Open Innovation: An Empirical Investigation of the key ingredients in the Science and Technology-based SMEs in the UK

By: Professor Pooran Wynarczyk, FRSA

Paper to be present at the Triple Helix VIII Conference, Madrid 20- 22nd, October, 2010

Professor Pooran Wynarczyk, FRSA
Director
Small Enterprise Research Unit (SERU)
Newcastle University Business School
1st Floor Citywall
Citygate
St. James' Boulevard
Newcastle upon Tyne
NE1 4JH
UK
Email: pooran.wynarczyk@ncl.ac.uk

Introduction

It is almost universally accepted that technological advance and innovation are the most important sources of productivity growth, competiveness and social and economic wellbeing (Edquist and McKelvey, 2000; Edquist, 2005; Wynarczyk, 2007a&b). Novel and high-technology product developments are seen as an effective way of gaining a leading edge over competitors and accessing new and niche markets (Lawson and Longhurst, 2006). Increasingly research and policy attention has come to focus on the small and medium-sized enterprise (SME) sector as a key source of new product development, innovation and suppliers of new technologies. Innovative SMEs appear, therefore, to be vital parts of a dynamic process of national and regional economic development (Wynarczyk and Thwiates, 2000). Evidence appears to justify the desire for improved technological performance in many firms, individuals, industries and economies and the needs to identify and support those factors capable of 'making a difference'. In recent years, there have been some major shifts in the way scientific research is carried around the world. It has been claimed that firms are moving away from the 'closed innovation model' in which most of R&D are carried out in isolation in their own laboratories to one in which they actively collaborate with other firms and higher education institutions (HEIs), i.e., 'open innovation' (Chesbrough, 2003; Chesbrough, et al, 2006; Lambert, 2004). As a result, extensive encouragement takes place in terms of, for example, R&D collaboration and technology sharing between firms and with other sectors such as the HEIs (e.g., Narula, 2002).

This paper builds upon recently completed projects, sponsored by the Economic and Social Research Council (ESRC) Science in Society Programme and Higher Education European Social Fund (HE ESF National). The empirical investigation presented in this paper is based on an in-depth survey, via a dedicated questionnaire, of 64 innovative SMEs operating in several key scientific and technology related sectors (e.g., chemical) in English regions of the UK. These firms have been selected on the basis that in the two years prior to this empirical investigation, they had been involved in new product development and innovation and had continued to be engaged in new product development and innovation, either operating in collaboration with other firms and higher education Institutes (HEIs), i.e., 'open innovation', a total of 33 firms or undertaking their innovation activities in isolation, i.e., closed innovation, a total of 31 firms.

The paper aims to identify and analyse the factors (key ingredients) that contribute to the innovation and new product development: activities, processes and capacity building of SMEs. The paper compares and contrasts some key innovation variables (e.g., R&D employment, R&D budget) as well as other related variables (e.g., the management structure and capacity) between ‘open innovation’ and ‘closed innovation’ firms. The key findings, based on several statistical tests, indicate that open innovation/ new product development activity of SMEs is a complex and multi- faceted process, highly related to and depended upon the cumulative effects of and interrelationship between several key ingredients, including, R&D expenditure, patent, size of the R&D team, R&D grants, as well as a well structured management team with complementary expertise.

The paper consists of six sections. Section one provides an overview of the key ingredients of innovation, followed by a section on open innovation. An overview of the SME sector is presented in section three, followed by a section on the role of UK Government intervention in science, innovation and R&D. Some preliminary findings are presented in section five, followed by some concluding remarks in the final section.

The Key Ingredients of Innovation

The combination of total amount of industrial R&D expenditure and the number of registered patents are commonly used to measure and compare the innovation performance in the advanced economies. A recent report on behalf of the OECD, that has examined the link between R&D and patenting for 19 OECD countries over the period 1986–2000 found a clear positive link between the principal effects for generation of patent and R&D in the business sector (Jaumotte, F. and Pain, N, 2005; Sainsbury, 2007).

It has been argued that compared with other advanced countries, British business is not research intensive, and in recent years its records of investment in R&D and patenting has been relatively low. UK business research is concentrated in a narrow range of industrial sectors, and in a small number of large companies, over 80% of UK R&D is conducted by the hundred most active companies, the main reasons beyond the productivity gap that exist between the UK and other comparable economies (Sainsbury, 2007; R&D Scoreboard, 2009; OECD, 2003).

