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ABSTRACT

There is now substantial evidence on the positive contribution universities can make to helping firms' innovation. Building university-business collaborations, however, confronts the 'two-worlds' paradox, and the difference in institutional logics and priorities between businesses and universities. Here, we consider whether firms' experience from prior collaboration can generate learning which can help to overcome the two-world's paradox and improve their ability to generate new-to-the-market innovations in collaboration with universities. Based on panel data for UK companies, we find evidence of significant learning effects in the commercialisation pipeline for new-to-the market innovation. Firms working with, say, customers in one period are significantly more likely to collaborate with universities in subsequent periods. Further down the pipeline, collaborating with universities increases the probability of a firm making new-to-the-market innovations (as opposed to new-to-the-firm innovation) by 21-24 per cent regardless of firm size. The commercial benefits of collaborative, new-to-the-market innovation are concentrated in medium and larger firms with no significant effect for small companies. There is the potential for policy intervention both to increase levels of small business-university collaboration and assist smaller firms to maximise the commercial benefits of collaborative, new-to-the-market innovations.

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Keywords: Innovation, university, collaboration, learning

CONTENTS

1. INTRODUCTION

There is now substantial evidence from a range of countries on the positive role of universities in helping firms to innovate successfully (Petruzzelli 2011; Laursen and Salter 2004; Mansfield 1995; Bellucci and Pennacchio 2016). Paradoxically, however, there is also substantial evidence of the difficulties which firms, particularly perhaps smaller firms, encounter in establishing, structuring and sustaining productive collaborative relationships with universities (Laursen and Salter 2004; Roper et al. 2005). Building university-business relationships confronts what Hall (2003) describes as the 'two-worlds' paradox, and the difference in institutional logics and priorities between businesses and universities (Dasgupta and David 1994). This creates 'orientation-related barriers' and 'transaction-related barriers' to university-business collaboration reflected in conflicts over the creation or exploitation of knowledge (Abeda et al. 2010), the timeliness (Tapsir et al, 2010) as well as the time-horizon of research projects (Dunowski et al. 2010), the prioritization and management of intellectual property (IP) and the bureaucracy of university administration (Bruneel et al. 2010)[1]. This paradox often means that, despite significant impacts, firms rate universities contribution to their innovation relatively poorly (Howells et al. 2012) and that levels of university-business collaborations are below those between individual firms (Drejer and Jorgensen 2005).

The positive contribution of universities to innovation reflects the wider literature on the role of collaboration for innovation (Love, Roper, and Bryson 2011; Woerter and Roper 2010; Rantisi 2002). Numerous studies have demonstrated the value of collaboration with customers (Mansury and Love 2008; Love and Mansury 2007), suppliers (Smith and Tranfield 2005; Takeishi 2001), consultants etc. (Tether and Tajar 2008) as part of firms' innovation activity. Collaboration may also have other advantages, for

[1] Clearly orientation- and transaction- related barriers are not mutually exclusive, with differences in institutional logic, particularly around publishing and/or the protection of knowledge manifest in conflicts around IP.

example, in sharing risks, in accelerating or upgrading the quality of the innovations made, and signaling the quality of firms' innovation activities (Powell 1998). There is also increasing evidence that developing external collaborations involves organisational learning as firms' ability to structure and manage such relationships improves with experience (Love, Roper, and Vahter 2014). Two main learning mechanisms are envisaged in existing studies: the possibility that firms may become better at managing or structuring external collaborations; and, the possibility that experience may enhance firms' cognitive capacity to absorb external knowledge extending the number of useful collaborations (Laursen and Salter 2006; Leiponen and Helfat 2010).

Here, we consider whether learning from prior collaboration helps firms to collaborate more effectively with universities, and how such collaborations impact on new-to-the-market innovation. New-to-the-market innovation creates the potential for creative destruction and first-mover advantages for the innovating firm and has other advantages in terms of helping the first mover to learn rapidly about the markets and build brand loyalty among customers (Ulhoi 2012; Markides 2006; Kopel and Loffler 2008) [2]. Collaboration may be particularly important in generating new-to-the-market innovations which involve greater risks associated with technological complexity and profitability than new-to-the-firm innovation (Keizer and Halman 2007; Roper, Du, and Love 2008; Cabrales et al. 2008; Astebro and Michela 2005).

Our analysis makes use of the panel data element of the UK Innovation Survey covering the 2004 to 2012 period. This allows us to identify causal links between learning processes, collaboration with university partners and

[2] A key issue for innovators in any market place, however, is their ability to sustain their position of market leadership. In some sectors – biotechnology or engineering – this may involve formal strategies such as patenting to protect intellectual property; in other sectors more strategic approaches may be adopted such as frequent changes or upgrades to product or service design. Aggressive pricing also provides a way in which market leaders may protect any first mover advantages (Ulhoi 2012).

innovation. We make three main contributions to the existing literature. First, we examine firms' choice of new-to-the-market innovation strategy, identifying the role of university collaboration as part of firms' innovation decision. Second, we are able to provide evidence on how firms' learn to collaborate more effectively, with customer and supplier collaborations driving subsequent university collaborations. And, finally, we connect university-business collaboration to new-to-the-market innovation, an effect which proves both robust and of significant scale.

The remainder of the paper is structured as follows. Section 2 outlines our view of new-to-the-market innovation strategy and firms' collaboration decisions. Sections 3 and 4 profile our data and empirical methodology. Section 5 deals with empirical results and Section 6 discusses the implications. Our results do not resolve the two-worlds paradox but do suggest that firms with prior experience of innovation collaboration may be better able to resolve at least part of the paradox when it arises.

2. CONCEPTUAL SETTING AND HYPOTHESES

2.1 New-to-the-market innovation strategy and learning

Firms' decision to invest in innovation depends on expected post-innovation returns, which will themselves depend both on a firm's capabilities and the market environment (Du et al. 2007). Given a decision to engage in innovation, firms then need to decide the type and nature of innovation in which they are going to invest. Different kinds of innovation – i.e. incremental or radical, product or process – will induce different competitive effects, address different kinds of market opportunities, and require different knowledge inputs. In this context, radical or new-to-the-market innovation (NTMI) poses some specific challenges (Kopel and Lofler, 2008; Markides 2006; Keizer and Halman 2007; Roper, Du, and Love 2008; Cabrales et al. 2008; Astebro and Michela 2005). As Keizer and Holman (2007, p. 30) suggest: 'Radical innovation life cycles are longer, more unpredictable, have more stops and starts, are more context-dependent in that strategic considerations can accelerate, retard or terminate progress, and more often

include cross-functional and or cross-unit teamwork. Incremental projects are more linear and predictable, with fewer resource uncertainties, including simpler collaboration relationships'[3].

