direct experiential learning, through senior manager participation in the funded innovation project, and inter-organisational learning, through senior manager interactions with the knowledge provider as part of their funded project. Given attitudes are learned predispositions that can be altered through learning processes (Burcharth et al, 2014; Crano and Prislin, 2006), our argument is that the learning processes induced by innovation vouchers provide new and persuasive evaluative information to senior managers that influence their support for innovation, risk tolerance and openness to external knowledge. Impacts of public support are assessed via the concept of additionality (Buisseret et al, 1995), which examines how much additional attitudinal change innovation vouchers induce, when compared to the level of attitudinal change that would have occurred if the same participant had not received the innovation voucher (i.e. counterfactual) (Hsu et al, 2009; Radas et al, 2015).

3.0 HYPOTHESIS DEVELOPMENT

Prior empirical research suggests that innovation vouchers fund additional innovation projects that would not otherwise occur (Bakhshi et al, 2015; Cornet et al, 2006; SQW, 2014). Thus, innovation vouchers provide senior managers with new direct experiences of the innovation process. These experiences provide senior managers with new evaluative information that may generate a greater understanding of the innovation process and learning that induces improvements in their absorptive capacity and innovation competences (Knockaert et al, 2014; Radas et al, 2015). For example, Bakhshi et al (2011) noted that 80.3%, 78.8% and 72% of participants in the UK creative credits innovation voucher programme reported increased innovation strengths, successful knowledge transfer and a greater willingness to innovate from innovation vouchers. This enhanced understanding and innovation competences may significantly improve senior manager confidence regarding their ability to successfully conduct

and manage innovation activities in future, resulting in increased support for innovation. In addition, senior managers may also obtain new direct experience of the ‘value’ that innovation processes generate, such as new knowledge creation (Czarnitzki and Delanote, 2015) and innovation outputs (Bakhshi et al, 2015). Senior managers may gain new insights from their interactions with their innovation voucher collaborative partner, such as, a solution to or advice on how to tackle their specified innovation problem, new ideas, new information on markets and technologies, and feedback regarding the efficacy of their project (Laursen et al, 2011), which could significantly enhance future innovation activities. For example, Bakhshi et al (2011) found 75.8% of firms receiving an innovation voucher were more likely to engage in future innovation. These new positive experiences could strengthen support for innovation by providing new evaluative information that demonstrates the positive outcomes from senior managers encouraging and providing resources to innovation activities.

Taken together this suggests innovation vouchers will provide new evaluative information through direct experiences of the innovation process and the positive consequences of innovation that may strengthen support for innovation (Bohner and Dickel, 2011; Green and Cluley, 2014). Moreover, as senior managers actively seek innovation voucher support, we propose that this new evaluative information will be viewed as relevant, and given the information regarding the potential ‘value’ of innovation, it will also be viewed as favourable and convincing. Finally, as senior managers choose their own innovation voucher collaborative partner, we further propose that senior managers will perceive their partner as credible. This suggests the new evaluative information stemming from innovation vouchers will be persuasive (Petty and Brinol, 2010; Petty and Wegener, 1998), increasing the likelihood that it will strengthen support for innovation. Thus:

H1: Receipt of an innovation voucher positively influences senior manager support for innovation.

Participation in an innovation voucher project enables senior managers to directly confront a moderately risky decision, as while the innovation voucher greatly reduces the financial risk, senior managers still commit finite organisational time and non-financial (e.g. materials, human capital) resources to the project. Moreover, some monetary resources are committed as firms must cover the tax associated with the innovation voucher expenditure themselves; which here is 20% value added tax, or up to £1,000. As these resources are extremely limited in micro and smaller firms, senior managers will have chosen to allocate the resources to the innovation voucher project at the expenses of other activities. The experience of this risky decision and of managing the uncertainty associated with the process could provide new evaluative information that alters senior manager perception of the risk and their risk tolerance (Brachert *et al*, 2015; Bohner and Dickel, 2011; March and Shapira, 1987). Studies have shown that senior manager experience of the outcomes of risky decisions influences their risk preferences (Latham and Braun, 2009). That is, the experience of positive outcomes from choices involving risk, results in individuals repeating the decision, i.e. becoming more risk tolerant (Denrell and March, 2001). As prior empirical research shows that public support and innovation vouchers generate value, such as knowledge generation (Czarnitzki and Delanote, 2015) and innovation outputs (Bakhshi et al, 2015), we propose that through experiencing a positive payback from their investments in the innovation voucher project, senior managers risk tolerance will strengthen, as they now associate higher rewards and lower risks with innovation. Moreover, as public support stimulates firms to undertake riskier (e.g., more basic R&D or more technologically challenging) innovation projects than

they would otherwise fund (Falk, 2007; Hsu et al, 2009), senior managers may also gain direct experience of risk in technological and knowledge terms. As with support for innovation, we propose the evaluative information stemming from an innovation voucher will be persuasive to senior managers given its content and source (Petty and Brinol, 2010; Petty and Wegener, 1998). Thus:

H2: Receipt of an innovation voucher positively influences senior manager risk tolerance

Innovation vouchers provide senior managers with direct new experience of external collaboration with a new external partner (Bakhshi et al, 2015; InnovateUK, 2012). This enables senior managers to directly experience the external knowledge being provided by their knowledge provider to their innovation project, and the value the external knowledge contributes to the project. For example, Bakhshi et al (2011) noted 78.8%, 72% and 50.8% of participants in the UK creative credits innovation voucher programme reported knowledge transfer from their knowledge provider, access to specialised skills, and greater insights on new market opportunities that could enhance future innovation efforts. For example, the received knowledge inputs could accelerate firms' innovation projects (Bakhshi et al, 2011; Cornet et al, 2006), enabling them to commercialise and benefit from their project (Knockaert and Spithoven, 2014) and free-up invested resources (e.g., human capital and finance) for other projects (Heijs, 2003) more quickly. The external collaboration experience could also develop managerial cognitions and capabilities to identify, manage and benefit from external collaborations in future (Love et al, 2014; Powell et al, 1996; Sampson, 2005).

