You can lead a firm to R&D but can you make it innovate?

UK Evidence from SMEs

Professor Marc Cowling[1]

Brighton Business School

England

E-mail: M.Cowling2@brighton.ac.uk

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Abstract

The UK Government introduced tax credits for SMEs to promote and support R&D in 2000. Since then the policy has become more generous in this respect, particularly since 2008. In this paper we use the National Systems of Entrepreneurship (NSE) as a conceptual framework in which to question whether SMEs take-up of tax credits has actually led to an increase in product, service, or process innovations. Our evidence suggests that (a) SME engagement with the policy is fairly randomly distributed across the sector, and (b) there is little additional product-service innovation to justify the expenditure in foregone taxes given the current distribution of credits, but (c) there is evidence of enhanced radical process innovations, particularly when combined with strong capability and planning at the firm level.

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1. Introduction

"Long-run economic growth and welfare resides on the production of new knowledge and its implementation into new or improved products or processes. For this reason, identification, evaluation and correction of the detrimental effects of potential under-investment in R&D activities have a prominent place in the policy agendas of all industrialized countries." (Mancusi and Vezzuli, 2014, p.1)

In this paper we use the National Systems of Entrepreneurship (NSE) conceptual framework to trace out the effects of a change in the institutional (innovation focus) and policy (R&D tax credits) regime designed to remove a perceived barrier to entrepreneurial innovation by examining the extent to which the entrepreneurial population engaged with the new regime and policy and whether the expected gains from doing so were realised. The policy shift reflected political and economic concerns that the UK was under-performing on innovation to the extent that Freel (2000; p.60) concluded that, "despite the universally declared primacy of innovation in economic and firm growth, standard measures point to a historical and continuing under-achievement in the UK". This conclusion was restated by Mancusi and Vezzuli (2014) in relation to Europe. Further, there were related concerns that SMEs in particular faced a binding constraint when seeking to invest in R&D and innovation (Lee, Sameen, and Cowling, 2015; Czarnitzki, 2006; Czarnitzki and Hottenrott, 2011).

As to why there might be an under-investment in R&D, the seminal work of Arrow (1962) argued that it is a widely held view that the private returns to knowledge production have been below the social returns. At the heart of this lies the inability of private firms to fully appropriate the returns to innovation outputs particularly where technology spill-overs exist which act to reduce the private sector's incentives to engage in the socially optimal level of innovative activity (Guceri, 2013). In this sense there is a part of R&D investments can be considered as a public good. And it is this aspect which has encouraged governments across the world to intervene in the market to encourage private firms to undertake higher levels of R&D than they might choose otherwise.

As entrepreneurs are assumed to be the key agents driving innovation (Acs and Audretsch, 1988), it is appropriate here to consider how entrepreneurs' willingness and ability to innovate are shaped, and potentially constrained, by the entrepreneurial ecosystem they operate in. The concept of National Systems of Entrepreneurship (NSE) provides a focus and a context within which to examine these relationships. Here country level entrepreneurship is a systematic phenomenon in which infrastructure, policies and institutions "determine a country's ability to produce and take advantage of scientific discoveries and technological innovation" (Acs, Autio, and Szerb, 2014; p.476). This framework reinforces the links between population-level processes and the institutional context within which these processes are embedded.

The importance of NSE is well grounded in the empirical literature which has established three features of country-level entrepreneurial activity. Firstly, entrepreneurial performance is driven by complex and systematic interactions. Secondly, there is a pathdependency in the sense that country-level entrepreneurial differences persist over time (Levie and Autio, 2011). Thirdly, individual entrepreneurial action is regulated by contextual factors, specifically, culture, institutions, and resource munificence (Autio and Acs, 2010). In our context this is important as we are implicitly questioning whether the UK governments' intervention in the NSE driven by institutional (innovation related R&D policy) change aimed at alleviating an entrepreneurial resource constraint (the user cost of capital), through its interactions with the entrepreneurial population, supported higher innovation performance levels.

The NSE conceptual model argues that the actions of entrepreneurs are an important element of the entrepreneurial process, but it is the interaction between the entrepreneurial and institutional context that is critical. And it is this process that drives the allocation of resources. This is distinct from the National Systems of Innovation (NSI) literature which largely places the entrepreneur as a secondary agent in a system where the production of opportunities is determined by institutional factors. Indeed, the NSI literature (Radosevic, 2007) has empirically captured entrepreneurial activity, not as an individual actor, but as a process of experimentation. In this framework, who is performing the entrepreneurial function is secondary.