Firms will undertake new-to-the-market innovation only if the expected post innovation returns exceed the corresponding costs. These costs will depend both on firms organisational and knowledge capabilities at the time of the decision to invest and their capacity to match internal organizational structures to the needs of more radical innovation (Henderson 1994; Stringer, 2000). This will require significant investment in internal discovery processes, and/or the development of an external knowledge search and collaboration strategy. However, as Stringer (2000) notes relying solely on internal R&D activities (and existing organizational routines) is unlikely to result in radical innovation. Instead, in order to reduce the cost of learning and thus, the uncertainty associated with introducing new-to-the-market innovation, firms may engage with external collaborators and source new ideas, knowledge and complementary skills (Hottenrott and Lopes-Bento 2016). Participation in such networks gives firms the opportunity to interact, and share information, with other partners, and at the same time gain experience in selecting and managing collaborative relationships (Nieto and Santamaria 2007).

Learning by experiencing collaboration may allow firms to develop new knowledge routines, and acquire new competences which benefit their ability to introduce new-to-the-market innovation. Improved partner selection and management routines, for example, may reduce transaction costs, and enable firms to more effectively capture the knowledge flows from external collaborators. Firms may also develop a better understanding of the specific capabilities of different partner types and their potential contribution to either incremental or more radical innovation (Miotti and Sachwall 2003). Firms' collaboration capabilities may also depend on their prior innovation

[3] See also Leifer et al. (2000).

experience. Where a firm has prior experience of NTMI, either building purely on internal knowledge or collaboration, they are more likely to have an understanding of the knowledge requirements of radical innovation and the nature of the required internal investments or collaborative relationships (Geroski et al. 1997). Through time, this suggests that firms which engage in consistent innovation and/or collaboration will learn both which types of collaboration are of most value, and how to maximise the payoffs from those relationships. This may be reflected in persistent partnerships and, through time, the build-up of trust (Gulati 1995), the exchange of tacit and more fine-grained information and knowledge (Gilsing and Noteboom 2006), and the closer integration of internal and collaborative innovation routines (Das and Teng 2000; Belderbos et al. 2015).

In terms of new-to-the-market innovation, universities and other public knowledge sources have, arguably, two specific advantages as innovation collaborators. First, radical innovation requires frontier-edge knowledge which itself is likely to require significant R&D investment.

Customers or suppliers, for example, are unlikely to provide the new knowledge to drive NTM innovation but rather, provide solutions that build incrementally on firms' existing activities (Lopez-Vega et al. 2016)[4]. Second, NTM innovation may create significant economic benefit increasing the potential threat from moral hazard associated with collaborative relationships. Universities and other public knowledge providers generally have little commercial incentive to cheat as well as robust (and sometimes bureaucratic) administration of intellectual property (Kaufmann and Todtling 2001). In addition, co-patenting with Universities has been found to enhance market value and signal to the market the presence of novel technologies (Leten et al. 2013). Offsetting these advantages are the two-worlds differences in institutional logics and priorities between businesses and

[4] Lopez-Vega et al. (2016) examine partner search through the lens of search heuristics and categorise knowledge search activities to build experimentally on previous solutions through repeated experiences as 'situated search paths'.

universities which may create tensions around project timelines, rewards and commercialisation (Dasgupta and David 1994).

2.2 Hypotheses

NTM innovation is expensive, risky and complex. Firms may therefore seek external collaborators who can augment their own internal knowledge structures and share the costs and risks of innovation (Fey and Birkinshaw 2005; Nieto and Santamaria 2007; Un et al. 2010; Hotternott and Lopes-Bento 2016). Potential collaborators differ, however, both in terms of the breadth and depth of knowledge they possess, but also in terms of their willingness to share that knowledge with potential collaborators (Un et al. 2010). Because of such differences, firms' choice of innovation collaborators will depend on the type of R&D resources firms seek to access, which, in turn, depends on their own knowledge profile (Miotti and Sachwald 2003).

Notwithstanding evidence that external knowledge sourcing can make a significant positive contribution to firms' innovation performance (Oerlemans et al. 1998; Grant and Baden-Fuller 2004), the effect may vary depending on the external partner (Lopez-Vega et al. 2016). In general, innovation collaboration is more common with supply chain partners - suppliers or customers - than with other organisations such as universities (Abreu et al. 2008). One possible explanation is that firms engage primarily in 'local' knowledge search activities, close to their current knowledge base. Here, orientation-related barriers are lower (Bruneel et al. 2010) and customers and suppliers represent local knowledge partners where knowledge accessed builds on firms' existing resources (knowledge stocks) and capabilities (routines) (Lopez-Vega et al. 2016). In contrast, 'distant' search with partners such as universities is more difficult, requires new capabilities, and leads to knowledge which is further removed from the firms' current knowledge base but with greater potential to lead to breakthrough innovation outcomes (Bingham and Spradlin 2011; Lopez-Vega et al. 2016).

This suggests that a learning effect exists in external knowledge sourcing along at least two-dimensions. First, through forming collaborations with

'local' knowledge sources i.e. where cognitive distance is lower, this develops knowledge sourcing capabilities in the firm and reduces orientation-related barriers between the firm and external partners. This enhances not only the firm's knowledge stock but also their capability to collaborate with more 'distant' external partners. That is, 'interactional knowledge stores enable effective expansion of relationship types in the relationship portfolio, which in turn facilitate explorative and exploitative innovation simultaneously' (Fang et al. 2011, 746). Second, through external collaboration for innovation, firm's 'functional knowledge store' is enhanced with further collaborations building on this functional capability (Johnson et al. 2004; Fang et al. 2016). In other words, external collaboration with vertical (non-university) partners reduces orientation-related barriers to cooperation through enhancing both general knowledge of identifying, accessing, co-developing and absorbing external knowledge, as well as specific knowledge related to innovation and the identification of new technological and market opportunities. This suggests the following:

Hypothesis 1: Learning to collaborate

Prior experience of external knowledge collaboration for innovation with non-university partners will increase the probability of subsequent collaboration with university partners.