According the data provided by the Business Monitor MA14 (2008), over the period 1996 to 2006, the expenditure on R&D performed in the UK businesses experienced a steady increase, from £9,297m in 1996 to £14,306 million in 2006. In broad terms, the greatest absolute sums are spent on R&D in chemicals, aerospace, electrical machinery and services (Business Monitor, MA14, 2008). In 2006, around 149,000 people were estimated to be employed in industrial R&D in the UK, of whom the majority were employed as: scientists and engineers (94k, 63%); technicians, laboratory assistants and draughtsmen (28k, 19%); and administration and other staff (28k, 19%). More specifically, the highest number employed in R&D are found in: pharmaceuticals, medical chemicals and botanical products (28K, 19%); computer and related activities, (20K, 13%); aerospace (16K, 11%) and machinery and equipment (16K, 8%). The remaining product groups account for 49% of employment in R&D, (Business Monitor, MA14, 2008).

Data provided by the Europa R&D Scoreboard suggests that SMEs performing R&D represent only 2.5% of all SME companies in Europe and independently owned SMEs account for only 3% of the total R&D in UK business (R&D Scoreboard, 2009). The information provided from Europa, shows that the percentage of organisations which are involved in innovation activities in the UK are directly correlated to the size, the latest data produced by Europa (EU Industrial R&D Investment Scoreboard) shows that approximately 25% of firms with 10-49 employees are innovatively active, compared with over 40% of businesses with 50-249 employees and just over 50% with more than 250 employees. More specifically, the highest number employed in R&D were found in pharmaceuticals, medical chemicals and botanical products (26K, 18%), computer and related activities, (19K, 13%), aerospace (15K, 10%), and machinery and equipment (12K, 7%). The remaining product groups account for just over 50% of employment in R&D (MA14, 2007). At a corporate level, in 2005, the highest number of R&D workers are found in businesses employing between 1000 and 4999 workers and less than 40% of researchers in the business enterprise sector are employed in SMEs (MA14, 2008).

Open Innovation

In more recent years, there have been some major shifts in the way scientific research is carried around the world. It has been claimed that firms are moving away from the 'closed innovation model' in which most of R&D are carried out in isolation in their own laboratories to one in which they actively collaborate with other firms and higher education institutions, i.e., 'open innovation' (Chesbrough, 2003, 2004; Chesbrough, et al, 2006;

Lambert, 2003). Henry Chesbrough (2003), in his pioneering book, 'Open Innovation', states that: '*the wealth of innovations that diffused out of these [corporate] laboratories since the 1960s is not likely to recur from those labs in the future, given the labs' shift in orientation away from basic research. The seed corn that will create the innovations of twenty years hence will have to be provided elsewhere in the society'* (p.191).It has been argued that the closed innovation approach to innovation is, increasingly, becoming unsustainable and a new form of innovation, i.e., 'open innovation' is emerging in its place. The 'open innovation' allows for firms to combine external and internal ideas and use both internal and external paths to market their products, as they attempt to advance their technologies (Chesbrough, 2003, p. 23). Open innovation allows for internal ideas to be taken to market through external channels, outside the firm's internal mechanisms, order to generate additional value. Hence, 'open innovation' removes many of the boundaries such as location, and technological, and internal resources that stands in the way of developing new products and entering new markets (Chesbrough, 2003; Industry Week, 2004). It has been argued that open innovation could provide access to information, technologies, and modern laboratory facilities that may take years and require major R&D investment to acquire in-house (Chesbrough, 2003; Chesbrough, et al, 2006; Industry Week, 2004). To become and remain competitive in the increasingly knowledge-based economies, industry needs to collaborate with universities and other firms to transfer their inventions into innovative products through 'open innovation'. Scientific researchers need to become more mobile, willing to undertake their scientific research in other laboratories, jointly with other researchers and where opportunities for progression of their knowledge and ideas exist (Lambert, 2003).