More broadly, the NSE model argues that economic development depends in alleviating the binding institutional barriers, in this case those preventing entrepreneurs from realising their innovation potential. This requires that policy intervention must be co-ordinated across policy domains relevant to entrepreneurship in recognition of the fact that policy actions are, to a significant degree, inter-dependent. This was highlighted in a

UK empirical study of innovation and growth in high-tech firms (Coad, Cowling, Nightingale, Pellegrino, Savona and Siepel, 2014) which showed that superior innovation driven outcomes required not only financial capital for investment in R&D, but the human capital resources to efficiently use this financial capital. In isolation having more of either was highly inefficient.

2. The UK Institutional and Policy Regime (NSE)

In the context of the UK, and more specifically its' SME sector, the government was initially concerned with incentivising innovation through tax incentives by encouraging higher levels of informal and formal equity investment. This, it was believed, would allow experienced business angels and venture capitalists to target innovative SMEs with the highest growth potential and channel 'patient' capital to them. The end policy goal in this context was more innovation and indirectly more jobs and higher levels of productivity through the creation of more new technology based firms (NTBFs) and the growth of existing new technology based firms (Cowling, Bates, Jagger, and Murray, 2008).

The chosen vehicles were the Enterprise Investment Scheme (focusing on individual equity investors making direct investments in SMEs) and Venture Capital Trusts (focusing on pooling individual investor investment capital and making larger venture capital investments in SMEs). The EIS was initiated in 1994 and the VCT scheme in 1995. Both schemes are still running today with more favourable tax relief terms on investments (30%) than was the case in their founding years (20%).

The policy focus on directly attempting to stimulate higher levels of R&D from the UK SME sector began in 2000 with the SME R&D Tax Credit scheme which had a rate of relief amounting to 150 percent of eligible expenses. In 2008, this rate was raised to 175 percent, and increased further to 200 percent in 2011 and 225 percent in 2012. This type of policy intervention is used widely across the developed world (Lokshin and Mohnen, 2010), who state that many governments rely on fiscal incentives to lower the user cost of R&D and thereby stimulating business investment in research and development above the level that would occur in the absence of such incentives. They further contend that the market failures due to R&D externalities and asymmetric information between lenders and borrowers for the financing of R&D projects are often cited to justify the existence of such government programs. But the scale of foregone tax is not trivial (OECD, 2007).

3. R&D, Tax Credits, and Under-investment

There is a large body of literature that has established the key role that R&D plays in explaining variations in the growth and productivity rate of firms, regions, and countries (Aghion and Howitt, 1998; O'Mahony and Vecchi, 2009; Bravo and Marin, 2011). Government interest in R&D policy has reflected the fact that it typifies the public goods problem in that the social returns to undertaking R&D are often higher than the private returns (Becker, 2014; Grilliches, 1998). The most common policy interventions to address this under-investment problem are R&D tax credits and direct R&D subsidies. In a broad ranging review of the early empirical literature on the effects of R&D tax credits, Hall and van Reenan (2002) generally found a positive effect on R&D

expenditure, although the magnitude of the effects exhibited substantial variation. The body of more recent empirical work has largely taken advantage of more sophisticated econometric techniques that are available and we briefly review this work.

An empirical study of the UK from Guceri (2013) took the addition of the large company R&D tax credit scheme as a natural experiment and posed the critical question of whether the R&D impact generated through the this widening (raising of the firm size threshold) of R&D tax relief was "high enough for these enhanced tax incentives to generate the desired level of R&D expenditures by the private sector" (p.1). Her findings, using a DID approach, found that, relative to the SME scheme, the large firm scheme stimulated positive returns for the economy measured by increased cash value of R&D minus the cash value of foregone tax. But this neglected, to a large degree, the fact that after the first two years of the SME scheme when R&D spending rose from 6.8% to 7.0% of sales, by 2004 mean R&D spend for SMEs had fallen to 6.4% of sales.

The empirical question tested by Lokshin and Mohnen (2010), using Dutch data for the WBSO (R&D fiscal incentive programme), was whether this increased the level of R&D conducted, by lowering the user cost of capital. They concluded that the WBSO had increased the overall level of R&D spending, but importantly, that, "the long-term ineffectiveness of a fiscal incentive scheme like the Dutch WBSO reflects the dead-weight loss related to a level-based system of R&D tax incentives" (p.16). But they also concede that substantive R&D spill-overs have been reported in the literature and in principle, would act as a positive counterbalance to the inefficiency of the R&D support scheme. Bloom, Griffith and Van Reenen (2000), in their long panel of nine OECD countries, found that tax incentives were effective in increasing R&D intensity, and additional evidence that the generosity of the incentive can affect firms' locational decisions.