Beyond the potential for learning arising from collaboration with non-university partners, learning also occurs through recurrent 'distant' collaborations. Bruneel et al. (2010) discuss this in terms of recurrent collaborations with universities helping to overcome orientation-related and transaction-related barriers to collaboration. Their findings support other research (Thune, 2011; Gomes et al. 2005; Hall et al. 2003; Van Dierdonck and Debackere 1988) that, it is through repeated collaboration that routines are established on issues such as research targets, dissemination of results and timing of deliverables. These routines reduce attitudinal (orientation-related) barriers to collaboration for both business and university partners (Tartari et al. 2012) and may also have a - more limited - effect on reducing

transaction-related barriers to collaboration i.e. agreement on intellectual property (IP) issues.

Fang et al. (2011) conceptualise this learning effect as relationship-specific memory defined as the 'stored knowledge of collective insights, beliefs, routines, procedures and policies accumulated from interactions, and is shared between partner organizations' (p. 744). In their study of high-tech manufacturing firms in Taiwan they found that the development of relationship-specific memory was fundamental in reducing cognitive distance between partners and the potential for cognitive failure. Recurrent collaboration therefore increases communication and coordination between partners and serves to overcome orientation-related barriers to collaboration such as attitudinal differences and potential conflicts of interest between partners. This suggests that prior collaboration with an external partner – and particularly a more 'distant' cognitive partner (Lopez-Vega et al. 2016) – will result in subsequent collaboration, therefore:

Hypothesis 2: Recurrent collaboration

Prior collaboration with universities for innovation will increase the probability of subsequent collaboration with universities for innovation.

Essentially similar experiential learning effects may also arise from firms' prior experience of undertaking new to the market innovation. These effects arise from the cumulative and path-dependent nature of innovation activity which builds on existing resources, capabilities and relationships. Empirical research on the persistence of innovation has, however, found that while product and (to a slightly lesser extent) process innovation activities persist from one period to the next, firms find it difficult to sustain high levels of innovation over time, with this being particularly difficult for smaller firms (Roper and Hewitt-Dundas 2008; Cefis and Orsenigo 2001). Sustaining an ability to introduce new-to-the-market innovations is likely to require firms to adopt a strategic approach to partner choice (Bengtsson et al. 2015). For example, Kohler et al. (2012) identify those partner types most strongly

associated with success in introducing NTM innovation for a large group of European firms. Their findings suggest that 'science-driven search' with universities and research institutes and 'supplier-driven' search are most strongly associated with NTM innovation. Conversely, 'market-driven' search with customers is most strongly linked to, more imitative, new-to-the-firm innovation. This suggests that firms' innovation strategy – whether focused on NTM or incremental innovation – will influence their external knowledge search behaviour and partner choice (Hung and Chou 2013; Wu and Shanley 2010). In addition, firms' prior experience of having introduced NTM innovation may act as a signal to university partners of their capability to apply advanced technology in highly innovative ways (Penin 2005; Nokkala et al. 2008). This leads to our third hypothesis:

H3: Prior NTM innovation

Firms' having previously undertaken new-to-the-market innovation will form innovation collaborations with universities.

Internal discovery processes and external collaborations with universities and other partners provide the knowledge inputs to the process of innovating. A number of studies emphasise the positive impact of collaboration for innovation (Un and Asakawa 2015; Fitjar and Rodriguez-Pose 2013; Suh and Kim 2012; Love and Roper 2004) and the positive contribution of university collaboration in particular. University collaboration may provide firms with access to a range of different resources to enable NTM innovation, including access to research findings, instruments, experimental materials, human capital and research techniques (Cohen et al. 2002), access to skills and knowledge (Zucker and Darby 2001) and access to facilities and equipment (Lawton-Smith and Bagchi-Sen 2006). These resources may complement firms' own internal investments but may also act as a substitute. For example, George et al. (2002) found that biotech companies collaborating with universities had lower R&D spend but higher levels of innovative output than other similar firms. This suggests our final hypothesis:

Hypothesis 4: From knowledge to innovation

Collaboration with universities will increase the probability of introducing new to the market innovation.

3. DATA AND METHODS

3.1 The UK Innovation Survey

Our analysis is based on the UK Innovation Surveys (UKIS) covering the period 2004 to 2012. This survey is non-compulsory and is conducted every two years, resulting in a pooled cross section dataset comprising fives waves of data. Questionnaires are sent by post using as a sampling frame the Interdepartmental Business Register, after stratifying for firm size (in terms of number of employees), region and industry sector. Achieved response rates range from 51.1 per cent in wave 7 (covering firms' innovation activity over the period 2008-2010) to 58 per cent in wave 4 (covering 2002-2004)[5]. The UK Innovation Survey applies the definitions and type of questions defined in the OECD Oslo Manual (2005) and, for innovating firms, provides detailed information on the nature of firms' innovation and their collaboration with universities and other partners[6]. The survey also provides information on a range of other firm-level characteristics which we use as control variables. Each wave consists of approximately fourteen thousand firms resulting in a pooled database of around seventy five thousand observations. However, due to the UKIS being a sample survey the dataset is extremely unbalanced. Consistent with our theoretical framework we introduce a dynamic element in our empirical analysis and we therefore focus on those observations where firms responded to two consecutive waves of the survey.

[5] See: https://www.gov.uk/government/collections/community-innovation-survey
[6] Filters included in the UKIS mean that questions on collaboration for innovation are only asked of firms which undertook some innovation in products or services, or processes in the period covered by the survey.

This significantly reduces the effective sample size to around a thousand observations per wave.

3.2. Dependent variables

Modelling disruptive innovation is not a straightforward task. Since Christensen (1997) coined the term 'disruptive technologies' a range of different measures have been used. In the UKIS, respondents who indicated that they introduced either a new or significantly improved product or service were then asked to indicate whether their 'business introduced a new good or service to the market before competitors'. Based on firms' responses we construct a binary variable which takes the value of 1 if the innovating firm has introduced a NTM innovation and 0 otherwise. 45 per cent of innovating firms indicated that they introduced a NTM product or service rather than a new-to-the-firm (NTF) product or service during the survey period (Table 1). This proportion varied very little between firm sizes (Table 1). A second dependent variable is also available in the UKIS related to the proportion of firms' sales derived from NTM innovation. This measure – standardly used in studies of firms' innovation activity – provides an indication of the initial market success of firms' innovation activity.