Small and Medium- Sized Enterprises (SMEs)

It is now widely acknowledged that small and medium sized enterprise (SME) sector is the key component of economic growth. The major shift in public policy focus, during the early 1980s, towards the promotion and development of new small firms as *the* vehicle for job creation, reinforced by Birch's startling results for the USA in 1979, ensured that the SME sector would be and remain a key focus for policy makers, politicians and academics. Over the past three decades, the UK has experienced a substantial increase in the number of enterprises, from some 2.4 million in 1979 to over 4.8 million in 2009 (BIs, 2009). There are now over 23 million enterprises operating in Europe, representing 99% of all EU companies and providing jobs for some 75 million people (www.eipa.eu, 2009). There is increasing evidence that new or small firms play an important role in the production of innovation, which is not only considered crucial to the growth of output, productivity, competitive advantage, high quality employment and overall success of the economy, but also a fundamental driving force behind rising living standards (DTI, 2003; Sheikh and Oberhoizner, 2001). However, while it is evident that in aggregate terms small firms play an important role in local and national economic development, only a small proportion of enterprises from the total SME population are responsible for the majority of positive effects. Indeed, the EC's Enterprise Directorate-General (DG) has recognised that from the total population of European SMEs, only a fraction (2%) are responsible for the majority of competitive innovations and thus jobs created and they are, as such vital to regional and national economies insofar as they stimulate growth and diversity in the knowledge base. In a progressively pan-global economy, SMEs face competition from an increasing number of companies. SMEs often lack the resources available to compete globally. However due to their ability to innovate, overseas markets offer large potential for entry into new sectors (Narula, 2002). It is estimated that "one *fifth of SMEs face foreign competition in the domestic market while exporters typically confront considerable competitive pressures in overseas markets*". (Requena-Silvente, 2005 pg 237. See also Cosh and Hughes, 1997). Many SMEs are unable to compete directly with large companies due to the lack of resources available; however they perform well in niche markets due to their propinquity to the market and ability to change rapidly. This provides a strong competitive advantage against larger companies (Narula, 2002, pg 2). A study performed by Narula states that it is extremely costly to maintain R&D departments for any size of organisation, particularly SMEs, however the level of innovation per head of R&D employee is higher for SMEs than it is for larger companies. (Narula, 2002). A study by Bond *et al* (2002) identified high returns associated with firms who are concerned with R&D.

UK Government Intervention

The importance of 'open innovation', particularly, the business-university R&D collaboration was widely recognised by the previous UK Government. During the previous Labour Government's era, three major reports underpinned the science, innovation, technology and R&D policies, initiatives and investment in the UK, namely:

1. SET for Success: the Report of Sir Gareth Roberts' Review (2002) The supply of people with science, technology, engineering and mathematical skills
2. Lambert Review of Business-University Collaboration (2003)
3. The Race to the Top: A Review of Government's Science and Innovation Policies, Lord Sainsbury, (2007)

In March 2001, the then Labour Government commissioned Sir Gareth Roberts to undertake a review on the supply of science and engineering skills in the UK. The Roberts Review, published in 2002, identified a number of fundamental and deep seeded problems in the supply of STEM skills, including significant falls in the real numbers taking physics, mathematics, chemistry and engineering qualifications, particularly amongst girls and shortage of qualified science and maths teachers. The review concluded that these downward trends indicated a future shortage of people in SET employment that could undermine the Government's attempts to improve the UK's research and development (R&D) intensity, productivity and competitiveness (Roberts 2002). The review made a number of recommendations, representing the challenges for the Government, employers and education system to assist the government to build and secure a stronger supply of qualified and skilled people in the science and engineering fields, hence achieving the Government's agenda and targets for raising the R&D and innovation performance of the UK to match the world's best.

In 2003, the then Government commissioned Richard Lambert to undertake a review of business-university collaboration in order to identify and demonstrate the opportunities that are being created by open innovation, both in the way business undertakes research and development (R&D), and in the way that universities are opening their doors to new forms of collaboration with business partners for the transfer and exchange of knowledge. The review highlighted the fact that compared with other countries, 'British business is not research intensive, and its record of investment in R&D in recent years has been unimpressive'. The review revealed that UK business research is concentrated in a narrow range of industrial sectors, and in a small number of large companies, the main reasons beyond the productivity gap that exist between the UK and other comparable economies. The Review, building upon the pioneering work of Henry Chesborugh (2003), conlcuded that the amount of collaboration between business and university was increasing and that government funding for knowledge transfer activity in universities, the so called "third stream funding", had generated a noticable cultural change in universities to built up their capacity to transfer knowledg to the business community. However, the report identified some areas that needed further progress, including a stronger engagement from business, particularly small and medium sized businesses.

In 2007, Lord Sainsbury was commissioned by the then Prime Minister to produce a major review of the UK Government's science and innovation policies and to make recommendations for the future. The review, 'The Race to the Top, focused, in particular, at the role that science and innovation can play in enabling the UK to compete successfully against low-wage, emerging economies such as China and India. The review set out a strategy and made a number of recommendations that believed UK should adopt in order to be a winner in "the race to the top".