A Norwegian study by Cappelen, Raknerud, and Rybalka (2012) is closest to ours in that it considered whether the SkatteFUNN R&D tax credit impacted on the recipient firms innovation activities, including new or improved products, to the firm and market, new or improved processes, and patent applications. Using the innovation survey, they report that 36.1% of firms accessed the tax credit over a three year period, 36.7% introduced a new to firm product, 19.5% a new to market product, and 22.4% a process innovation. Their general results show that the tax credit contributed to process innovation and incremental product-service innovation (new to firm but not market), but not patenting activity or radical (new to market) innovation. They conclude that these sorts of improvements were unlikely to be associated with significant spill-overs that generate the wider benefits that policy-makers desire. The Norwegian findings contrast with those identified in a similar Canadian R&D tax credit study (Czarnitzki, Hanelc, and Prosad, 2011), which, using a cross-sectional manufacturing innovation survey, found that R&D tax credits had a positive impact on innovation outputs including product innovations and sales growth associated with those innovations. They also found that radical (Canada first and new to world) innovation was associated with the tax credit.

So what is the broader goal of governments in incentivising R&D? This can be traced back to the endogenous growth models of Romer (1990) and Aghion and Howitt (1992).

This class of models are characterised by large scale effects linking country level R&D to the growth of technological knowledge in a direct and positive way (Bottasso, Castagnetti and Conti, 2013). It follows that a fundamental measure of country economic well-being, such as GDP per worker, grows largely through a knowledge accumulation process given diminishing returns to physical capital.

Equally, there is an implicit belief that R&D delivers more innovation *per se* and that the mechanism is a direct one that requires no prior internal competencies or resources. Yet more recent work, by Coad, Cowling, Nightingale, Pellegrino, Savona and Siepel (2014), using VAR models to establish causality on the Community Innovation Survey panel of UK firms, found that without prior firm level employment growth, particularly of graduate quality labour, increasing R&D intensity would not deliver the growth in new to market products and services which ultimately would lead to more rapid sales growth.

In this respect our research question then becomes; Are R&D tax credits claimed by UK SMEs associated with product or service innovation, or process innovation at the firm level? In a broader sense, we are questioning whether the institutional focus of the NSE on innovation, supported through a specific public policy designed to alleviate a credit constraint for SMEs in respect of investing in innovative capacity, worked. Due to the nature of the data available to us, we are also able to establish a key separation, that of product or service innovations, and process innovations that are new to the firm (upgrading existing innovation levels of products, services or processes) or completely new to the market (radical innovations). Clearly, from a public policy standpoint both are desirable, but we might hypothesise that completely new to market product or service innovations will generate higher private returns through higher levels of subsequent firm level growth, and higher social returns through more positive spill-overs into the wider economy.

4. Data and Methodology

Our data is the Small Business Survey, a UK government dataset of Small and Medium Sized Enterprises (SMEs). These firms are defined as those with fewer than 250 employees, although we exclude those without employees as these firms may face particular issues relating to R&D. We use the most recently available waves of the data, which is 2012. Our data is a cross-sectional survey of 5,723 UK SMEs, with a series of retrospective questions to capture change over time.

The sample frame for the SBS is the Dun & Bradstreet database. The survey is conducted using Computer Assisted Telephone Interviewing (CATI) with interviewers asking to speak to owners, proprietors, managing directors or other ‘senior decision makers’. The sample is stratified by nation, size and sector with some boosts (dealt with through weights, which are provided by the UK Department for Business, Innovation and Skills to make findings representative of the general business stock). There is no resampling between waves and given the scale of the sample such resampling is unlikely to be a significant problem. Once ineligible firms are excluded from the sample, the response rate was just over 58 percent in 2012, up from 52 percent in 2010 (Department for Business, Innovation and Skills, 2013b).[2]

The innovation section variables of specific interest to us here are;

Have you introduced new or significantly improved products or services in the past twelve months?

Are these new to your business, or completely new (i.e. not introduced by anybody before you)?

Have you introduced new or significantly improved processes in the last twelve months?

Are these new to your business, or completely new (i.e. not introduced by anybody before you)?

Have you applied for or received tax credits in the last 3 years?

These variables are expressed as in the Community Innovation Survey and adopted in the Norwegian R&D tax credit study of Cappelen, Raknerud, and Rybalka (2012). For our purposes, we define innovations that are completely new (i.e not introduced by anybody before you) as radical innovations. A radical product innovation is a new product that incorporates a substantially different core technology and provides substantially higher customer benefits relative to previous products in the industry. This is broadly in line with the “Canada first” and “world innovation” definitions adopted in the Czarnitzki et al (2012) study. A radical product innovator is the firm that first commercializes a radical product innovation (Ettlie and Rubenstein, 1987).