In terms of university collaboration, our measure is derived from a question 'did your business co-operate on any innovation activities with any of the following: universities or other higher education institutions (HEI)?'[7] and takes the value of 1 if the firm reports a collaboration with a HEI and 0 otherwise. 20 per cent of innovating firms reported university collaboration over the 2002-12 period, with such cooperation significantly more likely for larger businesses (Table 1).

[7] In the UKIS firms were asked to indicate separately whether university (and other) collaborators were regional, national or international. Here, we aggregate these variables into a single binary variable which takes value 1 if a firm collaborated with a university regardless of location.

3.3. Econometric Strategy

We estimate the following bivariate dynamic and recursive model which simultaneously estimates the probability of introducing new-to-the-market innovation ($NTMI_i$), conditional on the likelihood of collaborating with a University (UNI_COOP_i). More specifically,

$$NTMI^*_{it}=\alpha_0+\alpha_1 UNI\_COOP_t+\alpha_2 OTH\_COOP_t+\alpha_2 FLC_t+\varepsilon_{1t} \quad (1)$$

$$UNI\_COOP_t=\beta_0+\beta_1 NTMI_{t-1}+\beta_2 UNI\_COOP_{t-1}+\beta_3 OTH\_COOP_{t-1}+\beta_4 FLC_t+\varepsilon_{2t} \quad (2)$$

$$\varepsilon_1,\varepsilon_{21}\sim N_2[(0,0),(1,1,\rho)]$$

where OTH_COOP_t denotes collaboration with other innovation partners and FLC_t are a set of firm and sector level controls. ε_{1t} and ε_{2t} are random errors assumed to be independently and identically distributed as a bivariate normal with unitary variance and correlation coefficient equal to $\rho = corr(\varepsilon_{1t}, \varepsilon_{2t})$. Equation (1) here is the standard innovation production function relating innovation outputs in the current period to knowledge inputs from investment within the firm or external collaborations (Leiponen and Byma 2009; Leiponen 2012). Equation (2) reflects the effects of learning and expected returns on the probability of collaborating with a university (Love, Roper, and Vahter 2014).

In principle, we could allow for a feedback loop in our system of equations, i.e. a direct effect of the probability to introduce new-to-the-market innovation on the likelihood of collaborating with a University; however a coherency problem arises. Goureiroux et al. (1980) and Maddala (1983) prove this model is inconsistent, and prior parameter restrictions are needed in order to be logically consistent. Our assertion is instead that the decision to cooperate with a university in the current period is determined by firms' previous experience of collaboration and from its past innovation activity (Rosenberg 1976).

The correlation coefficient between the two error terms (ε_{1t}, ε_{2t}) accounts for all possible omitted or unobservable factors that drive both the probability to introduce new-to-the-market innovation and the likelihood of collaborating

with a university. The significance of $\hat{\rho}$ represents a 'proof of the goodness of this approach'. In other words, if $\hat{\rho}$ is not significantly different from zero, the error terms are not correlated and the model can be consistently estimated using two univariate probit models. On the other hand, if $\hat{\rho}$ is significantly different from zero, the estimates of two separate probit models are inconsistent and joint estimation is required. Finally, in all models we allow for clustering of errors due to the non-independence of observations within the same firm capturing at least part of any unobserved heterogeneity.

Where our new-to-the-market innovation indicator is binary, it might be appropriate to estimate the two equations using simple probit estimators. However, as we suggest in Hypothesis 1, the decision to cooperate with a university and introduce new-to-the-market innovation may be inter-related with elements of firms' innovation strategy. Potential endogeneity suggests that univariate probit models might produce biased and inconsistent results and we therefore use a bivariate probit model which simultaneously estimates the probability of introducing new-to-the-market innovation ($NTMI_i$), conditional on the likelihood of collaborating with a university (UNI_COOP_i). Where our new-to-the-market innovation indicator is the percentage of sales, bounded at zero, we use a tobit estimator allowing for potential endogeneity of university collaboration. Both models are implemented using the CMP module in Stata (Roodman, 2011).

3.4. Explanatory Variables

Variables reflecting collaboration with other types of innovation partners are defined in a similar way to that for university collaboration (Table 1 and Annex 1), with the most common collaborators being suppliers (44 per cent of firms) and customers (49 per cent of firms). In the innovation production function (equation (1)) we include firms' concurrent decision to collaborate with a university and other types of partners as explanatory variables. However, the decision to collaborate with a University is potentially dependent on previous learning effects from past collaboration with a university and other partners as well as previous new-to-the-market innovation. In equation (2) we therefore incorporated the lagged decisions to

collaborate with university and other types of partners as well as the previous new-to-the-market innovation as explanatory variables.

We have also included in our analysis a set of control variables which previous studies have linked to dimensions of innovation activity examined here. In the innovation production function, we include a binary indicator of whether or not the firm has an in-house R&D capability (Love and Roper, 2001, Griffith et al., 2003) which we anticipate will be positively associated with the probability that a firm will introduce new-to-the-market innovation. Second, we include another binary variable reflecting firms' innovation related investments in design. Furthermore, we have included a dummy variable for the importance of standards in firms' innovation activities and, here, we also expect a positive effect on new-to-the-market innovation propensity. In order to capture any market scale effects we have included a binary variable indicating whether or not a firm was selling in export markets and a Herfindahl index to approximate industrial concentration and firms' market power. Previous studies have linked exporting and innovative activity through both competition and learning effects (Love and Roper 2013).

Turning to the control variables included in the collaboration model (equation (2)), we include a variable reflecting the strength of firms' human resources – the percentage of the workforce which are graduates in science and engineering (Leiponen, 2005; Freel, 2005; Hewitt-Dundas, 2006). In addition, we include a dummy variable reflecting the importance of publications as a knowledge source in firms' innovation activities. For both controls we expect a positive effect on the decision to collaborate with a University. Finally, in both equations we control for firm size by incorporating the (log) employment in the estimated models to reflect the scale of plants' resources, and we allow for sectoral and temporal heterogeneity by including sectoral dummies at the 2-digit level and wave dummies.