Lichtenthaler and Ernst (2006; 376) underscore the important role of (positive) experience influencing attitudes to external knowledge stating firms could “attempt to influence the attitudes of individuals by increasing their experience with external knowledge or by communicating other persons' positive experiences”. Similarly, Mehrwald (1999), Herzog (2011) and Kathoefer and Leker (2012) illustrate the role of experience with external knowledge in shaping attitudes to external knowledge in different contexts. As such, we propose that the additional direct experience senior managers obtain of external knowledge and its value for their innovation activities (e.g., access to specialised skills) through innovation vouchers, provides new evaluative information about the role and value of external knowledge for their innovation activities that stimulates increases in their openness to external knowledge (Antons and Piller, 2015; Lichtenthaler and Ernst, 2006). As above, we propose the evaluative information from an innovation voucher will be persuasive to senior managers given its content and source, increasing the likelihood that it will strengthen openness to external knowledge (Petty and Brinol, 2010; Petty and Wegener, 1998). Thus:

H3: Receipt of an innovation voucher positively influences senior manager openness to external knowledge

4.0 DATA AND EMPIRICAL STRATEGY

The dataset comes from a survey undertaken during 2015 in the United Kingdom. The survey was administered to organisations that received an innovation voucher from Innovate U.K. (IUK) between 2012 and 2015, and to a similar group of companies that had not received an innovation voucher from IUK during this period. IUK is the

U.K. government's national innovation agency, responsible for providing approximately £500 million of innovation support to U.K. firms. They run the largest innovation voucher programme within the U.K, supporting approximately 2,500 firms since 2012. To be eligible for the programme firms must be a micro, small or (less prevalent) medium sized firm (per EU definition) that requires assistance with a problem representing a significant challenge for the company (e.g. new product development). In addition, the firm cannot have previously worked with their proposed partner and can only receive one voucher (InnovateUK, 2012). Unlike most forms of public support (Radas et al, 2015), vouchers are awarded via *random allocation* among firms that apply and meet the eligibility criteria (InnovateUK, 2012). Each voucher is worth a maximum of £5,000 and must be used within 6 months of approval.

Firms that had received IUK innovation vouchers were identified using IUK's register of public innovation support (Gov, 2017). Between September 2012 and May 2015, 2541 firms were awarded an innovation voucher. The survey was administered via telephone to 1,073 of these firms, which had completed their innovation voucher and were contactable via telephone. After removing observations with systematic missing data, 366 responses were received representing a response rate of 34.10%. For this study, we focus on a sub-set on the responses where the respondent was the founder (83% are founders) or a senior management team member (e.g., CEO, MD, COO). This leaves us with 323 respondents (30.10% RR) in the treatment group. The sample is broadly representative of the population in terms of geographic region, firm size and amount claimed. For the control group, the sample was selected to mirror the distribution of size and industry characteristics. Email addresses were obtained from Kompass for the founder, CEO or senior manager of each organisation. The same survey (minus the innovation voucher questions) was administered to 3,256 senior managers via email in 2015, with two follow up reminders sent. After removing observations with systematic missing data, 297 responses were received, representing a response rate of 9.12%. The control sample is broadly representative of the underlying population. Of the total sample, 87.43% are micro firms, 10.8% are small firms and 1.77% are medium firms: 95.58% of the firms have 20 employees or less, hence, we are primarily concerned with very small firms here.

4.1 Econometric Method

Public innovation support typically has two forms of selection. First, firms self-select into programmes and second, policymakers select whom to fund (Radas *et al*, 2015). However, the innovation vouchers examined here are allocated in a random draw (InnovateUK, 2012). That is, firms self-select into the programme and the innovation vouchers are awarded randomly. This allocation mechanism is employed in other innovation voucher programmes (e.g. Bakhshi et al, 2015); however, it is not ubiquitous within the U.K. (e.g. Interface Scotland). The self-selection mechanism means that firms who apply may differ in their underlying characteristics from those who do not. These differences may influence the outcomes of interest meaning the selection effect needs to be explicitly modelled. Matching estimators are a prevalent technique employed to estimate the effectiveness of public innovation support while accounting for selection bias (Radas *et al*, 2015). Here we employ nearest neighbour propensity score matching to estimate our treatment effects (PSM). We chose PSM as it has been shown to generate estimates consistent with true experimental conditions (Dehejia and Wahba, 1999) and requires no functional form or error term distribution assumptions (Caliendo and Kopeinig, 2008). However, a caveat is matching only controls for selection on observable characteristics; thus, we must maintain an assumption that we

observe all important determinants in our models (Caliendo and Kopeinig, 2008). We examine the validity of this assumption in a robustness check (table 5).

Our fundamental question refers to how much additional attitudinal change occurred when the firm received an innovation voucher, when compared to the counterfactual scenario of the same firm not receiving an innovation voucher. The below equation illustrates this question as the average treatment effect on the treated (ATT):

$$E(ATT) = E(A^T | V = 1) - E(A^C | V = 1) \quad (1)$$

Where V refers to treatment status; $V=1$ for the treatment group and $V=0$ for the control group. A^T refers to the outcome variable and A^C the potential outcome realised if the same participant had not been treated. However, as A^C cannot be directly observed - cannot participate and not participate simultaneously – it must be estimated from a control group that did not receive an innovation voucher. However, due to the selection bias outlined above, it cannot simply be the mean difference in the outcomes of participants and a general sample of non-participants (Caliendo and Kopeinig, 2008). We employ Rubin's (1977) conditional independence assumption (i.e. potential outcome and participation are statistically independent for those with the same set of exogenous characteristics) to overcome this selection problem. This allows us to estimate the counterfactual outcome from a control group of non-treated firms that are similar in exogenous characteristics (represented by X in equation (2) and (3)). Matching enables us to identify those with the same set of exogenous characteristics (X) by finding in a group of nonparticipants those most like the treated firms. If the conditional independence assumption holds:

$$E(A^C | V = 1, X) = E(A^C | V = 0, X) \quad (2)$$

and the ATT becomes:

$$E(ATT) = E(A^T | V = 1, X = x) - E(A^C | V = 0, X = x) \quad (3)$$

Here, we conduct PSM, that is, we pair each treated firm with their closest non-recipient. The pairs are selected based on their similarity on the propensity score (represented by x in equation 2 and 3), that is, their probability of receiving an innovation voucher conditional on their exogenous characteristics (X) (Rosenbaum and Rubin, 1983). The propensity score stems from a probit model, with the dependent variable a dummy indicating receipt of an innovation voucher, and the independent variables, the firm and senior manager background characteristics that influence receipt of an innovation voucher (Caliendo and Kopeinig, 2008). We match on the propensity score to overcome the “curse of dimensionality” (Rosenbaum and Rubin, 1983).