[2] Response rates are not available for the 2007/8 survey.

The basic (weighted) statistics show that 14.2% of firms were in receipt of R&D tax credits' over the last three years. This suggests that their use is limited to a small, but significant, minority of the total SME population. On innovation, we find that 32.7% of SMEs are engaged in product or service innovation and 23.7%% in process innovation. Of these firms, 61.0% are engaged in both simultaneously, which suggests a high degree of complementarity between different types of innovative behaviours as predicted by Milgrom and Roberts (1995). For those firms engaged in product or service innovation, 14.1% were completely new innovations. The equivalent for process innovating firms was 13.0%. Again, this suggests that radical innovations, even amongst generally innovative firms, are a rare event. Expressed as a percentage of the total stock of all firms, radical product or service innovation is conducted by 4.6% of firms and radical process innovation by 3.1% of all firms.

The set of explanatory variables can be broadly characterised into three groups. These include (a) firm level characteristics (age, size, sector, legal form, family ownership, board size, international market presence, use of accountants, and growth orientation), (b) business capabilities in terms of new market entry, product or service innovation, and process innovation, and, (c) strategic business planning and development in the areas of new markets, skills, leadership, new staff, productivity, products and services and processes.

[INSERT TABLE 1 HERE]

On firm characteristics, we note that the typical firm is between 11 and 20 years old, operates from a single site (92.6%), has 2 board members, and is in family ownership. It is classified as a micro business having between 0 and 9 employees. Around one in seven firms has an international market presence, and an absolute majority have a strategic intention to grow over the next two to three years. The dominant legal forms are Sole Proprietorships and Private Limited.

In terms of strategic planning, as defined by plans fully written into the business plan, we observe that the most commonly held planning objectives were to develop new markets, enhance skills, and introduce process innovations. On firm level capabilities, we note that these were highest in the area of process innovation and lowest in the area of new market development. Some 46.4% of firms had high level capabilities in the area of process innovation compared to only 31.3% in product or service innovation and 20.2% in new market development. Prior to our core analysis we generate two indices, the first relates to *planning intentionality* (an index of 6 planning items, alpha=0.774), and the second to *capability* (an index of 3 capabilities items, alpha=0.586). We also create a planning-capability interaction term.

[INSERT TABLE 2 HERE]

From the correlation matrix (Table 2), we observe that R&D tax credits have low correlations with our innovation, planning and strategic capability variables. The highest correlation is 0.05 between R&D tax credits and planning new products or services. Since survey data is used for our empirical analysis, further exploration of the potential issues arising from common method bias is apposite, particularly in the context of planning and capabilities, but also potentially in our innovation measures. Here we note that the correlations between product-service and process innovation is 0.42 and between product-service innovation and planning is 0.35 and 0.31 for capabilities. Further, the correlation between radical product-service innovation and radical process innovation is 0.35. In terms of planning and capabilities, the correlation is 0.35. In general, the correlations for our innovation measures are higher for planning than for capabilities. Using a PCA test for common method bias between planning and capabilities with 9 components, we generate a KMO overall measure of 0.5036, which suggests that common method bias is not a particularly critical issue in this context. Extending our PCA, to include 2 additional innovation components, results in a substantial decline in the KMO overall measure to 0.2472. At this point we do not discard the potential for planning and capabilities to play a mediating (or other more direct role) in the impact of R&D tax credits, and also in the determination of receipt of tax credits.

Our specific (micro-level) research questions are whether receipt of an R&D tax credit is associated with (a) a higher probability of a firm introducing new or significantly improved products, services or processes, and (b) a higher probability of a firm introducing a completely new to market innovation. Given the explicit focus of the R&D tax credit, we might hypothesise that they are associated with firms undertaking some form of innovation.

But these specific research questions are nested in a wider set of broader research questions that relate to NSE. Here we question whether a change in the institutional context, here an explicit focus on creating environment supportive of higher innovation levels, via a specific policy of reducing the financial barriers to SMEs conducting R&D (the R&D tax credit) had the effect of engaging greater numbers of SMEs in the innovation process by removing a perceived barrier to innovation.

The dependent variables of interest are all coded in binary form. The most basic form of regression to deal with the models we want to estimate is the probit regression in which Y_i is regressed against a vector of explanatory variables, X_i:

$$\Pr(Y_i = 1 | X_i) = \frac{1}{1 + \exp(-X_i\beta)}$$

Where $\Pr(Y_i = 1 | X_i)$ is the probability of a firm innovating given its characteristics $X_{i,}$ which is a vector of independent variables and β the corresponding vector of coefficients, including firm specific characteristics (e.g age, size, industry sector), strategic planning measures, and a measure of capabilities, and a dummy variable for the R&D tax credit.