4. EMPIRICAL RESULTS

In Table 2 we report dynamic bivariate probit models of the innovation strategy decision to develop NTM innovation in collaboration with a university (equations 1 and 2). Both models include sectoral and time period dummy variables (not reported). We find strong evidence of significant residual correlations between the two elements of the bivariate probit suggesting the simultaneity of firms' innovation and collaboration decisions. This finding is consistent for both our full-sample estimation and for small, medium and larger firms (Table 2). The implication is that for firms of all sizes, strategy choices relating to the type of innovation firms introduce are strongly inter-linked with their decision to collaborate with universities (Monjon and Waelbroeck 2003; Belderbos, Carree, and Lokshin 2004).

Our first two hypotheses relate to potential learning effects. Does collaboration with other types of organisations (e.g. suppliers, customers) for innovation in a previous period help firms overcome the two-worlds paradox (Hypothesis 1)? And, does having prior collaboration with a university mean that firms are more or less likely to continue some similar relationship (Hypothesis 2)? For our full sample we find little evidence of dynamic economies of scope (Love, Roper, and Vahter 2014), with no evidence of any significant learning effects from prior collaboration with customers, suppliers or competitors (Table 2). There is, however, some evidence that previous collaboration with consultants slightly increases the probability of university collaboration. The scale of each of this effect can be identified from Table 3 which reports the marginal values derived from the models reported in Table 2. In each case we report marginal values where a firm has no university collaboration but where a firm is undertaking NTM innovation. In panel (b), which relates to the determinants of university collaboration, the negative coefficient on prior consultancy (-0.01) therefore implies that a firm is around one per cent less likely to have no university collaboration if it previously collaborated with consultants. Or, put more simply, collaborating with consultants increases the probability of university collaboration by around one per cent (Table 3).

Those learning effects which prove statistically significant differ between firm sizebands (Table 2), although as with the consultancy effect for all firms, the effect sizes remain relatively small (Table 3). For small firms (with less than 50 employees), prior collaboration with customers increases the probability of university collaboration by around 1.4 per cent, while prior supplier and competitor collaboration have small negative effects on the probability of university collaboration (Table 3). For medium and large firms, prior collaboration with consultants proves significant, increasing the probability of university collaboration by 2-3 per cent. Other potential learning effects prove weak or insignificant (Table 3). Overall, while we do find some evidence of statistically significant learning effects from prior collaboration, these effects are relatively small.

Larger effects, which are consistent across firm sizebands, are evident from prior collaboration with universities. On average, collaborating with a university in one period means that firms are 8.7 per cent more likely to continue that collaboration into the next (three year) period (Table 3). Two explanations are possible for this sizeable effect. First, it may simply be that in some instances collaborative projects between firms and universities are longer than a single survey period (3 years) and therefore the same project or projects are being captured in two survey observations. Second, it may be that firms experiencing university collaboration become aware of the benefits they derive, and continue that relationship in subsequent periods (Bellucci and Pennacchio 2016). From our data it is impossible to distinguish between these two possibilities, but Spanish data suggests that the vast majority of university-industry collaborations are of two years duration or less (Montoro-Sanchez, Mora-Valentin, and Guerras-Martin 2006)[8], suggesting

[8] More specifically of 800 agreements analysed by Montoro-Sanchez et al. (2006, Table 5), 11 per cent of collaborations were of 0-12 months duration, 60.9 per cent were 13-24 months duration, 26.7 per cent were 25-36 months long and only 1.6 per cent exceeded 36 months.

that a learning effect may be the primary explanation for the observed persistence in university collaboration.

Our third hypothesis relates to the relationship between undertaking NTM innovation in the previous period and subsequent university collaboration. Again, this effect proves positive and significant for all firm sizebands: undertaking prior NTM innovation increases the probability of current university collaboration by 2.0-3.4 per cent over and above any effect from prior university collaboration (Table 3). Possible explanations for this positive effect depend on whether firms undertaking NTM innovation in the previous period were collaborating with a university. For firms undertaking NTM with university collaborators, it is likely learning effects predominate as experience helps firms to understand the value of university collaboration. For firms undertaking NTM without a university partner a number of learning mechanisms are possible. First, it is possible that through undertaking NTM innovation, firms developed their absorptive capacity which made it easier to collaborate with universities in future (Enkel and Heil 2014; Bellucci and Pennacchio 2016). Second, the experience of undertaking NTM innovation without a university partner may have highlighted the potential value of university input to subsequent developments reflecting firms' own bounded knowledge-base, particularly where firms have substantial absorptive capacity (Belderbos, Gilsing, and Suzuki 2016). Finally, prior NTM innovation may be acting as a positive signal to potential university partners of firms' internal capabilities and therefore their attractiveness as a future partner (Comino and Graziano 2015).

Our final hypothesis relates to the impact of university collaboration on NTM innovation itself. Here we anticipate, and find, a positive relationship with university collaboration increasing the probability that a firm will undertake NTM innovation by 21-22 per cent (Table 3). This effect is strongly significant and consistent across firm sizebands. It is also consistent with evidence from other studies which suggest the value of collaboration for radical innovation (Zang et al. 2014), and the more specific value of university knowledge (Bellucci and Pennacchio 2016). We also examine the impact of university collaboration on firms' sales derived from new to the market innovations and

again find positive and significant effects (Table 4). Across all firms, university collaboration increases sales of new to the market products or services by around 4.1 per cent. For small firms, this effect is smaller (1.4 per cent) and insignificant, but for medium and larger firms there are strong and significant effects with university collaboration adding 12.3-15.9 per cent to sales of new to the market innovations (Table 4).

A range of other control variables also prove important in determining the probability of NTM innovation (Table 3). Design investment, exporting and in-house R&D are all positively associated with NTM innovation, and have a combined effect close to that of university collaboration. Customer collaboration also proves important for small, as well as medium sized firms, increasing the probability of NTM innovation by 7.7 and 4.5 per cent respectively. We find no evidence that either collaboration with consultants or suppliers has any significant influence on the probability of NTM innovation.

5. DISCUSSION AND CONCLUSIONS

Our analysis suggests three main empirical results which provide some new insight into the formation of university-business collaborations for innovation and the results of that collaboration. First, we find evidence that learning from prior collaboration with customers, suppliers etc. increases the probability that, subsequently, firms will collaborate with a university for innovation. These learning effects are relatively small in scale, however, increasing the probability that a firm will collaborate with a university by no more than around five per cent in aggregate (Table 3). Other experiential factors prove more important in shaping firms' decisions to collaborate with a university in any period – particularly past university collaboration and prior experience of undertaking NTM innovation.