In matching, a key assumption is that sufficient overlap exists between control and treated groups (i.e. common support). We estimate common support using *pscore* and drop observations outside this region (Caliendo and Kopeinig, 2008). We also examine the density distribution of the propensity scores in the treated and control groups (Figure 1) (Caliendo and Kopeinig, 2008) to understand if within the common support region, the two groups display similar distributions. Further, even when the overlap assumption is satisfied, it remains that large gaps may exist between the propensity scores of the two closest firms available for match. This would lead to poor matches as the participants being compared are not that comparable. To avoid ‘bad matches’ we implement

a caliper restriction (Caliendo and Kopeinig, 2008), which imposes a threshold to the maximum distance allowed between matched participants. If the distance is above this threshold, the treated observation is dropped to avoid biasing the estimates (Caliendo and Kopeinig, 2008). We follow common practice (e.g. Czarnitzki and Delanote, 2015) by implementing a 0.05 caliper. The matching process is implemented using the ‘teffects psmatch’ command in Stata 14, which matches each treated firm to at least the two closest control firms as standard.

4.2 Treatment Variable

We consider whether the firm has received an innovation voucher from IUK between the years 2012 and 2015. This takes the form of a dummy variable, equal to 1 if the firm received an innovation voucher and 0 otherwise.

4.3 Dependent Variables

We use three attitudinal variables as our outcome variables; namely, support for innovation, risk tolerance and openness to external knowledge. To measure each attitude, we deploy four items for each attitude from previously deployed scales (Burcharth et al, 2014; Cooper and Kleinschmidt, 1996; Hurley and Hult, 1998; Kraiczy *et al*, 2015a; Scott and Bruce, 1994), which capture both direct and indirect measures of the attitudes (Bohner and Wanke, 2002) (Appendix 1). Respondents indicated on a five-point Likert-scale the extent to which they agreed or disagreed with each item. For construct validity, both exploratory and confirmatory factor analyses (EFA & CFA) were estimated. The EFA (varimax rotation with Kaiser normalizations), including all twelve items, indicates a three-factor solution (Hair et al, 2009). Two items did not load significantly (>0.50) onto any factor and are excluded from the analysis (Hair et al, 2009). The re-estimated EFA without these items also indicates a three-factor solution and all ten items load highly (>0.50) onto their intended constructs with no significant cross-loadings (Hair et al, 2009; Farrell and Rudd, 2009). CFA was then performed on each variable (Appendix 1, table A), with comparative fit index, normed fit index and root mean squared error approximation all indicating good model fit. All items have high ($>.696$) statistically significant standardised factor loadings and each construct has an acceptable average variance extracted (0.501 to 0.680) (Hair et al, 2009; Mackenzie et al, 2011). Moreover, the AVE exceeds the square of the correlation between the factors (0.224-0.336) (Hair et al, 2009). For all three attitudes, inter-item correlations (0.50-0.68) all exceed 0.30, inter-total correlations (0.81-0.90) all exceed 0.50, composite reliability (0.75-0.89) exceeds 0.70, commonalities exceed or are extremely close to the conservative 0.50 level (0.484-0.799), and Cronbach’s Alpha (0.751, 0.848 & 0.898) exceeds 0.70 (Hair et al, 2009; Fornell and Larcker, 1981; Nunnally and Bernstein, 1994). Collectively, these tests suggest the construct validity, discriminant validity and reliability of our attitudinal constructs (Cheng and Shiu, 2008; Enkel et al, 2017).

Two main approaches exist to compute the summarized values of our three attitudinal constructs (Hair et al, 2009). First, summated scales, where the arithmetic mean of the respective items for each attitude are summed and then standardised. As each item loads highly onto their respective attitude and possesses acceptable Cronbach’s Alpha, inter-item correlation, item-total correlations, and communalities (see above), our scales display sufficient unidimensionality and reliability to utilise the summated scale approach (Hair et al, 2009). Second, factor scores, where a single score is generated from the factor loadings of all variables loaded on a factor. Factor scores account for the loading value of all items on a factor, hence individuals with higher loadings receive higher scores (Hair

et al, 2009). As summated scales are more commonly used in the innovation literature (e.g., Burcharth et al, 2014; Clausen and Korneliussen, 2012) and more easily interpreted (Hair et al, 2009), we use summated scales to construct our main dependent variables. For robustness, we also estimate the matching with dependent variables constructed from factor scores (Hair et al, 2009) (see table 4).

4.4 Control Variables

We include several firm and senior manager level variables in our probit model that could influence treatment status and innovation-orientated attitudes. First, we include firm age as older firms are often more reluctant to pursue innovation (Balasubramanian and Lee, 2008). We also allow for a potential non-linear relationship by including firm age squared. Second, we include firm size measured as the log of the number of employees in 2012 to control for size influences. Third, we include R&D intensity, measured via the proportion of R&D employees to total employees in 2012, and human capital, measured via the proportion of employees that had a bachelor degree or higher in 2012. We expect firms with higher R&D intensities and human capital to possess greater levels of absorptive capacity and innovativeness, and thus be more likely to seek an innovation voucher and possess innovation-orientated attitudes (Alecke et al, 2012). Fourth, we include export, a dummy variable equal to one if the firm exported during 2012, as exporting firms are often more innovative, potentially due to the learning that occurs from participation in export markets, and thus, may be more likely to seek innovation vouchers and possess innovation-orientated attitudes (Golovko and Valentini, 2011). Following matching best practice, as size, human capital, R&D intensity and export may be affected by treatment, we measure them at the beginning of the innovation voucher period considered (2012) to avoid endogeneity (Caliendo and Kopeinig, 2008). Finally, at the firm level we include NTBF (dummy variable equal to one if the firm is a high or medium technology manufacturing, or a knowledge-intensive business service firm, that is less than five years old), as prior studies suggest NTBF firms benefit more from public support (Czarnitzki and Delanote, 2015), and five industry dummy variables (high-technology manufacturing, medium-technology manufacturing, low-technology manufacturing, knowledge intensive business services, and primary and other industries), to capture industry effects.