Given the obvious selection bias issue in terms of only those firms undertaking some form of innovative behaviour in the first instance being observed at the second stage where the innovation activity is classified as new to the firm only or completely new, our starting point was to estimate a probit specification of the standard Heckman sample selection model.

$$\Pr(Y_2 = 1 | X_i, Y_1) = \frac{1}{1 + \exp\{-(X_i\beta + Y_1\alpha_1 + RD\_Tax\_Credit\alpha_2)\}}$$

Here the first model is coded 1 if the firm is engaged in innovative activity and 0 otherwise. In the second step, which is conditional upon firms being coded 1 in the first step, firms are coded 1 if their innovative activity is completely new and 0 otherwise. The equations are identified through geographic regional dummy variables and an urban-rural variable to capture regional (and city) innovation systems and potential beneficial spillover effects which would increase the probability that new knowledge stimulates radical innovation. However, the model tests for independence between the two product-service innovation and process innovation equations (LR test $=chi^2(1) = 0.46$, Prob > chi2 = 0.498 and LR test $=chi^2(1) = 0.009$, Prob > chi2 = 0.767) indicated that, in fact, they are independent of one another and thus can be estimated as single equations. What this implies is that the decision to engage in innovative activity in the first instance is not systematically related to a firm introducing completely new innovations. That is, the underlying processes at work which drive completely new innovations are not the same as those which drive the decision to engage in general innovative activity.

We now move on to estimate single equation models to identify factors associated with firms who are engaged in product or process innovation activity (compared to those who are not) and an additional model for those firms engaged in product or service and process innovation simultaneously. And then we estimate further models for those introducing completely radical (new to market) innovations (compared to those who are not). A particular point of focus here is on any potential effects on innovation activity associated with being in receipt of an R&D tax credit. As both of our dependent variables of interest are coded in binary form we estimate a probit model and calculate the marginal effects for ease of interpretation. Aside from our R&D tax credit dummy variable, we include the same core set of variables tested in our initial sample selection model.

5. Results

Here we present the results of our probit models for product or service innovation, process innovation, combining product or service and process innovation (as opposed to undertaking either one but not the other), completely new product or service innovation, and completely new process innovation.

5.1 Product or Service Innovation

On firms' probability of engaging in product or process innovation, we find there is a consistency between firm level capability and actually achieving product or service level innovations (model 1). Here firms with high capability levels have a higher probability of engaging in product or service innovation. But no comparable effects were found for planning (intentionality), or indeed in respect of the planning*capability interaction term. Additional evidence relating to human capital and capability is found in the positive association between board size and engagement in product or service innovation.

In terms of whether R&D tax credits are associated with an increased probability of engaging in product or service innovation, we find no statistically significant effect. This insignificance holds even when we interact R&D tax credit with planning and, separately, capability (model 2). Equally, we find very little evidence that firm size, age or industry sector had particular associations with an increased (decreased) probability of engaging in product or service innovation. In this sense, it would appear that (incremental) product or service innovation is randomly distributed across firms of different size classes, stages of development, and industry sectors. The defining characteristics in this sense, relate to capability. This suggests that whether or not product or service innovation occurs depends on internal firm resources, particularly in respect of human capital. And further, that regardless of firm size, age or industry sector, some firms will have the human capital required to innovate and some will not. When these, superior human capital capabilities are combined with an explicit growth intention the chances of actual innovation occurring increase significantly.

5.2 Process Innovation

The general results for engaging in process innovation are largely consistent with those established for product or service innovation. On the potential effect of R&D tax credits we find no statistical effect, either as a single variable (model 3) or when interacted with planning and capability (model 4). And there is very little evidence that firm size, age or industry sector had particular associations with higher or lower levels of process innovation. Our findings highlight the importance of planning intentionality and capability, with a larger positive effect from planning. This is enhanced by firms having broader human capital at board level.

5.3 Completely New Product or Service Innovation

The probability that a firm introduces a product or service innovation that is completely new to market is fundamentally associated with the internal capabilities of firms in respect of product or service level innovation (model 5). R&D tax credits were not found to be associated with radical product or service innovation either on its own (model 5) or in combination with planning and capability (model 6). Being orientated to growth was also found to have positive effects across alternative models. Further, being a process innovator was associated with a higher probability of being a radical product or service innovator suggesting that the relationship in complementary.