Our other key results relate to the innovation impacts of university collaboration and suggest some marked differences between the benefits derived by small firms (with 10-50 employees) and larger companies. In particular, while firms of all sizes benefit similarly from university

collaboration in terms of bringing new products or services to market, the commercial benefits derived from those new products or services differ markedly by firm size. Collaboration with universities is associated in our data with a 21-22 per cent increase in the probability of undertaking NTM innovation, an effect which is broadly similar in size for firms in all sizebands. However, while collaboration with universities is associated with a 12.3-15.9 per cent increase in sales from NTM innovations for medium and larger firms we find no significant sales effect for small firms. In other words, while university collaboration is helping small firms bring NTM products and services to market, small firms appear unable to derive significant commercial benefits from these innovations.

In policy terms it is useful to think about our results in terms of a commercialisation pipeline with three phases: the formation of university-business collaborations; the success of those collaborations in generating new-to-the-market offerings (either products or services); and, the effective commercialisation of these new innovations. In terms of the formation of university-business collaborations for innovation, it is clear that larger firms are more active: 25 per cent of larger innovating firms (with more than 250 employees) were collaborating with universities compared to 17 per cent of small firms (Table 1). This is broadly similar to the pattern of collaboration with consultants: 32 per cent of large innovating firms were collaborating with consultants compared to 19 per cent of small innovating firms (Table 1). Lower levels of collaboration by small firms may relate information failures relating to firms' perceptions of the benefits of university collaboration, the capabilities of university partners and their trustworthiness (Hewitt-Dundas and Roper, 2016; Bellucci and Pennacchio, 2016). If more small firms are to benefit from university collaboration for innovation this means over-coming any such information failures, and the 'two worlds' paradox which may influence the success of small business-university collaborations. Our evidence suggests that prior collaboration with other organisations which help firms learn to collaborate effectively can be helpful although effect sizes are relatively small. This suggests the continued value of other mechanisms to initiate small firm-university collaboration. Innovation Vouchers, for example, have proved an attractive and effective mechanism for initiating

such relationships (Sala, Landoni, and Verganti 2016; Matulova et al. 2014), and our evidence suggests that once a firm starts collaborating with a university for innovation this tends to continue.

The other aspect of the commercialisation pipeline where there are marked contrasts between the success of small and larger firms is in the commercialisation of new-to-the-market innovations derived from university collaborations. The general issues here reflect differences in the capabilities of larger and smaller firms to appropriate the benefits of innovation (Perez-Cano 2013), with smaller firms generally adopting less effective appropriation strategies (Holgersson 2013). Resource constraints may also mean that small firms are less able to develop and implement effective product launch strategies or export market plans. For example, Kuester et al. (2012) based on 780 German firms find that small size reduces firms' ability to generate effective product launch activities from within the firm. Their study also highlights the importance of such internal activities – linked to firms' other products/services and capabilities - for more radical products. For small firms, in particular, this may suggest the value of near market initiatives to support the effective introduction of new-to-the market products or services derived from university collaborations.

More generally, our results re-emphasise the important contribution of universities to innovation, and the particular role which universities play for firms whose strategies focus on NTM innovation (Laursen and Salter 2004). For these firms, university knowledge may provide the impetus for radical product or service development and the associated first mover advantages (Kopel and Loffler 2008; Xin, Yeung, and Cheng 2010). More broadly, our results suggest the potential role of universities in stimulating disruptive innovation, and the associated creative destruction processes with both their positive and negative connotations: 'the creation is usually accomplished by invaders – new firms or entrants from other industries – while the destruction is suffered by the incumbents'[9]. In this sense, industry incumbents have little

[9] Rosenbloom and Christensen (1994, p. 656) as quoted in Bergek et al. (2013).

to gain from seeing universities collaborate with, and empower potential 'invaders', which may in time become competitors.

Our analysis provides some new insight into the role of learning effects and university collaboration in the commercialisation pipeline for new-to-the-market innovations. Two significant limitations are evident, however. First, in our current analysis we focus on university collaboration as a single entity. Previous studies have suggested, however, that collaboration with local or national universities may yield rather different outcomes to collaborating with international universities. Second, our analysis here is cross-sectoral and, for the moment we simply control for sectoral contrasts in our analysis. Exploring these sectoral contrasts in more detail may provide further insight into the variety of commercialisation pipelines and a more defined set of policy priorities.

Table 1. Descriptive Statistics

	All firms (N=3581)		Small (N=1181)		Medium (N=1296)		Large (N=1104)	
	Mean.	Std Dev.	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
New to Market Innov ((0/1))	0.45	0.50	0.45	0.50	0.43	0.50	0.46	0.50
New to Market Innovation Performance (%)	9.638	17.174	13.144	21.080	8.467	15.021	7.218	13.791
Uni Collab (0/1)	0.20	0.40	0.17	0.37	0.19	0.39	0.25	0.43
Consultancy Collab (0/1)	0.24	0.43	0.19	0.39	0.22	0.41	0.32	0.47
Customer Collab (0/1)	0.49	0.50	0.44	0.50	0.48	0.50	0.54	0.50
Supplier Collab (0/1)	0.44	0.50	0.37	0.48	0.42	0.49	0.53	0.50
Competitor Collab (0/1)	0.19	0.40	0.18	0.39	0.18	0.39	0.22	0.41
Employment (Log)	4.67	1.53	3.13	0.47	4.65	0.55	6.38	1.06
In house R&D (0/1)	0.75	0.43	0.74	0.44	0.76	0.43	0.76	0.43
Design (0/1)	0.51	0.50	0.50	0.50	0.50	0.50	0.55	0.50
Exporter (0/1)	0.63	0.48	0.56	0.50	0.69	0.46	0.66	0.47
Herfindahl Index 0-1	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03

Table 2. The innovation strategy decisions: The probability of introducing new-to-the-market products and university cooperation