At the senior manager level, we first account for the senior manager education, captured via an ordinal education variable ranked between 1 and 3: less than higher education, bachelor degree and postgraduate degree. Those with more advanced levels of education may be more likely to invest in R&D and support innovation, thus, increasing the likelihood to seek innovation vouchers and possess innovation-orientated attitudes (Barker and Mueller, 2002; Honjo *et al*, 2014). We also include other career experience, an ordinal variable indicating how many different industries the senior manager has worked in scaled between 1 and 5. Those with greater other career experiences may be proficient in multiple knowledge domains, have greater diversity of knowledge and higher absorptive capacities, increasing their propensity to seek innovation vouchers and possess innovation-orientated attitudes (Crossland et al, 2014). Further, we account for senior manager enterprise tenure, an ordinal variable indicating how many years they have been at the enterprise, as prior studies suggest senior managers with longer tenures are less inclined to innovate (Barker and Mueller, 2002). Finally, we account for senior managers age and functional background, measured via two dummy variables, the first equal to one if the senior manager is 55 years or older and the second equal to one if the senior manager has a science, engineering or technology background. We

choose these measures as past studies indicate that older senior managers are more conservative, and hence less innovative, and this background is associated with R&D spending (Hambrick and Mason, 1984; Barker and Mueller, 2002).

4.5 Common Method Variance

As survey results may be biased by common method variance (CMV), several ex-ante and ex-post remedies were implemented to reduce CMV concerns (Podsakoff et al, 2012). First, the treatment variable (i.e. innovation voucher) is obtained from a different source (i.e. government records) than the attitudinal variables in the matching and the control variables in the propensity model. Second, the treatment variable is objective (i.e. yes/no), alleviating ambiguity that may increase CMV concerns. Finally, the answer scales of the key dependent and treatment variables are different, alleviating CMV concerns arising from common scale properties. Collectively, these ex-ante remedies reduce the likelihood of a potential CMV influence (Podsakoff et al, 2012). Ex-post two statistical tests were performed. First, Harman's one-factor test, which consists of a factor analysis including all dependent, explanatory and control variables. The variables do not load onto one general factor and the first factor accounts for approximately 36% of the total variance, which despite the limitations of Harman's one-factor test (Podsakoff et al, 2003), suggest no reason to suspect significant CMV. Following recent studies (Bstieler and Hemmert, 2015; Fernandez et al, 2010; Lowe and Alpert, 2015) we also conduct the marker variable technique to consider the potential influence of CMV (Podsakoff et al, 2012). We use foreign group (firms being a member of a foreign enterprise group) as the marker variable, which we do not believe theoretically relates to our dependent variables and possesses the lowest correlation (Lindell and Whitney, 2001). None of the correlations between the dependent and independent variables change notably or become insignificant when accounting for this variable, further suggesting CMV is not a serious problem (Podsakoff et al, 2012).

4.6 Descriptive Statistics

Table 1 presents descriptive statistics for the treated (column I) and control (column II) groups separately. As can be seen, most means of our dependent and independent variables differ meaningfully between the treated and control firms. Treated firms on average seem to be younger, smaller, more R&D intensive and export active and have greater human capital. Treated firm senior managers also have higher levels of education, greater career experiences, shorter tenures, and are more likely to be younger and possess a science, engineering or technology functional background. Moreover, treated firm senior managers possess more positive innovation-orientated attitudes than control firm senior managers.

Table 1: Descriptive Statistics

Variables	Measure	Treated Group		Control Group		T-Test
		Mean	Std Dev	Mean	Std Dev	
Support for Innovation	0-5	4.61	0.50	4.27	0.76	***
Risk Tolerance	0-5	3.94	0.71	3.48	0.90	***
Openness to External Knowledge	0-5	4.23	0.69	3.69	0.85	***
Firm Age	Years	10.86	16.38	12.83	14.05	
Firm Age Square	Years Squared	385.69	2191.21	361.46	1554.18	

Employment (lg)	No of Empl lg	1.21	1.00	1.25	1.13	
R&D Intensity	%	49.61	43.99	25.67	37.51	***
Human Capital	%	52.68	43.63	38.57	42.70	***
Export	0-1	0.33	0.47	0.21	0.41	***
High-Technology Industry	0-1	0.05	0.21	0.08	0.28	*
Med-Technology Industry	0-1	0.16	0.36	0.06	0.24	***
Low-Technology Industry	0-1	0.15	0.36	0.12	0.33	
KIBS Industry	0-1	0.43	0.49	0.23	0.42	***
Primary and Other Industry	0-1	0.04	0.21	0.05	0.22	
New-Technology Based Firm (NTBF)	0-1	0.29	0.45	0.12	0.32	***
SM Education	1-3	2.27	0.74	2.01	0.83	***
SM Enterprise Tenure	1-4	2.39	1.10	2.77	1.16	***
SM Other Career Experience	1-5	3.00	1.36	2.79	1.32	**
SM Science, Engineering or Tech Background	0-1	0.48	0.50	0.29	0.45	***
SM Age	0-1	0.24	0.42	0.35	0.47	***

*** $p \leq 0.01$ ** $p \leq 0.05$ * $p \leq 0.10$

5.0 RESULTS

We first run a probit model to estimate the propensity score. We performed the standard multicollinearity checks on the model, with VIF scores indicating no multicollinearity issues. As shown in table 2, R&D intensive and exporting firms are significantly more likely to self-select into innovation vouchers. Firms whose senior manager possesses a greater level of education are also more likely to self-select into innovation vouchers. Contrary to expectations, the remaining firm and senior manager level characteristics are all statistically insignificant. Next, we match firms based upon the propensity score using the nearest-neighbour method (Rosenbaum and Rubin, 1983). Before we examine our results however, it is imperative to examine how effective the matching has been in balancing the distribution of characteristics in the treatment and control groups. We do this by graphing the density scores pre- and post- matching (Caliendo and Kopeinig, 2008). As seen in figure 1, differences in the density scores prior to matching have been removed, with both samples post-matching, displaying very similar density distributions. Standardised mean differences and t-tests also indicate little difference remaining post-matching (available from authors upon request). Thus, we can conclude the matching was successful in balancing the distribution of relevant covariates and the innovation voucher caused the remaining differences in our outcome variables