Equally important are the non-results as they offer evidence on the questions of where radical innovation might occur, and where public policy might target support. On this we find very little evidence that radical product or service innovations are associated with particular size classes of firm, firms at a specific point in their life cycles, or firms in particular industry sectors. This is in accord with many of the more recent studies on firm growth which have concluded that growth in more randomly distributed across firms, and more temporary, than previously thought (Coad, Frankish, Roberts and Storey, 2012).

5.4 Completely New Process Innovation

On radical process innovation, we find the clearest positive association with product innovation (model 7). R&D tax credits were found to have a (marginal) positive effect on their own (model 8), but a very high and significant positive effect when combined with capability and planning. This suggests that it is the unique combination of high human capability, clear strategic intent, and a relaxation of capital constraints that drive radical process innovation.

There is also clear variation in terms of industry sector, with non-metals manufacturers, transport & communications firms, and other manufacturing firms being more closely associated with radical process innovation. This is the first evidence of a clear industry sector association.

In terms of how our findings relate to previous empirical literature, we have the most commonality with the Norwegian study of Cappelen et al (2012) in that both studies find a bigger tax credit effect on process innovation and a lesser or null impact on product-service innovation, particularly in the case of radical product-service innovations. Thus, whilst both these studies find modest effects of R&D tax credits, neither is as stark as the Dutch study of Lokshin and Mohnen (2010) who found no evidence to support the effectiveness of R&D tax credits as a positive policy choice. All these studies contrast with the very positive product innovation effects established in the Canadian study of Czarnitzki et al (2011). On this basis, it would appear that earlier studies which tended to focus on the relationship between R&D spend and tax credits, and generally found positive effects, ignored the fact that R&D spend does not necessarily translate into innovation without other key institutional and firm level factors being in place.

5.5 Who Receives R&D Tax Credits?

Given that, in general, we observe that innovation is much more randomly spread across the business population than we might have *a priori* expected, it is interesting to question whether the distribution of R&D tax credits reflects this apparent randomness across broad firm characteristics such as age, size, and industry sector. We estimate one additional probit model with our dependent variable expressed as our R&D tax credit dummy and firm size, age, industry sector, legal form, planning and capability etc as our set of explanatory variables (model 9).

Here we find strong differences across industry sectors with firms operating in primary sectors (agriculture, mining, forestry and fishing) having the highest probability of receiving an R&D tax credit. In contrast, firms operating in non-metals manufacturing, retail and wholesale, and transport & communications had relatively low probabilities. In this respect tax credits are not as widely distributed across industry sectors as innovative potential. And even in the case of radical process innovation, where certain industry sectors were found to be important, these do not correspond largely with those favoured with tax credits.

We also find a negative association between firm age and the probability of receiving a tax credit. Here firms older than 10 years of age had a 7.5% to 8.6% lower probability of tax credits. This again, does not reflect the fairly random distribution of all forms of innovative activity across firm age bands. But it does appear to reflect the potential for capital constraints to disproportionately impact on the youngest SMEs. In this sense the NSE is working to level the playing field for young firms. Finally, we note that the distribution of tax credits is positively related to strategic planning, the intention to innovate and develop, but not to capability, the ability to manage innovation and growth.

6. Conclusion

The UK Government introduced tax credits for SMEs to promote and support R&D in 2000. Since then the policy has become more generous in this respect, particularly since 2008. In this paper we questioned whether SMEs take-up of tax credits has actually led to an increase in product, service or process innovations as might be expected given that the tax credit effectively lowers the user cost of R&D. We set this in the wider context of a NSE which in the UK focused on generating higher innovation levels through a specific policy of R&D tax credits. The policy was intended to remove a binding capital constraint on the ability of SMEs to fund investment in innovative capacity.

Our evidence suggests that there is not a clear cut case, in terms of justifying the expenditure in foregone taxes given the current distribution of credits. But we do find evidence that the R&D tax credit supported process innovation. This effect was further enhanced for firms with high capability levels and strong levels of planning. Thus, we suggest that a reasonable policy implication is that public policy-makers should encourage firms to build up internal capability and make a strategic commitment to innovation.

In the context of the UK NSE and policy framework, our evidence suggests that innovation is widely dispersed and randomly distributed across firms of all sizes, ages and industry sectors. Following on from this, we suggest that public policy needs to take a wider, and more integrated view, which incorporates access to finance, international market development, and building internal firm level capabilities.