	All firms (N=3581)	Small (N=1181)	Medium (N=1296)	Large (N=1104)
(a) Probability of new-to-the-market Innovation				
Uni Collab (0/1)	0.863***	0.781***	0.758***	0.816***
	(0.122)	(0.161)	(0.116)	(0.340)
Consultancy Collab (0/1)	-0.008	0.089	-0.146**	0.087**
	(0.073)	(0.062)	(0.119)	(0.042)
Customer Collab (0/1)	0.195***	0.270***	0.158	0.092
	(0.057)	(0.111)	(0.096)	(0.076)
Supplier Collab (0/1)	0.051	0.042	-0.009	0.095
	(0.085)	(0.108)	(0.026)	(0.103)
Competitor Collab (0/1)	-0.008	-0.048	0.131	0.051
	(0.092)	(0.080)	(0.076)	(0.084)
Employment (Log)	-0.005	-0.101**	-0.014	0.035
	(0.018)	(0.054)	(0.019)	(0.030)
In house R&D (0/1)	0.384***	0.308***	0.552***	0.403***
	(0.042)	(0.056)	(0.067)	(0.133)
Design (0/1)	0.239***	0.412***	0.166	0.173
	(0.038)	(0.022)	(0.050)	(0.111)
Exporter (0/1)	0.300***	0.270***	0.247***	0.380***
	(0.043)	(0.050)	(0.039)	(0.067)
Herfindahl Index 0-1	-0.341	12.596	2.284	-12.110
	(7.183)	(9.387)	(9.039)	(11.968)
cons	-0.699	-8.083	-8.219	1.035
	(0.910)	(5.565)	(4.828)	(1.508)
(b) University Collaboration				
New to Market t-1, (0/1)	0.402***	0.270***	0.356***	0.351***
	(0.076)	(0.111)	(0.108)	(0.143)
Uni Collaboration t-1, (0/1)	1.132***	1.240***	1.052***	1.147***
	(0.054)	(0.141)	(0.102)	(0.144)
Consultancy Collab t-1, (0/1)	0.127*	-0.054	0.270**	0.307***
	(0.073)	(0.045)	(0.106)	(0.105)
Customer Collab t-1, (0/1)	0.000	0.185**	0.099	0.055
	(0.036)	(0.085)	(0.049)	(0.185)
Supplier Collab t-1, (0/1)	-0.092	-0.194***	0.066	-0.206
	(0.125)	(0.043)	(0.096)	(0.199)
Competitor Collab t-1, (0/1)	-0.004	-0.148**	-0.220*	0.052
	(0.036)	(0.064)	(0.125)	(0.070)
Employment (Log)	0.085***	-0.015	-0.046***	0.160***
	(0.019)	(0.097)	(0.034)	(0.053)
Sci & Eng Grads (No.)	0.010***	0.009***	0.010***	0.012***
	(0.001)	(0.001)	(0.002)	(0.001)
Publications (0/1)	0.497***	0.527***	0.529***	0.295***
	(0.086)	(0.120)	(0.068)	(0.056)
cons	-2.811***	-1.225***	-1.623***	-7.792***
	(0.176)	(0.377)	(0.185)	(0.482)
athrho	-0.472***	-0.453***	-0.508***	-0.390**
	(0.081)	(0.179)	(0.072)	(0.234)
rho	-0.440***	-0.425	-0.468***	-0.371**
	(0.065)	(0.147)*	(0.056)	(0.202)
Wald test of rho=0	34.294***	6.429***	49.432***	2.762*

Notes and sources: UK Innovation Survey, waves 4-8 pooled sample. All models include wave and industry dummies. Standard errors in parentheses * p<0.05, ** p<0.01, *** p<0.001.

Table 3. Marginal effects for the probability of introducing new-to-the-market products and university collaboration

	All firms (N=3581)	Small (N=1296)	Medium (N=1204)	Large (N=1181)
(a) Probability of new-to-the-market innovation				
Uni Collab (0/1)	0.247***	0.221***	0.213***	0.212***
	(0.033)	(0.046)	(0.032)	(0.083)
Consultancy Collab (0/1)	-0.002	0.025	-0.041	0.023**
	(0.021)	(0.017)	(0.033)	(0.011)
Customer Collab (0/1)	0.056***	0.077***	0.045*	0.024
	(0.016)	(0.031)	(0.027)	(0.020)
Supplier Collab (0/1)	0.015	0.012	-0.003	0.025
	(0.024)	(0.031)	(0.007)	(0.027)
Competitor Collab (0/1)	-0.002	-0.014	0.037*	0.013
	(0.026)	(0.023)	(0.021)	(0.022)
Employment (Log)	-0.008	-0.027**	-0.001	-0.006
	(0.006)	(0.013)	(0.005)	(0.007)
In house R&D (0/1)	0.110***	0.087***	0.156***	0.105***
	(0.012)	(0.016)	(0.019)	(0.036)
Design (0/1)	0.068***	0.117***	0.047***	0.045
	(0.011)	(0.006)	(0.014)	(0.028)
Exporter (0/1)	0.086***	0.076***	0.070***	0.099***
	(0.012)	(0.014)	(0.011)	(0.017)
Herfindahl Index 0-1	-0.098	3.572	0.644	-3.147
	(2.053)	(2.657)	(2.546)	(3.094)
(b) University Collaboration				
New to Market t-1, (0/1)	-0.031***	-0.020***	-0.027***	-0.034***
	(0.005)	(0.007)	(0.008)	(0.012)
Uni Collaboration t-1, (0/1)	-0.087***	-0.092***	-0.078***	-0.111***
	(0.007)	(0.016)	(0.007)	(0.017)
Consultancy Collab t-1, (0/1)	-0.010*	0.004	-0.020***	-0.030***
	(0.006)	(0.003)	(0.008)	(0.012)
Customer Collab t-1, (0/1)	0.000	-0.014**	-0.007**	-0.005
	(0.003)	(0.007)	(0.004)	(0.018)
Supplier Collab t-1, (0/1)	0.007	0.014***	-0.005	0.020
	(0.010)	(0.004)	(0.007)	(0.020)
Competitor Collab t-1, (0/1)	0.000	0.011**	0.016*	-0.005
	(0.003)	(0.005)	(0.009)	(0.007)
Sci & Eng Grads (No.)	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Publications (0/1)	-0.038***	-0.039***	-0.039***	-0.028***
	(0.007)	0.010	(0.005)	(0.004)

Notes and sources: UK Innovation Survey, waves 4-8 pooled sample. All models include wave and industry dummies. Standard errors in parentheses * p<0.05, ** p<0.01, *** p<0.001. Base case: New-to-the-market innovation: yes; university collaboration: no.