The then Government's response to the recommendations made by Roberts Review was, initially, outlined in *Investing in Innovation,* and subsequently expanded upon in the *Science and Innovation Investment Framework 2004-2014*. These documents set out the Government's serious commitment in achieving a step change in the quality of science education and increasing the supply of qualified STEM workforce. It has outlined the Government's ambition to create an education and training environment that delivers the best in science teaching and learning at every stage, and is responsive to the needs of learners, employees, employers and the wider economy. Subsequently, the Science and Innovation Investment Framework 2004-2014, next steps, published in 2006 set new ambitions targets, for UK science and innovation over the next decade, in particular their contribution to economic growth and public services, and the attributes and funding arrangements of a research system capable of delivering this. As part of its review, the Government considered and responded to the Lambert Review of Business University Collaboration and established the Department for Innovation, Universities and Skills (DIUS).

Subsequently, DIUS and the Confederation for British Industry (CBI) were given the joint responsibility of responsibility to facilitate the interchange of innovation expertise between the public and private sector, including the secondment of private sector experts into the public sector for the purpose of mentoring in pro-innovation procurement. Several new measures were introduced under the remit of DIUS, including for example:

-Innovation Vouchers to be given to at least 500 businesses to work with a knowledge base institution of their choice, with the aspiration to be increased to at least 1000 per year by 2011, an investment of some £3 million to initiate collaborations between SMEs and the knowledge base.

-Appropriate finance to become available for all innovative businesses at all stages of their growth. This was set out in a "guide to innovation finance" based on the "No Nonsense Guide" on access to finance.

-To forward the Sainsbury Review recommendation to develop a national Proof of Concept specification to be delivered by the RDAs, which will provide access to facilities and have a strong focus on investor readiness.

-In conjunction with the Technology Strategy Board working to take forward the Sainsbury recommendation to double the number of Knowledge Transfer Partnerships, increasing their flexibility and applicability to a range of educational institutions including FE colleges.

-To continue to develop the 'Lambert' online toolkit of model university business licensing agreements, which cuts the cost and complexity of IP transactions.

The Empirical Investigation

The prime purpose of this paper is to, empirically, identify the key ingredients of open innovation in science- and technology-based SMEs in England. This paper builds upon an initial database of some 60 science and technology SMEs, operating in the North East of England, created via a dedicated questionnaire, as part of the research carried out under the umbrella of the ESRC Science in Society Programme over the period 2005–2007 (see e.g. Wynarczyk, 2007a). Subsequently, the survey was updated and extended to other firms and regions of England through sponsorships by the HE-ESF National Programme and the ESRC Impact Grants over the period 2006–2008. As a result, some 400 SMEs, out of 1,500 that had been approached, responded positively. In the process of identifying these firms, a number of publicly available databases were also consulted, including FAME and Companies House, using the SIC codes for the definition of science and technology sectors. However, only 64 could be identified as indigenous SMEs (less than 250 employees), involved in new product development and/or innovation activities at the time of the survey and provided breakdown of R&D (employment and expenditure), as well as employment and management data. The firms were asked to provide data on external collaboration with their partners such as other enterprises and universities, i.e., whether they operated in open innovation model or closed innovation. A close examination of the information provided revealed that 33 of the 64 surveyed firms could be classified as ‘open innovation’ firms, and the remaining 31 firms as ‘closed innovation’ firms.

The empirical findings presented below are based on univariate analyses. Pearson correlation coefficients have been used to test the significant differences within and between closed and open innovation variables. Paired samples t-tests to measure the significant differences between employment and management capacity variables by male and female.

The following section provides the results of some preliminary data analysis.

The Employment Characteristics

The construction of total employment by open and closed firms is presented in Table 1. As the table clearly illustrates, around 3 per cent of the firms had no employees and the largest surveyed firm had 104 employees. Around 44% of the surveyed firms had less than ten employees and only 14 per cent had more than 50 employees. The Z-score of ‘0.726’ derived from Mann Whitney U-test reveals no significant differences between the overall employment characteristics of the ‘open’ and ‘closed’ innovation firms. However, a slightly higher proportion of open innovation firms had more than 50 employees (16 per cent compared with 13 per cent of closed innovation firms). As the table reveals smaller firms are also likely to be involved in open innovation activities. Around 84% of the open innovation firms had less than 50 employees.

