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The Forgotten Knowledge Transfer

Caroline Chibelushi
University of Wolverhampton,, c.chibelushi@wlv.ac.uk

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Caroline Chibelushi
School of Computing and IT, University of Wolverhampton, UK
c.chibelushi@wlv.ac.uk

Abstract

The growth of the world's economy depends on knowledge creation; an aspect that allows innovation. Universities create, store, transmit knowledge, and conduct PhD research programs which are innovative. Although most of this knowledge is well stored, it is not transmitted, developed further, and sometimes not reused. Similarly, UK SMEs are said to be the innovation champions, but most SMEs' ideas are not developed to a marketable product. Both the researchers and SMEs face various problems such as financial constraints, lack of skills, knowledge, support and trust. This paper highlights the need to manage knowledge creation and its outputs so as to raise innovation levels in the UK. The method used in the paper is not the 'pseudo-scientific' (in the context of social sciences) model of theory, hypotheses, empirical results and conclusions but the far older method of collecting and probing observations with the intent of generating discourse and debate.

Keywords

PhD, research, innovation, SMEs.

1. Introduction

The future prosperity of the UK economy depends on its ability to become more productive, mainly because the country is facing a business backdrop of increasing global competition and rapid technological change (BERR, 2008, DTI, 2008). There is evidence that for the first time the UK has lost its place in the elite top five nations for innovation, as measured by the World Intellectual Property Institute (WIPO). WIPO's information is based on the patents registered which showed that UK is not in the top five countries for patents filed under the Patent Co-operation Treaty. In February 2007, Britain fell into sixth place behind the US, Japan, Germany, South Korea and France. This is a matter of concern as China is set to overtake the UK (i2010 Working Group, 2007) at a fast pace.

In contrast, SMEs appear increasingly to be crucial to the success of the UK economy as it was shown that the majority of growth between the years 1995 and 2000 in size of the business population was from SMEs (Johnston, 2003). Mainly, the evidence shows that most new innovations come from SMEs as they are not committed to existing practices or products (Maguire, 2007). Jutla et al. (2002) support this claim by stating that SMEs are more entrepreneurial and willing to innovate in comparison to larger companies, which have to follow some organisational hierarchy. This means that 'SMEs are an important link to boosting the levels of innovation in the national economy and fostering greater competition both domestically and increasingly, internationally' (Dyerson et al. 2007).

Innovation is one of the critical events that are likely to trigger learning. In the case of technology-oriented companies, the innovation concept considered by this research includes 'both radical and incremental changes in thinking, in things, in processes or in services' (Mckeown, 2008). Companies no longer need only to be fast to provide services or products,

but come up with new, improved quality and cost effective products and services. Innovation is one of the drivers that can help the company to achieve its growth objectives. As Davila et al. (2006) state that, 'Companies cannot grow through cost reduction and reengineering alone . . . Innovation is the key element in providing aggressive top-line growth, and for increasing bottom-line results' (p.6).

Recently, Marvel et al. (2007) provide evidence that shows positive correlation between human capital and breakthrough innovation. Their findings suggest that education level and deep knowledge based on years of experience are more important for creating successful innovation than broad experience across multiple areas. Marvel et al. (2007) findings reveal that only technology knowledge was greater for those entrepreneurs who created radical innovations.

However, most new sophisticated technological products face problems such as lack of adequate knowledge, new product development experience and financial resources (Feeser et al. 1990, Shan, 1990, Zahra et al. 1993). Technology-oriented SMEs which are involved in innovation find themselves highly vulnerable and easy fail with less than 50% of them lasting for five years (Li et al. 2002; O'Shea et al. 1998). The increased importance of innovation and its high failure rate has attracted a considerable interest from managers and researchers to examine and discover means to achieve successful innovation.

Most literature (such as Zahra et al. 2002) considers the lack of adequate knowledge, new product development experience and financial resources to be one of the innovation limitations faced by innovators. Another gap is associated with lack of appropriate government initiatives/activities to support companies which are involved in innovation (Chibelushi, 2008; Chibelushi et al. 2008).