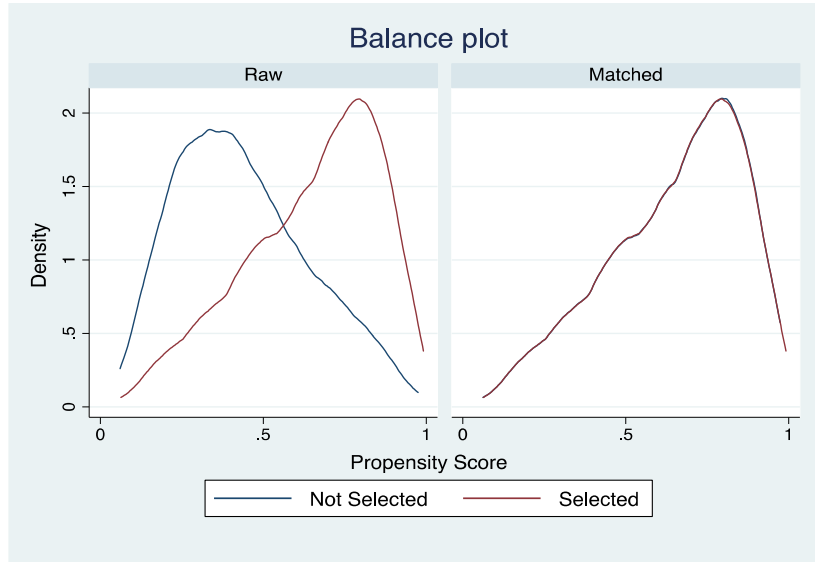
Table 2: Probit Model Results

Variables	Coeff.	Std. Err.	Z
Firm Age	-0.001	0.004	-0.31
Firm Age Square	0.000	0.000	0.82
Employment	-0.022	0.030	-0.74
R&D Intensity	0.002***	0.000	4.30
Human Capital	-0.000	0.000	-0.11
Export	0.155***	0.057	2.67
High-Tech	-0.104	0.100	-1.04
Med-Tech	0.328***	0.091	3.57

Low-Tech	0.265***	0.074	3.58
KIBS	0.284***	0.066	4.27
Primary and Other	0.176	0.110	1.61
NTBF	0.124	0.078	1.58
SM Education	0.063*	0.032	1.93
SM Enterprise Tenure	-0.038	0.028	-1.36
SM Other Career Experience	0.016	0.017	0.95
SM Science, Engineering or Tech Background	0.068	0.049	1.37
SM Age	-0.072	0.053	-1.34
Constant	-0.878***	0.298	-2.95
Observations	549		
Log-Likelihood	-308.912		
Chi-square	136.00		
McFadden R2	0.1804		

*** $p \leq 0.01$ ** $p \leq 0.05$ * $p \leq 0.10$. Marginal effects at the mean are reported.

Figure 1: Density Distributions of Propensity Score Pre- and Post- Matching



Our results are shown in Table 3 as ATT. We find support for hypothesis 1, as innovation vouchers have a small positive impact on senior manager support for innovation, strengthening their attitude by 0.179 points or 4.05% ($p < 0.05$). We also find support for hypothesis 2, as innovations vouchers have a small positive impact on senior manager risk tolerance, strengthening their attitude by 0.221 points or 5.97% ($p < 0.05$). Finally, we find support for hypothesis 3, with innovation vouchers having a small positive impact on senior manager openness to external knowledge, strengthening their attitude by 0.264 points or 6.65% ($p < 0.01$). Overall, the results indicate innovation vouchers induce small positive changes in senior manager attitudes to innovation, with the largest attitudinal change observed for openness to external knowledge. Given innovation vouchers explicitly involve firms participating in a new collaborative relationship (Bakhshi *et al*, 2015; Sala *et al*, 2016), the evaluative information senior managers obtain from innovation voucher participation may more directly relate to external knowledge.

Table 3: Propensity Score Nearest Neighbour Matching Results

Variables	Obs	Treated (Max 5)	Control (Max 5)	Difference	Diff as %	Std Err.	Z
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Support for Innovation	530	4.61	4.43	0.179**	4.05%	0.080	2.24
Risk Tolerance	530	3.93	3.70	0.221**	5.98%	0.106	2.09
External Knowledge	530	4.24	3.97	0.264***	6.65%	0.102	2.58

*** $p \leq 0.01$ ** $p \leq 0.05$ * $p \leq 0.10$

6.0 ROBUSTNESS CHECKS

We test the robustness of our results against three scenarios, beginning with different constructions of our dependent variables. First, prior innovation studies suggest respondents have difficulty making fine-grained distinctions on Likert scales, for example between agree and strongly agree, which may introduce measurement error (Leiponen and Helfat, 2010). To examine if this influences our results, we generate new dummy variables for each of the 10 attitudinal measure items, equal to one if the respondent agreed or strongly agreed, and zero otherwise. We then sum the 10 attitudinal measures onto their three respective attitudinal variables. We re-estimate our matching models with the new summed dummy variables as our dependent variables. As seen in table 4 column I, we again find small statistically significant positive impacts, indicating the robustness of our results.

Second, the summated scale approach we and others (Burcharth et al, 2014; Clausen and Korneliussen, 2012) utilise to construct our dependent variables has limitations if the variance of the four items are heterogeneous (Di Stefano et al, 2009). While the dimensionality and reliability tests (section 4.3) indicate our items possess sufficient unidimensionality and reliability to utilise the summated scale approach (Hair et al, 2009), we nevertheless check the robustness of our results. Factors scores alleviate this limitation by accounting for the loadings of all items onto a factor (Di Stefano et al, 2009). The re-estimated results using factor score dependent variables are shown in table 4 column II. As can be seen, we again find small statistically significant positive impacts, further supporting the robustness of these results.