This finding is interesting since previous studies on scientific/innovative SMEs had shown that these types of firms were more likely to be from the medium-sized sector (i.e. those between 50 and 250 employees) than small (i.e. those between 10 to 49 employees) or micro firms (i.e. those with less than 10 employees), (see for example, Wynarczyk and Thwaites, 2000). Furthermore, the information provided from Europa, (2010) suggests that the percentage of organisations which are involved in innovation activities in the UK are directly correlated to the size, the latest data shows that only around 25% of companies with 10-49 employees are innovatively active, compared with over 40% in businesses with 50-249 employees and some 50% of companies with more than 250 employees.

The R&D Employment

The importance of infrastructure --hard and soft elements-- to support innovation activity at the national, regional or firm level is acknowledged but creativity remains a human activity, whether in an individual working alone or in a team, in the public or private sectors. As stated in the UK Government's Innovation Nation White Paper (2008), *'government can foster innovation but it is people who can create an Innovation Nation (p1)'*. While the lone inventor/innovator remains an important player in the technological process, in today's world it increasingly means the highly qualified and trained professional employee, working in R&D teams within a laboratory of a private corporation or a public sector establishment (Freeman 1982). It has been argued that in the 20^{th} century technological advance became professionalized (Freeman 1974). For many nations and companies the reliance for invention and innovation on individuals working alone or by random chance became unacceptable and a growing and more systematic investment in factors likely to produce inventions and innovations took place. This led to growing employment and expenditure on R&D as, perhaps, the key factor in the innovation process and technological capability.

For the purpose of this section, surveyed firms were asked to indicate whether or not they had a dedicated R&D Team and, if so, to provide the breakdown of R&D employment. The construction of R&D Team by open and closed innovation firms is presented in Table 2. As the table shows, over half of the firms had no dedicated employee specifically responsible for the generation of R&D activities. The remaining 48 per cent, in aggregate, had some 171 R&D employees, 156 in open innovation firms and 15 working in closed innovation firms. The overall Z-score of 4.37 clearly demonstrates that the Open Innovation Firms are far more likely to have dedicated R&D teams and the Z-score of '4.16' demonstrates a positive relationship between the size of the R&D team and the open innovation firms. As the table shows, some 80" of the closed innovation firms had no dedicated R&D employees compared with only 20% of the open innovation firms. The range of R&D employees was only five for closed firms compared with 27 for open innovation firms. remaining 20 per cent of closed firms had between 1 to 9 employees firms with female R&D employees recruited less than five female R&D employees. In contrast, 15 per cent of the surveyed firms recruited more than ten male R&D employees.

The proportion of R&D employees as a percentage of total employment is one indication of the level of R&D effort and intensity. The results show 13 per cent of the total workforce of the surveyed firms was engaged in industrial R&D. However, only 2 per cent of the total workforce in closed innovation firms were R&D employees compared with 23% in open innovation firms.

R&D Expenditure

The distribution of R&D expenditure by open and closed innovation firms are displayed in Table 3. As mentioned above, a high proportion of the UK business research is concentrated in a narrow range of industrial sectors, and in a small number of large companies, over 80% of UK R&D is conducted by the hundred most active companies. These data clearly demonstrate the general lack of participation of SMEs in R&D. The overall results illustrated in Table 3 shows that less than half of the surveyed firms had a dedicated budget for R&D. However, open innovation firms are far more likely to have a dedicated budget for R&D than their closed innovation firms counterparts. Some 75% of the open innovation firms had a dedicated R&D budget compared with only 10% of the closed innovation firms. Some 40 of open innovation firms had budget of over £100,000. An examination of data reveals that open innovation SMEs are more likely to receive financial assistance in terms of R&D grants from the UK Government's departments. Some 55% of the open innovation firms had received R&D grants compared with only 15% of the closed innovation firms.

Managerial Capacity by Open and Closed Innovation Firms

In terms of engagement in and holding specific roles at senior and managerial levels, the results of the pearson correlations summarised in Table 4 clearly demonstrate that open innovation firms are far more likely to have a wells structured management team with diversity of roles both in scientific and non-scientific areas. The results, for example, show that some 50% of the open innovation firms had a manager specifically responsible for R&D, Compared with only 15% of their closed innovation firms counterparts. Open innovation firms were also far more likely to have a manager responsible for design (37% compared with 9% of closed innovation firms) and IT (50% compared with 38% of closed innovation firms). A significantly higher proportion of open innovation firms had a specific manager for finance (70% compared with 40% of closed innovation firms), marketing (70% compared with 30% of closed innovation firms) and exports (40% compared with 8% of closed innovation firms). Science and technology-based enterprises are usually set up and run by directors with scientific and technical expertise. Such firms do need to recruit managers with complementary skills, particularly in the areas of sales, exports and marketing to develop a more formal managerial structure in order for growth to be successfully achieved (Wynarczyk 2006). The role of HR manager is, equally, important in order to introduce and implement equal opportunity, work life balance and professional development policies and practices to address and promote diversity and inclusion in the SME sector, some 46% of the open innovation firms had a HR manger compared with 32% of closed innovation firms.