Previous literature examined the direct effect of resources and capabilities on the competitive advantage and performance of the company (Hall, 1993; Yeoh et al. 1999). Companies are said to be heterogeneous when it comes to resources and capabilities (Barney, 1991; Mahoney, 1995; Teece et al. 1997) as the two determine company competence (Chen, 2008). But in the modern business environment, innovation is a key factor for competitive advantage. However, innovation depends on technology commercialization competence. That is, SME competence in the use of technologies in products across a wider range of markets, to incorporate various technologies in products, and to get products to the market faster (Chen, 2008). These are aspects of innovation that are crucial to the survival of companies in relation to the speed of change in its business environment (Nevens, 1990). Companies and especially the innovative ones survive only if they can discipline their commercialization effort (Nevens et al. 1990). This may involve updating human capital, investing in ICT and other resources as well as taking advantage of knowledge transferred by university research activities (Chibelushi et al. To appear 2009, Siegel et al. 2004). Today, 'competition through cooperation' has become the foundation of a firm's attempt to gain innovation and learning advantages through technology competition among networks of multiple alliances, especially in high tech sectors (Gilsing et al. 2007)

Universities are increasingly being viewed by policy makers as engines of economic growth (Siegel et al. 2004). Research universities consider knowledge transfer as their role that is important to many business environments (Markman et al. 2005), and specifically those which involves innovation.

This paper considers the research ideas produced by students who complete their Doctor of Philosophy (PhD) in technology oriented subject to be a crucial means to close the gap in innovation, that is, the gap which is caused by lack of knowledge, and technology competence that exists within small firms. Since most ideas produced by these individuals are new and are meant to cater for a specific application, this can be classified as innovation. But most SMEs are considered to exist on 'hand-to-mouth' style (Duan et al. 2002). This is a limitation which may prevent them from been able to recruit these research–oriented, innovative and highly knowledgeable individuals. The main reason is that SMEs may not be able to maintain them for a long time. However, Zahra et al. (2002) state that, recruitment gives the firm access to knew technologies and knowledge which can facilitate rapid product development and accelerate technology commercialization. Chen (2008) support this by adding that experienced and highly-trained employees can implement changes more effectively in the internal business processes and technologies for successful technology innovations (Dertouzos et al. 1988). Based on the importance of recruiting researchers with appropriate knowledge, and the amount of innovative ideas produced each year by university research students, one may wonder why is the government not supporting researchers to further develop their ideas to products or support SMEs to absorb these ideas as well as the owners of the ideas and further develop them to raise the level of innovation in this country.

Unfortunately, the intellectual property portfolio is still a relatively new phenomenon for many universities, its complexities cause uncertainty in issues such as investors incentives, technology transfer 'pricing', legal issues, strategic objectives, and measurements and monitoring mechanisms (Siegel et al. 2004). This paper has identified some major gaps and hopes that discussing them may inform future research. In serving these aims, the paper examines PhD research and innovation in Section 2 to give a brief background to the technology-oriented research from the universities. Then, Section 3 discusses the innovation support as related to research students, while section 4 suggests a simple model that may help the innovative ideas from the researcher and SMEs to be developed to a product. Section 4 concludes the paper and suggests further work.

2. PhD Research and innovation

In general, Doctorates are awarded to students who have demonstrated the creation and interpretation of new knowledge, through original research or other advanced scholarship, of a quality to satisfy peer review, extend the forefront of the discipline, and merit publication (Quality Assurance Agency for Higher Education, cited in Tinkler and Jackson 2004, p.111). In Computer science and engineering this can involve the development of a model with algorithms that propose the development of a new product or service.

The Higher Education Statistics agency (HESA) reported that in the year 2006/2007 there were 13070 full-time Computer science postgraduate students (this includes masters and PhD) in UK (Day, 2008). Roberts (2002) review considers the number of science and engineering researchers in UK to be few because there is an increase in opportunities for skilled individuals to work outside research. His review concluded that this problem would act to constrain innovation in the UK, not only in science and engineering disciplines but more widely since the cutting edge research is multidisciplinary.

There are PhD students who are recruited after the university has been involved in certain collaboration with an end user, the Higher Education Business and Community Interaction (HEFCE, 2008) has defined collaborative research as that involving the universities, a public

funder and a third party (which could be, for example, commercial, public sector or from the third sector). A survey which was conducted on R&D managers suggested that academic research has led to innovation accounting for up to 5% of the industry sales (Mansfield, 1991; 1998; Beise et al. 1999). This paper considers this as a low percentage when compared to the number of PhD students who leave universities each year. Little research has been conducted in this area, however, those which were conducted in the pharmaceuticals industry highlight the importance of public investment in science, with one of the studies reporting a 30% return (Cockburn et al. 2000). The other group of PhD students are recruited without an end user or a particular application. Also, there are those who are funded by the research bodies such as EPSRC. This means that both types of students make 'complete new discovery' – which involves finding a problem, the solution and the user. This paper consider such discovery to be similar to innovation, hence this paper is focusing on this type of research.