Table 4. Sales of new-to-the-market innovation and university collaboration

	All firms (N=3581)	Small (N=1181)	Medium (N=1296)	Large (N=1104)
(a) Sales of new-to-the-market innovations				
Uni Collab (0/1)	4.085*	1.378	15.860***	12.392***
	(1.788)	(3.013)	(1.960)	(2.009)
Consultancy Collab (0/1)	0.164	1.967	0.438	-2.009
	(0.923)	(1.975)	(1.414)	(1.147)
Customer Collab (0/1)	0.839	2.951	0.745	-0.251
	(0.859)	(1.780)	(1.297)	(1.187)
Supplier Collab (0/1)	2.297**	4.443**	0.737	1.680
	(0.841)	(1.702)	(1.287)	(1.150)
Competitor Collab (0/1)	-0.749	-1.681	-1.293	-0.0357
	(0.945)	(2.016)	(1.470)	(1.211)
Employment (Log)	-1.557***	-3.832*	-0.461	-0.975*
	(0.229)	(1.519)	(1.043)	(0.458)
In house R&D (0/1)	1.686	-0.113	1.529	1.391
	(0.915)	(1.968)	(1.426)	(1.201)
Design (0/1)	2.861***	5.041**	0.726	2.007*
	(0.743)	(1.580)	(1.102)	(0.992)
Exporter (0/1)	1.242	0.943	-0.418	1.320
	(0.809)	(1.574)	(1.330)	(1.115)
Herfindahl Index 0-1	-14.07	-29.35	62.40	-11.48
	(28.91)	(105.4)	(80.77)	(36.11)
	18.42***	35.56***	3.802	6.191
Constant	(5.423)	(10.53)	(8.210)	(3.362)
(b) University Collaboration				
	0.004	0.002	0.012***	0.009**
Innovation performance t-1	(0.002)	(0.003)	(0.003)	(0.003)
	1.190***	1.376***	0.758***	0.766***
Uni Collaboration t-1, (0/1)	(0.084)	(0.149)	(0.141)	(0.145)
	0.227**	0.009	0.294*	0.306**
Consultancy Collab t-1, (0/1)	(0.084)	(0.161)	(0.128)	(0.115)
	0.075	0.125	0.147	0.0417
Customer Collab t-1, (0/1)	(0.082)	(0.147)	(0.122)	(0.122)
	-0.071	-0.228	0.0792	-0.143
Supplier Collab t-1, (0/1)	(0.081)	(0.146)	(0.123)	(0.123)
	-0.060	-0.169	-0.224	0.160
Competitor Collab t-1, (0/1)	(0.087)	(0.167)	(0.135)	(0.121)
	0.066**	0.0141	-0.0323	0.143**
Employment (Log)	(0.020)	(0.113)	(0.0889)	(0.0505)
Sci & Eng Grads (No.)	0.011***	0.009***	0.009***	0.014***
	(0.002)	(0.002)	(0.002)	(0.002)
	0.413***	0.527***	0.448***	0.217
Publications (0/1)	(0.080)	(0.143)	(0.129)	(0.113)
	-1.862***	-1.296	-1.324	-7.900
Constant	(0.398)	(0.681)	(0.713)	(1352.2)
	-0.157**	0.035	-0.745***	-0.705***
Rho	(0.074)	(0 .092)	(0.050)	(0 .066)
N	3374	1214	1036	1113
chi2	826.2***	273.5***	396.1***	466.5***
Bic	23763.9	8679.1	7235.2	8095.2

Notes and sources: UK Innovation Survey, waves 4-8 pooled sample. All models include wave and industry dummies. Standard errors in parentheses * p<0.05, ** p<0.01, *** p<0.001.

Annex 1: Variable Definitions

New to the market innovation	Dummy variable indicating whether firms introduced a new-to-the-market innovation at time t-1
New to Market Innovation Performance	The percentage of innovative sales due to New to the market innovation to firms total sales
Uni Collab	Dummy variable indicating whether firms cooperate with a University at time t
Consultancy Collab	Dummy variable indicating whether firms cooperate with consultants, commercial labs or private R&D institutes as part of their innovation activities at time t
Customer Collab	Dummy variable indicating whether firms cooperate with clients and customers from both private and public sector as part of their innovation activities at time t
Supplier Collab	Dummy variable indicating whether firms cooperate suppliers of equipment, materials, services or software as part of their innovation activities at time t
Competitor Collab	Dummy variable indicating whether firms cooperate competitors or other businesses in their industry as part of their innovation activities at time t
Employment (Log)	Log of number of employees (firm size)
In house R&D	Dummy variable capturing whether firms invest in in-house R&D
Design	Dummy variable capturing whether firms have invested in all forms of design
Exporter	Dummy variable capturing whether firms export
publications/standards	Dummy variable indicating that standards are important for firms innovation activities
Herfindahl Index	A measure of the size of firms in relation to the industry and an indicator of the amount of competition among them.
Sci & Eng Grads (No.)	Science and engineering graduates as a proportion of the workforce
Publications	Dummy variable indicating that publications are important for firms innovation activities

Annex 2: Correlation Matrix (N=3,581)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.New to Market Innov (0/1)	-													
2. New to Market Innovation Performance	0.35	-												
3.Uni Collab (0/1)	0.14	0.05	-											
4.Consultancy Collab (0/1)	0.11	0.04	0.46	-										
5.Customer Collab (0/1)	0.18	0.06	0.34	0.36	-									
6.Supplier Collab (0/1)	0.12	0.06	0.32	0.39	0.53	-								
7.Competitor Collab (0/1)	0.08	0.02	0.32	0.36	0.38	0.36	-							
8.Employment (Log)	-0.02	-0.14	0.09	0.14	0.06	0.12	0.07	-						
9.In house R&D (0/1)	0.24	0.10	0.19	0.17	0.17	0.12	0.07	0.00	-					
10.Design (0/1)	0.21	0.12	0.17	0.17	0.19	0.16	0.12	0.03	0.36	-				
11.Exporter (0/1)	0.19	0.05	0.17	0.11	0.10	0.03	-0.03	0.08	0.20	0.18	-			
12.Herfindahl Index 0-1	-0.05	-0.03	-0.02	0.00	0.00	0.00	0.04	0.05	-0.07	-0.05	-0.11	-		
13. Science and Engineer graduates	0.15	0.20	0.24	0.14	0.13	0.04	0.06	-0.07	0.18	0.11	0.21	-0.03	-	
14. Importance of Publications (0/1)	0.06	0.01	0.21	0.17	0.17	0.13	0.13	0.07	0.08	0.08	0.08	0.00	0.16	-

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