As mentioned above, the surveyed firms were selected on the basis that, at the time of the survey, there were engaged in innovation and new product development. The results summarised in Table 3 show that some 55 per cent of the surveyed firms were engaged in incremental development and changes to existing products, applying existing technology in new ways to find solution to a problem or satisfy an identified demand, 30 per cent claimed they had developed products new to their organisations, while 42 per cent had developed products new to the UK. In terms of comparison between the nature of innovation between open innovation and closed innovation firms, the table reveals some marked differences. As the Z-score of 5.20 shows that the open innovation firms are far more likely to introduce a new product to the UK than firm engaged in closed innovation. In contrast the Z-score of -4.20 shows that closed innovation firms are far more likely to be involved in making incremental changes to existing products.

Key Innovation Indicators

The results presented in Table 5 show that, those firms that are involved in open innovation are far more likely to introduce a new product to the UK than firm engaged in closed innovation. In contrast the Z-score of -4.20 shows that closed innovation firms are far more likely to be involved in making incremental changes to their existing products.

The results of pearson correlation tests summarised in Table 6 reveal some significant relationships between the open and closed innovation firms as well as within some key innovation variables. The results show, for example, that the open innovation firms are far more likely to have a formal R&D Department (corr= 0.438), to be involved in patent activities (corr=0.386), having a dedicated R&D Budget (corr=0.790), larger R&D team (corr=0.416), as well as having a senior manager specifically responsible for R&D activities (corr=0.306). A recent report on behalf of the OECD, that has examined the link between R&D and patenting for 19 OECD countries over the period 1986–2000 found a clear positive link between the principal effects for generation of patent and R&D in the business sector (Jaumotte, F. and Pain, N, 2005; Sainsbury, 2007). The results presented here confirm these findings and reveal significant relationship between patent and R&D employment (corr=0.362), patent and R&D Department (0.449) and patent and R&D Budget(corr-0.325). The results also reveal some significant relationship between the R&D variables, for example, R&D employment and R&D budget (corr=0.809.). The results suggest that open innovation firms are more likely to be R&D intensive and being involved in major innovation than closed innovation firms.

Some Concluding Remarks

This paper has attempted to identify and analyse the key ingredients of open innovation that contribute to the innovation and new product development: activities, processes and capacity building of SMEs. The paper has compared and contrasted some key innovation variables (e.g., R&D employment, R&D budget) as well as other related variables (e.g., the management structure between 'open innovation' and 'closed innovation' firms. Based on a sample of 64 innovative SMEs (33 open innovation firms and 31 closed innovation firms), operating in some key science and technology sectors the preliminary results have revealed some striking differences between some key innovation indicators (e.g., R&D employment, R&D budget, Patent, Government R&D grant), as well as management structures between open and closed innovation firms.

Innovation and new product development are seen as fundamental components of economic and welfare gains and a means of achieving competitive edges in markets and in satisfying social needs. Investment is business R&D is a high priority on the United Kingdom governments' agenda, as it is seen as a key driver for invention, innovation and increase productivity. In the United Kingdom Governmental 10-year framework for investment in science and innovation, the ambitious target of raising R&D from 1.9% of GDP to 2.5% of GDP between 2004 and 2014 was set (HRM, 2006).. Furthermore, projections suggest that between 2006 and 2014 the demand for science and technology professionals and science and technology-associated professionals will increase by 18% and 30%, respectively, compared with an increase for other occupations of only 4% (Herrmann, 2009). Innovation and R&D depend, in major part, on human endeavour so the greater number of people contributing to these activities the greater the likelihood of advance. The results presented in this paper clearly demonstrate that the open innovation firms are far mole likely to be R&D intensive than closed innovation firms. Open innovation firms are far more likely to have dedicated R&D teams and a significantly greater number of R&D employees than their closed innovation firms counterparts. A significantly higher proportion of open innovation firms are found to have a dedicated R&D budget, have accessed government R&D grant and were involved in patent activities. Open innovation firms were far more likely to be involved in the introduction of major and new products to the UK and their closed innovation firms that were more likely involved in making incremental changes to existing products. Open innovation firms were also far more likely to have a dedicated and formal management team with a managerial capacity in both scientific areas (e.g., R&D) and other areas such as finance, marketing and exports.