Most of the literature related to knowledge transfer and innovation has focussed on delivering professional training, consultancy and services, and researching and solving problems which are brought to the universities from the business community. Apart from the statistics showing the number of PhD student in the UK, little research has been conducted in relation to knowledge transfer and innovation that can be exploited from the output of PhD research programmes.

One of the reasons could be that the UK universities do not actively seek and encourage UK PhD applicants, as these are more likely to stay in the UK after graduation (EPSRC, 2006). The UK attracts large numbers of overseas scientists and engineers into ICT programs but many far-east students are returning home after completing their studies. Universities appear to focus on attracting foreign graduate students rather than UK students due to differential fees (EPSRC, 2006). Also, the UK government has regulatory barriers that may make it difficult for overseas students to stay and work in the UK after earning a PhD here. Evidence shows that there is a decline of quality and more will follow, given current levels of support and the nature of today's university research environment. This decline can have serious industrial consequences, since much of it is in areas with large actual or potential scope for industrial innovation in the UK (Arnold, 2005). The obvious need is to support and encourage the PhD research and develop a framework that will help further development of these ideas into marketable innovative systems.

With some government support, some Universities have developed initiatives to support students from their computer science engineering and technology degree courses who are talented or are willing to start their own business (e.g the SPEED* project). However, not many universities support or help PhD students' innovative ideas to continue to a marketable product. Similarly, there are government bodies which are set to support SMEs which want to innovate, but one will question as to why the UK is loosing its innovation position within the top five nations. There are many issues that are related to this problem, but this paper will discuss only some of the information related to innovative ideas generated by the computer science research students.

3. Researchers and Innovation support

Computer science PhD holders can be classified as innovators, scientist and entrepreneurs. Despite their potential, much of the attention and support has been focused on knowledge transfer programmes which are purposely to solve individual companies' problems. Innovative researchers with potential ideas have received less attention as most studies have

focused on individual scientists and entrepreneurs (Siegel et al. 2004), and fields which use computer science and not supporting computer scientists. For example Table 1 shows different studies conducted by researchers in relation to knowledge transfer.

Researcher	**Research Aim**	**Findings**	**Field**
Slaughter et al. (2006)	To identify a portfolio of knowledge transfer mechanism that can reduce the challenges experienced when deploying software	The study theorises and provides an empirical evidence about the design choices for a portfolio of knowledge transfer mechanism that can help in software process improvement	Information systems and computer science
Bercovitz et al. (2004)	To analyse the propensity of medical school researchers to file inventions disclosures	Three factors influence the decision to disclose inventions: norms at the university where the researcher was trained, the department chairs and peers	Medicine
Audretsch (2000)	To examine the extent to which entrepreneurs at university are different from other entrepreneurs	University entrepreneurs are matured and more scientifically experienced	Biotechnology
Clarke (1998)	Using 5 European universities with outstanding performance in knowledge transfer to examine the existence of an entrepreneur culture, and its relationship to their success	Entrepreneur culture is an important factor to scientist success	General
Louis et al. (1989)	Using 50 universities which received most funding from National Institute of health to measure the effect of university policies and structures on technology transfer	Technology transfer that involves commercialisation is not affected by university policies or structure	Life-science

Table 1: Research conducted in relation to the knowledge transfer

The majority of the studies in Table 1 are from fields which are different from computer science, and are not aimed at supporting the innovator.

In addition, there are government initiatives which are supposed to support SMEs in different aspects of their business (including innovation). For example, Knowledge Transfer Partnership (KTP), Knowledge Transfer Networks (KTN) and Technology Strategy Board (TSB). These aim to help business on their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK knowledge base. TSB is specifically promoting innovation, while the objective of a Knowledge Transfer Network is to improve the UK's innovation performance by increasing the breadth and depth or the knowledge transfer of technology into UK-based businesses and by accelerating the rate at which this process occurs. The Network must, throughout its lifetime, actively contribute and remain aligned to goals of the Technology Strategy Board. These programs mostly target university students who want to acquire their postgraduate degree (usually Masters Degree) through working on a project.