By far the clearest associations with all measures of innovation (incremental and radical) relate to firm level capabilities and to a lesser degree strategic intent (planning commitment). In short, you can throw as much money as you like at a firm with no coherent innovation strategy, strategic commitment or intentionality to innovation and little tangible is likely to happen. Going forward we argue that there are important questions around the efficacy of the current process by which R&D tax credits are distributed. Rather, we suggest that issuance of tax credits should take more account of a firms' strategic intent in respect of innovation and particularly its internal capabilities, both of which were found to have the closest and strongest associations with incremental and radical innovation. The NSE has a broader role to play in helping SMEs to build capability to be able to innovate and grow successfully than simply reducing the user cost of research and development.

However, there are limitations to our study and clear avenues for future research to explore. Regarding limitations, the most obvious one is the lack of time-series data relating to firm level performance. If we hypothesise that there is a potential R&D, innovation, performance (productivity, sales, profit) relationship, time-series data would allow such a link to be empirically tested. We also lack data on the scale of R&D tax credits in cash terms. A more refined measure would open up new possibilities for more focused assessments of the effectiveness of the policy instrument.

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Table 1: Sample descriptive statistics

Variable	Mean	S.D
Innovation Characteristics		
Product or service innovation	0.326	0.469
Process innovation	0.237	0.425
Completely new product or service innovation (conditional on innovating)	0.141	0.348
Completely new process innovation (conditional on innovating)	0.130	0.336
R&D tax credit	0.142	0.349
Firm Characteristics		
Single site	0.926	0.262
Family owned	0.611	0.487
Board size	2.01	1.545
Private limited company	0.314	0.464

Employment size band	1.307 (micro business)	0.570
Age band	2.807 (11-20 years)	1.123
International sales	0.139	0.346
Growth orientation	0.573	0.495
Strategic planning		
Planning index	0.000	0.685
Firm Capabilities		
Capabilities index	0.000	0.740

Table 2: Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	R&D tax credit	1.000													
2	Single Site	0.0743*	1.000												
3	Firm size	-0.1121*	-0.3860*	1.000											
4	Firm age	-0.0882*	-0.0752*	0.2220*	1.000										
5	International sales	0.033	-0.0697*	0.1778*	0.0600*	1.000									
6	Growth orientation	0.004	-0.1093*	0.2376*	-0.1452*	0.1786*	1.000								
7	Planning index	0.015	-0.2067*	0.4109*	-0.1021*	0.2278*	0.5436*	1.000							
8	Capability index	0.006	-0.1228*	0.1897*	-0.0592*	0.1751*	0.2276*	0.3554*	1.000						
9	Family firm	0.0416*	0.0690*	-0.1137*	0.0941*	-0.0725*	-0.0979*	-0.1072*	-0.018	1.000					
10	Board size	-0.028	-0.1504*	0.2463*	0.1395*	0.0495*	0.0613*	0.0991*	0.0386*	-0.2022*	1.000				
11	Product-Service innovator	-0.004	-0.0994*	0.1511*	-0.0477*	0.1658*	0.2137*	0.3465*	0.3127*	-0.022	0.0582*	1.000			
12	Process innovator	-0.004	-0.1143*	0.2161*	-0.0670*	0.1170*	0.1960*	0.3599*	0.2637*	-0.0721*	0.1189*	0.4178*	1.000		
13	Product-Service new innovation	0.049	-0.040	0.0998*	0.004	0.1455*	0.0759*	0.1320*	0.1375*	-0.047	-0.017	.	0.052	1.000	
14	Process new innovation	0.042	-0.014	0.0693*	0.035	0.054	-0.005	0.041	0.1146*	-0.003	-0.022	0.052	.	0.3514*	1.000

Table 3: Innovation modes and R&D tax credits (marginal effects reported)