This is a draft paper and currently under revision. It is envisaged that the preliminary data analysis presented in this paper will be used to develop a typology of open innovation in SMEs as well as a multi-variate statistical model cable of measuring the cumulative effects of the key ingredients of open innovation.

References

Cosh, Andy D. and Hughes, A.. (1997) British Enterprise in Transition. Growth, Innovation and Public Policy in the Small and Medium Sized Enterprise Sector 1994-1999, ESRC Centre for Enterprise.

Edquist, C. (Ed), (1997), “Systems of innovation: Technologies, Institutions and Organisations, Pinter, London

Edquist, Charles (2005): *Systems of Innovation. Technologies, Institutions and Organizations.* London and New York: Routledge

Chesbrough, H. (2003). Open innovation: The new imperative for creating and profiting from technology (ISBN: 1-57851-837-7). Boston: Harvard Business School Press.

Chesbrough, H. (2004). "MANAGING OPEN INNOVATION." Research Technology Management **47**(1): 23-26.

H. Chesbrough, W. Vanhaverbeke and J. West, (2006). “Open Innovation: Researching a New Paradigm.” Oxford University Press, London, 2006

Industry Week (2004), Open Innovation, Rewards and Challenges, www.industryweek.com, (accessed on 12 Sept, 2010).

Jaumotte, F., & Pain, N. (2005). From ideas to development: The determinants of R&D and patenting. OECD.

Freeman, C. (1974). The economics of industrial innovation. Harmondsworth: Penguin Books.

Freeman, C. (1982). Technological infrastructure and international competitiveness. Industrial
and Corporate Change, 3(3), 541–569.

Lambert, R. (2003). Lambert review of business-university collaboration. London: HMSO.

Landstro¨ m, C. (2007). Queering feminist technology studies. Feminist Theory, 8(1), 7–26.

Lawson, C. P., & Longhurst, P. J. (2006). The application of a new research and development project selection model in SMEs. Technovation, 26(2), 242.

Narula, R. (2002). R&D Collaboration by SMEs: new opportunities and limitations in the face of globalisation. Available online 28 May 2002.

Requena-Silvente, F (2005) The Decision to Enter and Exit Foreign Markets: Evidence from U.K. SMEs. Small Business Economics 2005. volume 25, issue 3 page 237. Published by Springer Verlag KG.

Roberts, G. (2002). SET for success: The supply of people with science, technology, engineering and mathematics skills. Final Report of Sir Gareth Roberts' Review, April 2002. Available at http://www.hmtreasury.gov.uk/ent_res_roberts.htm. Accessed on 20 April 2010.

R&D Scoreboard, (2009), Business Innovation & Skills (BIS), (2008), http://www.bis.gov.uk/policies/innovation/white-paper

Sainsbury, Lord of Turville. (2007). Race to the top: A review of government's science and innovation policies. Available at http://www.hm-reasury.gov.uk/sainsbury. Accessed on 20 May 2010.

Wynarczyk, P. (2007a) **“**The Impact of Gender Innovation on Regional Technology, Economy and Society”, ESRC Science in Society Programme End of Award Report, Award Reference: RES-160-25-0039.

Wynarczyk, P**.** (2007b), “Addressing the “Gender Gap” in the Managerial Labour Market: The Case of Scientific Small and Medium-sized Enterprises (SMEs) in the North East of England”, Management Research News: Communication of Emergent International Management Research, vol.30, No.11 and 12, 942-954, ISSN 0140-9174, www.emeraldinsight.com.

Wynarczyk, P., and Thwaites, A.T., (2000), “The Role of Medium-sized Innovative Manufacturing Firms in Regional Economic Performance: Some Evidence from the Northeast Region of England." in New Technology Based Firms at the Turn of the Century Wim During, Ray Oakey and Michelle Kipling (eds), Elsever Science Ltd, May.