Also, there are five research councils: Biotechnology and Biological Sciences Economic and Social Research Council, Engineering and Physical Sciences Research Council, Medical Research Council, Natural Environment Research Council Science and Technologies Facilities Council, Arts and Humanities Research Council. These invest around £2.8 billion in research covering the full spectrum of academic disciplines from the medical and biological sciences to astronomy, physics, chemistry and engineering, social sciences, economics, environmental sciences and the arts and humanities (http://www.rcuk.ac.uk/default.htm – research councils in UK). Engineering and Physical Sciences Research Council (EPSRC) is the largest funding agency for research and postgraduate training relating to social and economic issues. It is the one that is related to most research in computer science. EPSRC supports independent, high quality research relevant to business, the public sector and voluntary organisations. Its planned total expenditure in 2007/08 was £181 million, in which at any one time it supports over 4,000 researchers and postgraduate students in academic institutions and research policy institutes. The support given by this research council is limited to maximum of 3 years, and it is usually made clear (and is well understood) that there would be no automatic renewal of funding (EPSRC, 2006).

There are also other government initiatives which are designed to support SMEs to innovate and become competitive. This includes instruments such as R&D tax credits, DTI innovation programmes (which include R&D grants, collaborative R&D and grants for investigating in an innovative idea) and regional development agencies (DTI, 2004). Others include government organisations such as Business Link, Business innovation Centre, Chambers of Commerce, Regional business development agencies, and others. These initiatives will be referred to in this paper as Government Initiatives to Support Business and Innovation (GISBI). Despite having all these government initiatives, very little is done to support the continuation of the innovative ideas produced by computer science research students from the universities in UK. Chibelushi et al. (2008) reported that 99% of the 206 ICT companies who were interviewed in the West Midlands claimed that government organisations are unable to support them when they want to innovate, while, 90% claim that instruments such as tax credits are very bureaucratic and it can sometimes waste companies resources to go through all the procedures which are usually unsuccessful. The report did not give the reasons for this, but highlighted the importance for further research in this particular issue.

There are some positive activities which are initiated by some universities, for example Staffordshire University organises a graduate exhibition (GradEx) each year for its computer science students. The exhibition aims at bringing students, companies and organisations together in which students are able to show their work to prospective employers who may offer these students jobs (GradEx08, 2008). GradEx is sponsored by private companies and professional bodies such as BCS (British Computer Society), IET (Institution of Engineering and Technology) and IMechE (Institution of Mechanical Engineering). Although this exhibition involves PhD students, the exhibition is designed to target the first degree final year student projects. Though this is a step towards supporting innovative ideas, this support is primarily aimed at helping students to secure jobs and not the advancement of the innovative idea. Similarly, the University of London conduct exhibitions (Capture & Context, 2007) to showcase its engineering students, but the aim is the same; to attract more students and help the students get employment, but not to support students to proceed with their ideas. One of the major drawbacks in this problem is the lack of enough researched and developed frameworks which can use all the above instruments, projects, organisation and universities

to support and develop a mechanism that transfers innovative knowledge of high qualified research students (mainly PhD) to a marketable product

4. Proposed framework

Innovation has always been considered to be a cornerstone of competitiveness (Denton, 1999; Jagle, 1999; Johannessen et al. 1999; Neely et al. 1998) and profitability (Bose et al. 2002; Roberts, 1999). When managed strategically, innovation can contribute to firms competitive advantage (Johannssen et al. 2001), company performance (Yamin et al. 1999) and market share (Robinson, 1990). Previous research that is related to innovation consider the role of technology and research and development (R&D) as contributors to innovation (Aghion et al. 1994; d'Aspremont et al. 2000; Gans et al. 2003; Hull et al. 1991; du Pre Guntt, 2004). Other research has also focused on the new product development (Jensen et al. 2001; Katila et al. 2002; Matusik, 2002; Romano, 1990; Shepherd et al. 2000). However, studies such as these offer less information when it comes to the consideration of the innovative ideas which are developed by the computer science research students. It can be noted that these innovative ideas and the challenges associated with them are important to businesses and the development of the UK economy as a whole. This paper partly addresses this research gap by presenting a framework (as shown in Figure1) that can guide the government, companies and universities to design mechanisms that can help them support the transfer of research students' innovative ideas into marketable products. The proposed framework is shown in Figure 1.