Table 4: Robustness Check - Matching with Dummy and Factor Score Dependent Variables

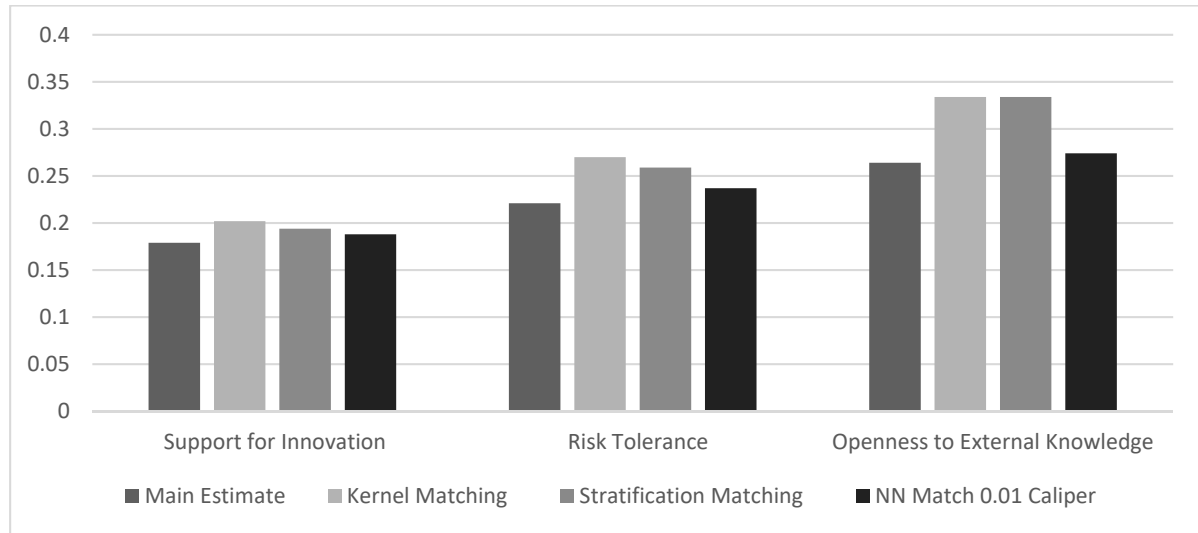
Dependent Variables	Summed Dummy (I)				Factor Score (II)		
	Obs	Difference	Std Err.	Z	Difference	Std Err.	Z
Support for Innovation	530	0.269**	0.109	2.46	0.242**	0.114	2.13
Risk Tolerance	530	0.307**	0.124	2.46	0.288***	0.111	2.58
External Knowledge	530	0.302**	0.138	2.17	0.223**	0.102	2.18

*** $p \leq 0.01$ ** $p \leq 0.05$ * $p \leq 0.10$

Next, we examine the sensitivity of our results to the use of a different matching estimator, as while different matching estimators generate the same results when undertaking exact matches with growing sample size, when the sample is smaller, treatment estimates can differ (Caliendo and Kopeinig, 2008). We re-estimate the results using kernel (matches firms using a weighted average of all control firms to construct the counterfactual), stratification (divides the propensity score into a set of intervals and within each interval estimates treatment

effects using the mean difference between the control and treatment groups) and nearest neighbour matching with the caliper restriction equal to the standard error of the propensity score (matches to the closest control firms within the 0.01 caliper) to examine the sensitivity of the results. These represent three of the other most common matching estimators (Alecko et al, 2012). As shown in figure 2, all estimators suggest similar estimates to our main estimates, suggesting our results are robust across matching estimators.

Figure 2: Robustness Check – Treatment Effect Estimations by Different Matching Approaches



Finally, matching relies on the conditional independence assumption, yet only controls for observable characteristics, meaning some unobservable characteristics (i.e. hidden bias) may exist that would violate this assumption. As this assumption is directly untestable, a sensitivity analysis can provide insight about whether plausible hidden bias exists that would undermine the matching results (Caliendo and Kopeinig, 2008). We implement a simulation-based sensitivity analysis (Nannicini, 2007) that includes simulated dummy variables in the propensity model representing different severities of hidden bias (See Ichino *et al* (2008) for a detailed explanation). First, we simulate a variable that mimics senior manager postgraduate education, which represents hidden bias in terms of senior manager ability (Barker and Mueller, 2002). Second, we follow Nannicini (2007) by generating two variables; the first considers the presence of a neutral hidden bias (i.e. occurs equally in all groups) and the second, a hidden bias that occurs much more when the firm is treated or has an above median strength attitude (i.e. strong confounder). The probabilities of these hidden biases occurring are represented by the outcome effect (occurring when firm is not treated and the senior manager has an above median strength attitude) and the selection effect (occurring when firm receives the treatment) in table 5. If the hidden bias drives our treatment estimates to zero under any plausible scenario, then our results are not considered robust to hidden bias (Nannicini, 2007). As seen in Table 5, the treatment estimates are equivalent to our main estimates when considering the presence of a neutral hidden bias and a hidden bias that mimics senior manager ability (i.e. postgraduate education). A strong hidden bias reduces the treatment estimate by approximately 58% for risk tolerance, 45% for support for innovation and only 28% for openness to external knowledge. As none of the treatment estimates reach zero, we can conclude that hidden bias would not significantly influence the implications of our results (Nannicini, 2007; Ichino *et al*, 2008).

Table 5: Sensitivity Analysis for Influence of Unobserved Characteristics

	Outcome Effect	Selection Effect	ATT	S.E.
<i>Support for Innovation</i>				
No Confounder			0.179	0.080
Neutral Confounder	1.072	1.021	0.190	0.108
Strong Confounder	4.247	6.550	0.099	0.141
Postgraduate	2.557	1.418	0.178	0.112
<i>Risk Tolerance</i>				
No Confounder			0.221	0.106
Neutral Confounder	1.087	1.023	0.233	0.144
Strong Confounder	4.422	7.219	0.094	0.191
Postgraduate	1.883	1.437	0.216	0.149
<i>Openness to External Knowledge</i>				
No Confounder			0.264	0.102
Neutral Confounder	1.070	1.040	0.306	0.127
Strong Confounder	4.483	6.695	0.192	0.168
Postgraduate	2.288	1.418	0.296	0.132

*Estimated using the Sensatt procedure in Stata (Nannicini, 2007).