Table 1: Employment Distribution of ‘Open’ and ‘Closed’ Innovation Firms

Size	All Firms	‘Open Innovation’ Firms	‘Closed Innovation’ Firms
0	5%	6%	3%
1 - 9	44%	42%	45%
10- 49	37%	36%	39%
50+	14%	16%	13%
Total	100%	100%	100%
Average	20	22	19
Median	11	12	11
Range	104	91	104
Sum	1287	679	608

Mann-Whitney U-Test between open and closed innovation variable and total employment
Z-score 0.772

Table 2: R&D Employment by Open and Closed Innovation Firms

Size	All Firms	‘Open Innovation’ Firms	‘Closed Innovation’ Firms

0	52%	20%	80%
1 – 9	36%	60%	20%
10+	10%	20%	0%
Total	100%	100%	100%
Average	3.0	5.0	0.0
Median	0.0	2.0	0.0
Range	27	27	5.0
Sum	171	156	15
% of Total employment	13%	23%	2%

Mann-Whitney U-Test between open and closed innovation variable and R&D employment: Z-score=4.37, significant at 1% level

Table 3: R&D expenditure in open and closed innovation firms

Size (1000)	All Firms	'Open Innovation' Firms	'Closed Innovation' Firms
0	53%	25%	90%
10 – 49	15%	27%	0.0%
50-99	13%	20%	5%
100-499	10%	24%	5.0%
500+	8%	15%	0.0%
Total	100%	100%	100%
Average	95	168	11
Median	0.0	35	0.0
Range	1000	1000	150

Mann-Whitney U-Test between open and closed innovation variable and R&D employment: Z-score=3.56, significant at 1% level

Table 4: Managerial Capacity by Open and Closed Innovation Firms

Specific Manager	ALL %	Open %	Closed %	Corr*
R&D	30	50	15	0.344**
IT	48	50	38	0.120

Design	28	37	9	0.325**
Marketing	50	70	30	0.310**
Finance	65	70	40	0.285*
Exports	23	40	8	3.60**
Personnel/HR	40	46	32	0.145

*corr= Pearson correlation coefficients between open and closed variable and managerial capacity
** Significant at 1% level

Table 5: Nature of innovation by Open and Closed Innovation Firms

Nature of Innovation	All Firms %	'Open Innovation' Firms %	'Closed Innovation' Firms %	Z-score
Incremental Change	55	25	80	-4.20**
New to the firm	30	55	25	3.20**
New to the UK	42	75	10	5.20**

Table 6: Person Correlation of key innovation related variables

		Open Close	RDEMP	R&DD	R&DE	Inc. change	new product/ or	new produ
Open/closed	Pearson Corr	1	.416**	.438**	.355*	.194	.375**	.654**
	Sig. (2-tailed)		.001	.000	.026	.130	.003	.000
RDEMP	Pearson Correlation	.416*	1	.517**	.809**	.142	.406**	.353*
	Sig. (2-tailed)	.001		.000	.000	.276	.001	.005
R&DD	Pearson Correlation	.438*	.517**	1	.473**	.309*	.424**	.566*
	Sig. (2-tailed)	.000	.000		.002	.014	.001	.000

R&DE	Pearson Correlation	.355*	.809**	.473**	1	-.007	.252	.315
	Sig. (2-tailed)	.026	.000	.002		.967	.122	.051
Inc. change	Pearson Correlation	.194	.142	.309*	-.007	1	.378**	.345*
	Sig. (2-tailed)	.130	.276	.014	.967		.002	.006
new product/ org	Pearson Correlation	.375*	.406**	.424**	.252	.378**	1	.497*
	Sig. (2-tailed)	.003	.001	.001	.122	.002		.000
A new product in the UK	Pearson Correlation	.654*	.353**	.566**	.315	.345**	.497**	1
	Sig. (2-tailed)	.000	.005	.000	.051	.006	.000	
Patents	Pearson Correlation	.315*	.267*	.531**	.324*	.168	.312*	.283*
	Sig. (2-tailed)	.011	.038	.000	.044	.191	.014	.026
No of patents	Pearson Correlation	.306*	.222	.503**	.620**	-.028	.134	.330*
	Sig. (2-tailed)	.016	.086	.000	.000	.831	.299	.009
FMT	Pearson Correlation	.317*	.283*	.405**	.350*	.160	.126	.179
	Sig. (2-tailed)	.011	.027	.001	.029	.214	.328	.164
Specific manager - R&D	Pearson Correlation	.344*	.413**	.615**	.407*	.378**	.352**	.359*
	Sig. (2-tailed)	.005	.001	.000	.010	.002	.005	.004

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

R&D Team

Management Structure

Patent (IPR) activities

Open innovation