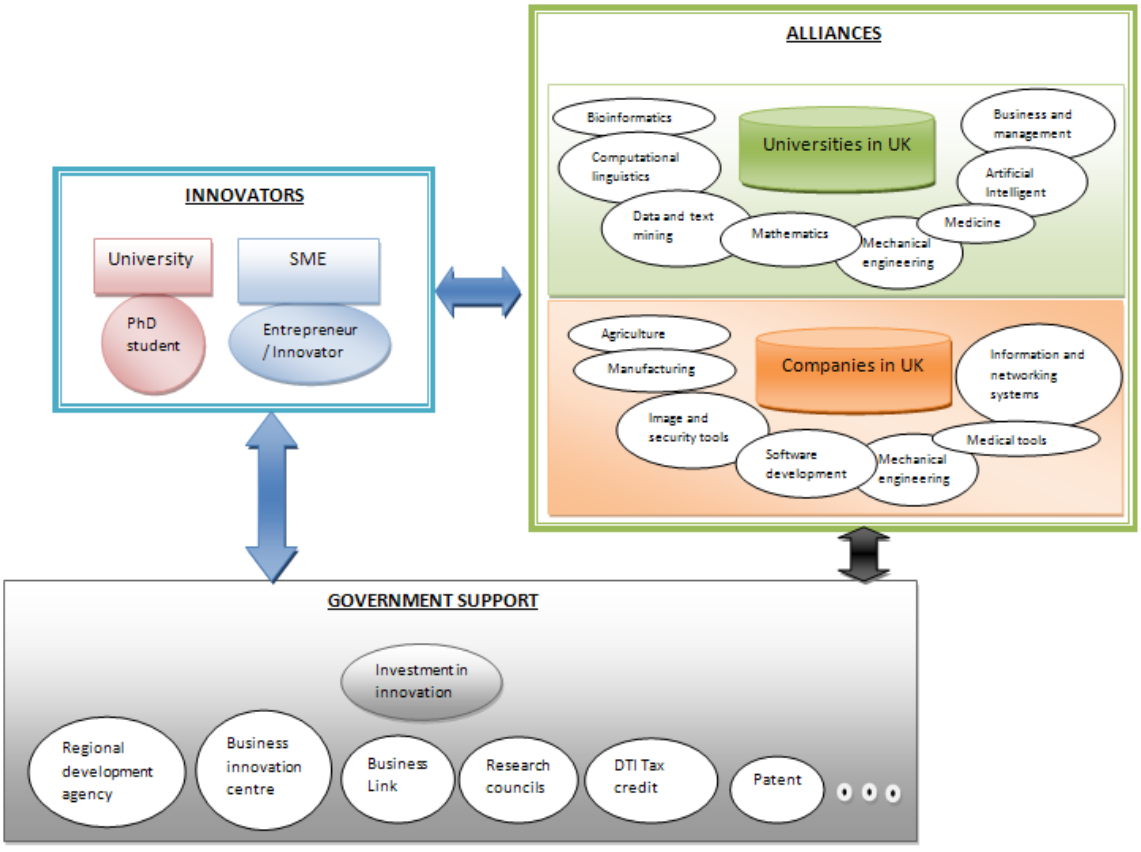

Figure 1: A framework to support both research students and entrepreneurs innovators

The framework consist of three main units; the innovators, the government support and the alliances. These are described as follows.

The innovators: The proposed framework (shown in Figure 1) aims to support the research students (PhD) and entrepreneurs (mainly SME representatives) who have an innovative idea. This is because both innovators have similar constraints which prevent them from been able to develop their ideas to a marketable product. For example, the common constraints include: limited or no financial capabilities, lack of appropriate resources, inability to protect the idea and develop trust to stakeholders. Other limitations includes lack of experience to manage innovation.

Government support: The government support that is suggested by this paper is an 'indirect support'; instead of the government giving these innovators money and other resources for free, the government should seek to invest in these innovative projects. This means that the government should use various types of its resources to support the development of the idea and the marketing of the end product, and recover the money and its resources over a certain period of time depending on the product sales. By doing so, not only will the resources be re-used over and over to develop new ideas, but the government will be able to track and provide full support on the projects and make sure that these projects are successful. The GIBSI shown in Figure 1 are purposely set up to support SMEs competitive advantage and innovation. However, recent research (titled: The ICT Adoption Research) which was conducted in ICT companies in the West Midlands indicate that many SMEs consider the GIBSIs to be focusing on the same activities (mainly to provide advice to SMEs and innovators) and achieve less than expected.