	Product-Service Innovation		Product-Service Innovation		Process Innovation		Process Innovation	
	Model 1		**Model 2**		**Model 3**		**Model 4**	
Variables	**dF/dx**	**P>z**	**dF/dx**	**P>z**	**dF/dx**	**P>z**	**dF/dx**	**P>z**
R&D tax credit	-0.083	0.237	-0.071	0.378	-0.043	0.520	-0.051	0.512
Employment size								
Micro	0.062	0.240	0.060	0.254	-0.002	0.973	0.000	0.998
Small	-0.049	0.421	-0.050	0.406	0.053	0.307	0.055	0.291
Medium	-0.086	0.253	-0.088	0.235	0.048	0.465	0.052	0.434
Firm Age								
6-10 years	-0.005	0.950	-0.005	0.951	-0.016	0.801	-0.014	0.826
11-20 years	0.036	0.680	0.038	0.665	-0.113**	0.033	0.111**	0.037
>20 years	-0.083	0.297	-0.082	0.300	-0.039	0.516	-0.038	0.522
International sales	0.011	0.120	0.108	0.115	0.046	0.386	0.042	0.429
Growth orientation	0.151**	0.014	0.152**	0.012	-0.028	0.613	-0.029	0.601
Strategic planning								
Planning index	0.033	0.492	0.025	0.601	0.145***	0.000	0.140***	0.000
Planning * R&D tax credit			0.135	0.182			-0.083	0.276
Firm Capabilities								
Capability index	0.183***	0.000	0.172***	0.000	0.100***	0.000	0.105***	0.000
Capability* R&D tax credit			0.052	0.613			0.108	0.250
Planning and Capability								
Planning*Capability	-0.005	0.913	-0.003	0.953	-0.064	0.145	-0.062	0.174
Planning*Capability*R&D tax credit			-0.222	0.210			0.007	0.952
Innovation								
Process Innovation	0.299***	0.000	0.300***	0.000				
Product Innovation					0.237***	0.000	0.238***	0.000
Plus controls	Yes		Yes		Yes		Yes	
N obs	2258		2258		2258		2258	

Pseudo R2	0.263	0.266	0.234	0.236

Table 4: New to Market Innovation modes and R&D tax credits (marginal effects reported)

	New Product-Service Innovation		New Product-Service Innovation		New Process Innovation		New Process Innovation	
	Model 5		**Model 6**		**Model 7**		**Model 8**	
Variables	**dF/dx**	**P>z**	**dF/dx**	**P>z**	**dF/dx**	**P>z**	**dF/dx**	**P>z**
R&D tax credit	0.024	0.804	0.059	0.735	0.028	0.707	0.177*	0.087
Employment size								
Micro	-0.010	0.900	-0.010	0.889	0.013	0.828	-0.002	0.974
Small	0.016	0.831	0.012	0.876	0.013	0.847	0.017	0.790
Medium	-0.032	0.696	-0.032	0.699	-0.008	0.912	-0.007	0.923
Firm Age								
6-10 years	-0.095	0.238	-0.096	0.236	-0.140***	0.005	-0.146***	0.002
11-20 years	-0.008	0.926	-0.009	0.920	-0.021	0.738	-0.042	0.457
>20 years	0.082	0.405	0.084	0.396	-0.032	0.604	-0.058	0.294
International sales	-0.011	0.856	-0.011	0.860	0.007	0.883	-0.004	0.934
Growth orientation	-0.012	0.912	-0.009	0.937	-0.038	0.686	0.002	0.979
Strategic planning								
Planning index	-0.120	0.131	-0.130	0.105	-0.080	0.191	-0.071	0.229
Planning * R&D tax credit			0.165	0.455			-0.240*	0.088
Firm Capabilities								
Capability index	0.115**	0.018	0.122**	0.012	0.061	0.154	0.051	0.215
Capability* R&D tax credit			-0.020	0.960			-0.823***	0.003
Planning and Capability								
Planning*Capability	0.146**	0.051	0.158**	0.039	-0.012	0.837	-0.033	0.559
Planning*Capability*R&D tax credit			-0.267	0.628			1.370***	0.000

Innovation								
Process Innovation	0.454***	0.000	0.463***	0.000				
Product Innovation					0.371***	0.000	0.362***	0.000
Plus controls	Yes		Yes		Yes		Yes	
N obs	679		679		679		679	
Pseudo R2	0.362		0.326		0.362		0.396	

Table 5: R&D tax credits (marginal effects reported)

	Model 9	
R&D tax credit	**dF/dx**	**Pr>z**
Single site	0.043***	0.012
Employment size		
Micro	-0.009	0.621
Small	-0.033*	0.072
Medium	0.034	0.372
Legal form		
Private limited	-0.058*	0.051
Public limited	-0.059***	0.000
Partnership	-0.042	0.077
Other	-0.052***	0.043
Firm Age		
6-10 years	-0.030	0.217
11-20 years	-0.070***	0.000
>20 years	-0.070***	0.000
International sales	0.008	0.704
Growth orientation	-0.027	0.243
Strategic planning		
Planning index	0.044***	0.007
Firm Capabilities		
Capability index	-0.006	0.638
Family owned	0.040**	0.017
Board size	0.003	0.573
Industry sector		
metals manufacturing	-0.054**	0.011
non-metals manufacturing	-0.101***	0.000
other manufacturing	-0.063***	0.006
construction	-0.059**	0.014
retail and wholesale	-0.069***	0.003
transport & communications	-0.071***	0.000
business services	-0.058	0.006
N obs	2258.000	
Pseudo R2	0.193	