7.0 DISCUSSION

This paper has investigated how innovation vouchers, through stimulating learning processes that provide new and persuasive evaluative information regarding innovation, risk and external knowledge, influence senior manager innovation-orientated attitudes within micro and smaller firms. Our main results and multiple robustness checks consistently show that innovation vouchers induce small positive changes in senior manager support for innovation, risk tolerance and openness to external knowledge. Thus, the results show innovation vouchers could play a key role in aiding firms to stimulate learning processes that provide new evaluative and persuasive information to strengthen these desirable attitudes (Bohner and Dickel, 2011; Clarysse et al, 2009). The magnitude of the attitudinal benefit for senior manager openness to external knowledge is marginally greater than for support for innovation and risk tolerance. This suggests that while innovation vouchers are effective in inducing learning that provides new and persuasive evaluative information about innovation, risk and their positive paybacks for organisations, the evaluative information relating to the role and value of external knowledge is particularly effective for attitudinal change. This could be because while all innovation voucher projects directly involve collaboration (Bakhshi et al, 2015; Cornet et al, 2006), thus providing new evaluative information regarding the role and value of external knowledge, the extent of innovation and risk could vary across projects (Bakhshi et al, 2011), and thus also the amount of evaluative information relating to innovation and risk. As such, the results suggest innovation vouchers are particularly an effective mechanism to acquire direct (positive) experience of external collaboration and positively alter senior manager openness to external knowledge. This is consistent with Mehrwald (1999), Herzog (2011) and Kathoefer and Leker (2012) who demonstrated the key role of direct and positive experience with external knowledge in changing attitudes to external knowledge. Moreover, the results also show the attitudinal benefit on risk tolerance is marginally greater than support for innovation. This suggests more of the evaluative information stemming from innovation vouchers relates to risk, or the evaluative information relating to risk is more persuasive.

However, while effective in stimulating attitudinal change, the amount of attitudinal change is small in all cases, ranging from between 4%-6%. This is consistent with other empirical research on innovation vouchers (Bakhshi et al, 2015; Sala et al, 2016), and more generally, the size of impacts identified from other forms of direct public innovation support (Herrera and Nieto, 2008; Kang and Park, 2012). For example, Dimos and Pugh (2016; 810) in a meta-analysis note “estimates of the genuine empirical effect mainly indicates a “small” positive effect”. In the case of innovation vouchers, the small magnitude of attitudinal effects could be attributed to the short duration of the support and the limited resources provided, limiting the amount of new and persuasive evaluative information stemming to senior managers, and thus their potential for attitudinal change. This aligns with existing research suggesting the extent of exposure influences attitudinal change (Holland et al, 2003) and that the number of collaborative interactions in publicly funded projects influences the amount of learning (Autio et al, 2008; Knockaert et al, 2014).

7.1 Implications for theory

First, we contribute to the literature on innovation-orientated attitudes by providing new insights into the learning initiatives firms can utilise to induce and strengthen these attitudes. Specifically, we extend understanding beyond firm level factors, such as employee training and socialisation processes (Burcharth et al, 2014; Burcharth and Fosfuri, 2014), by illustrating the important role innovation vouchers, through providing new and persuasive evaluative information, can play in stimulating positive attitude change. This demonstrates the utility of contextual factors, specifically public support for innovation, for firms to induce positive change in attitudes to innovation, risk and external knowledge (Ahn et al, 2017; Antons and Piller, 2015; Kraiczy et al, 2015a; 2015b). Moreover, our results extend prior studies which have focused on innovation orientation in large firms and SMEs (Kraiczy et al, 2015a) by providing evidence on the determinants of innovation-orientated attitudes in micro and smaller firms.

Second, we contribute to the innovation policy literature by advancing understanding of the additional impacts of public support for innovation (Herrera and Nieto, 2008; Hong et al, 2016; Kang and Park, 2012; Radas et al, 2015). Specifically, we demonstrate the efficacy of innovation vouchers in inducing positive changes in senior manager innovation-orientated attitudes, thus responding to the dearth of empirical evidence on behavioural additionality (Clarysse et al, 2009) and existing works assertion that a key objective of public support should be to positively change attitudes (Buisseret et al, 1995). In doing so, we advance a more nuanced understanding of the types of impact public support stimulates and should target when aiming to support innovation. This is important considering senior manager and employee attitudes can support or hinder innovation activities (Ahn et al, 2017; Burcharth et al, 2014; Wong and He, 2003). For example, the presence of negative attitudes to external knowledge within a firm could hamper policymaker efforts to stimulate greater engagement in external collaboration (King and Park, 2012; Hong et al, 2016). As such, public innovation support positively changing attitudes could strengthen policymaker efforts to stimulate greater innovation behaviour by creating more conducive innovation environments within firms. Moreover, changing attitudes could result in the longer-term innovation impacts sought by policymakers (Roper and Hewitt-Dundas, 2016), through attitudes influence on senior manager intentions, decision-making and behaviour (Kraiczy et al, 2015a). Thus, we call attention to the

need for greater focus on the under-developed attitudinal component of behavioural additionality (Afcha, 2011; Buisseret *et al*, 1995; DITRA, 2006). Moreover, the potential longer term impacts stemming from attitudinal change highlights the need for more longitudinal evaluation designs when examining the impacts of public support (e.g., Bakhshi *et al*, 2015).

Third, while existing empirical research has focused on firm level impacts of public support, we respond to calls for greater examination of additionality at different levels of analysis (Gok and Edler, 2012; Antonioli and Marzucchi, 2012) by illustrating additionality at the individual level. Strategic management (Felin and Foss, 2005) and innovation (Enkel *et al*, 2017) research increasingly recognise that to gain more granular understandings of organisations we need to examine the individuals that comprise them. Our findings support this idea, highlighting the need for policymakers and scholars to consider the individual level impacts of public support, if more accurate and comprehensive understandings of its effectiveness are to be obtained. Finally, we contribute new empirical evidence on the effectiveness of innovation vouchers at inducing additionality (Bakhshi *et al*, 2015; Cornet *et al*, 2006; Sala *et al*, 2016) thus, joining emerging research in suggesting innovation vouchers are a useful instrument to increase the innovativeness of micro and smaller firms, which are increasingly viewed as important sources of innovation (Baumann and Kritikos, 2016).