The proposed framework suggests that instead of using all these GIBSIs to support business and innovation, the government should identify a single unit which will be responsible for investing in innovative ideas. The framework shown in Figure 1 identifies 'Investment in Innovation' as a unit to achieve that. In this case, the ideas can come from SMEs or research students. This unit will have employees with various skills, for example, employees with: updated computer and engineering knowledge and skills, business management, marketing skills etc. Also, it may have an employee who is responsible for allocating the financial support for each innovative idea. The innovators (SMEs or research students) should present their ideas in a similar way as the television programme Dragons' Den[1]. Basically, this paper suggest that, instead of potential innovators going through a long and bureaucratic processes of applying for funding, patent etc, the innovation unit should invest their human resources to perform these activities. Not only will this process speed up the innovation process but encourage more innovators in the country to bring their ideas forward and in confidence.

Alliances:
The increased profitability that results from the contribution of academic research give companies good reason to work with academics or other companies from the computer science and engineering base. A report published in Science and Innovation investment framework 2004-2014 (DTI, 2004) states that almost a quarter of innovative companies in the UK, employing over 40% of the workforce, now turn to universities as a source of information. The obvious need that is presented by the framework shown in Figure 1 is to

[1] *Dragons' Den* is a television programme that originated in Japan where the format is owned by Sony. The format, which now airs internationally, consists of entrepreneurs pitching their ideas to secure investment finance from business experts (http://en.wikipedia.org/wiki/Dragons'_Den)

have two databases; one that stores companies profiles and their business specialities, and other with all research universities profiles and their main research speciality. For example, the database may contain information about a certain company as a firm which specialises in developing automatic systems to monitor medical conditions such as heart problems, their contacts, webpage etc. Similarly the database with all the universities may have some description on the research strength, e.g. specialisation in artificial intelligence system in law enforcement areas. This may be supported with information such as examples of successful and on-going projects in a particular field of research. These databases can either be regional or national but will act as alliances to the innovation process. Alliances enable companies to focus on their core skills and competencies. Although they may be one of the toughest and risky forms of partnership, but when they are well structured and the need of the partners is met, alliances can be one of the quickest and cheapest ways to grow (Thompson et al. 2005).

A typical example of the advantages of using alliances, is that of NIKE (a leading company in sporting and leisure footwear) focuses on product design, marketing and personal endorsement, but avoids manufacturing, which it subcontracts to specialists worldwide (Thompson et al. 2005). The same may apply to the innovators described in this paper; they can focus on the design and marketing side of their ideas but subcontract the manufacturing of the system to an alliance.

5. Conclusions and future work

Innovation, especially high-tech innovation, receives wide recognition of its important contributions to the economy (Drucker, 1985; Hayton, 2005). Over the last 25 years, two thirds of the net new jobs and 95% of the radical innovation have come from these entrepreneurial businesses (Allen, 1999; Timmons et al. 2003). However, high-tech innovators face greater problems, including lack of adequate knowledge of their environment, new product development experience as well as financial resources. As a result, UK has fallen from its position which was among the top five innovative countries. At the same time, UK has thousands of computer science and engineering research students who finish their research programme each year. The majority of these researchers produce models that represent new discoveries that can be used to improve different activities in our communities. This paper reveals that most of these researchers are foreigners and they tend to go back to their home countries. Consequently, the UK suffers some sort of brain drain that may have contributed to the development of high levels of innovations in countries such as China and India; which makes the business competition even tougher in an already turbulent economy.

Although this paper is not based on the formative research, it highlights the real problem which is in many computing and engineering university departments. That is, after the viva, most research students thesis are kept in some sort of archiving system and are hardly re-used. This paper consider this as a waste of innovative idea and is calling for the government to conduct research to examine how can those students who have potential ideas could be supported to further develop the ideas into products. By doing so, the UK government may be able to raise its levels of innovation, or even reduce the wide innovation gap between the UK and the USA that has existed for many years.

The paper has proposed a framework which could reduce the existing bureaucracy which is the main factor that discourages these innovators when requesting support from the government. The framework suggests that the government should act as a partner and not a donor for it to be able to: track the progress, recover and re-use the resources to develop

another idea. If this is achieved, the speed of developing an idea to a product will be increased, and hence may increase UK's revenue.

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