From a methodological perspective, this paper contributes in two ways. First, the sensitivity analysis shows accounting for unobserved heterogeneity (significantly) *reduces* the size of matching estimates of additionality. Given the limited empirical work accounting for unobserved heterogeneity (Alecke *et al*, 2012; Radicic *et al*, 2016), this suggests literature may currently over-estimate additionality effects (Dimos and Pugh, 2016). We join Radicic *et al* (2016) in presenting sensitivity analysis as an important method to account for the influence of unobserved heterogeneity. Second, the probit results show senior manager characteristics drive participation decisions into innovation vouchers. This joins recent studies (Enkel *et al*, 2017) in showing the importance of individuals for innovation and suggests matching research must move beyond solely controlling for firm characteristics (Radas *et al*, 2015), to also considering individual level characteristics, if the conditional independence assumption underpinning matching validity is to be satisfied (Rubin, 1977).

7.2. Implications for Policy & Practice

For policymakers, this paper calls attention to the need for greater focus on attitudes within innovation policy. Senior manager and employee attitudes can hamper or support firm innovation activities, and our results suggest innovation vouchers are an effective tool to stimulate positive attitudinal change. Incorporating a greater focus on stimulating attitudinal change, particularly of senior managers given their significant influence on firm decisions and behaviour, within innovation policy, could aid in stimulating firms to innovate by creating more innovation-orientated environments (Ahn *et al*, 2017; Kraiczy *et al*, 2015a). From a practical perspective, the results call attention to the attitudinal benefits of public support for micro and smaller firms. Particularly, innovation vouchers appear beneficial for increasing senior manager openness to external knowledge, which could aid firms in combating not-invented-here syndrome (Antons and Piller, 2015) and increasing their engagement in collaboration to spur innovation. Given the resource-constrained nature of micro and smaller firms, which could

limit their ability to themselves fund learning initiatives to stimulate attitudinal change (e.g., training) (Kotey and Folder, 2007), innovation vouchers could be a particularly attractive mechanism. As first, the support (helps to) funds the initiative to induce the attitudinal benefits and second, firms can advance their innovation projects through innovation vouchers alongside obtaining the attitudinal benefits. The key takeaway for policymakers and managers is innovation-orientated attitudes matter and innovation vouchers are a resource effective method to strengthen these attitudes.

7.3. Limitations and Future Research

Our study has several shortcomings that offer opportunities for future research. First, while we demonstrate the impact of innovation vouchers on senior manager innovation-orientated attitudes, future research could pursue other attitudinal impacts. For example, willingness to change (Musteen et al, 2006) or not-shared here (Burcharth et al, 2014) attitudes, given the potential relevance of the new evaluative information for the value of change processes (e.g., value of organising innovation differently through greater external knowledge utilisation) and external knowledge (see hypothesis 3), could be influenced, and hence represent fruitful areas for future research. Second, examining the generalisability of our findings to other programmes and organisational levels would be valuable. For example, many programmes do not explicitly involve external collaborations, and hence may offer fewer opportunities, or potentially different mechanisms, for attitudinal change. Moreover, in R&D subsidy programmes, where larger firms are more common, senior managers may be too far removed from the supported project to experience attitudinal effects. In such cases, R&D managers or the individual employees involved in the funded project could be more appropriate levels of analysis. Third, as common in additionality studies (Czarnitzki and Delanote, 2015; Radas et al, 2015) our control group could include both those firms who applied but were unsuccessful and those who did not apply at all. While the former is the ideal control group, given they also applied for the programme and were only unsuccessful due to random allocation; this group is not explicitly available for our study due to a lack of accessible information. Future work could strive to identify this group explicitly to achieve more fine-grained understanding of the influence of different control group states (e.g., didn't apply; applied but unsuccessful) on matching results. Finally, as our data is cross-sectional and we employ PSM, we are only able to control for observable differences in one period. While our results appear robust against unobserved heterogeneity, future studies should strive to collect and use panel data, with before and after observations, to control for selection on (un)observables, and gain a better understanding of innovation voucher effectiveness (over time). Moreover, these datasets would enable the examination of the longer-term impacts we suggested.

7.4 Conclusions

In this paper we examined how innovation vouchers, an increasingly prevalent form of public innovation support targeted to micro and smaller firms throughout Europe, influence senior manager innovation-orientated attitudes. After controlling for the self-selection bias inherent in innovation voucher treatment, we find that innovation vouchers, through providing new and persuasive evaluative information, induce small positive changes in senior manager support for innovation, risk tolerance and openness to external knowledge. The largest effect is observed on openness to external knowledge, suggesting innovation vouchers are a particularly effective mechanism to

change attitudes to external knowledge. Overall, these results provide new insights for innovation scholars, policymakers and managers regarding the effective learning initiatives firms can utilise to induce and strengthen innovation-orientated attitudes and the types of additionality impacts stimulated by public support for innovation.

APPENDIX

Table 1: Scale items for support for innovation, risk tolerance and openness to external knowledge

Construct	Items	Factor Loadings	Average variance extracted (AVE)
<i>Support for innovation</i>	I encourage creativity	0.819***	0.680
	I actively seek innovative ideas	0.890***	
	I try to assist in developing new ideas	0.868***	
	I want to provide adequate resources to innovative activities.	0.711***	
<i>Risk Tolerance</i>	I frequently venture into unknown territory on projects.	0.696***	0.501
	I strongly encourage employees to take risks.	0.705***	
	I perceive innovation as too risky and resist it ^{ab}	/	
	I am willing to stick my neck out and take risks.	0.724***	
<i>Openness to External Knowledge</i>	I regularly use knowledge from external partners in innovative projects.	0.749***	0.652
	The application of external knowledge to our innovation projects is as valuable as the application of knowledge generated internally.	0.832***	
	Knowledge from external sources significantly contributes to our innovative efforts.	0.839***	
	I have more trust in knowledge generated internally, than in knowledge generated externally ^{ab}	/	

Note: Items measured on a Likert scale from 1 to 5. *** $p \leq 0.01$ ** $p \leq 0.05$ * $p \leq 0.10$. The p-value indicates the statistical significance of the factor loading in the CFA models. ^a Item excluded in EFA due to insignificant (<0.50) factor loading. AVE calculation does not include item as it does not form part of the final factor solution (Hair et al, 2009). ^b Reverse coded.

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