ENTERPRISE EDUCATION AND THE ADOPTION OF NEWER TECHNOLOGIES WITHIN SMALL FIRMS[i]

Dylan Jones-Evans
Cardiff University
Centre for Advanced Studies (CASS), Cardiff University, 44-45 Park Place, Cathays Park, Cardiff, United Kingdom, CF10 3BB.
Phone: +44 (0) 2920 876063 Email: enlli@btconnect.com

Thompson, P.
University of Glamorgan
GEM Project, Business School, University of Glamorgan, Pontypridd, United Kingdom, CF37 1DL.
Phone: +44 (0) 1443 483370 Email: pthompso@glam.ac.uk

Kwong, C.
Project, Business School, University of Glamorgan, Pontypridd, United Kingdom,
University of Glamorgan
Phone: +44 (0) 1443 483370 Email: ccykwong@glam.ac.uk

Abstract

Enterprise education has been regularly cited as a tool which can be utilised to not only increase the level of entrepreneurship within an economy, but also the success of those enterprises started. This paper explores the extent to which participation in enterprise education is associated with the adoption of new technology within new businesses. As this is one way that businesses can remain competitive not only within their own countries but when competing against international competition. Using data from the Global Entrepreneurship Monitor survey from the UK, the study finds weak evidence that those undertaking enterprise education in the form of university based schemes or government sponsored training schemes are more likely to be using newer technology. However, this relationship is relatively weak and does bring into question whether many enterprise courses are effective value for money.

1. Introduction

Research has indicated that entrepreneurship plays a vital role in creating wealth, employment, diversity and innovation in an increasingly competitive global economy (Van Stel et al., 2005; Ács and Audretsch, 2003; Thurik, 2008). As such policymakers wishing to boost their economies may implement policies aimed at encouraging greater development of entrepreneurial behaviour. One mechanism through which this might be accomplished is through the provision of enterprise education, with courses at school providing many children in the UK with a first experience of enterprise. However, just generating interest in entrepreneurship is not necessarily enough, courses should also provide prospective entrepreneurs with the relevant skills and abilities required for starting a business and running it successfully (Kuratko, 2005; Gorman et al., 1997). This way the economic benefits of start-up activity can be maximised.

Using data drawn from the Global Entrepreneurship Monitor (GEM) UK surveys for the years 2005 to 2007 this study attempts to identify if participation in enterprise education shows any evidence of increasing the probability that entrepreneurs remain competitive through one particular mechanism, the adoption of newer technology within their businesses. The impact of enterprise education from four different sources (school based enterprise education, university based enterprise education, formal work placements, and government training schemes) are explored.

The remainder of the paper is structured as follows. Section 2 reviews the existing literature relating to technology adoption and education in particular that aimed specifically at developing the entrepreneurial skills within existing or future small business owners. Section 3 introduces the GEM data, and methodology adopted within this study. Section 4 presents the results and Section 5 concludes.

2. Entrepreneurship education and innovation

Whilst many public policies have attempted to simply boost the level of small business ownership in the UK in general, there is an acknowledgement that a large proportion of employment created by small business is from a small number of high growth businesses. Innovation and the use of new technology is strongly associated with higher levels of growth (Marsh, 1996), and also survival particularly in the smallest and youngest firms (Cefis and Marsili, 2006), and therefore should be encouraged. Publicly sponsored schemes to encourage greater innovation have suggested that one method of achieving this is through provision of education specifically designed for enterprise, to help unlock the ‘knowledge base’ held by institutions like universities, an approach which would seem likely to succeed

given that US evidence finds new firm formation higher in sectors more closely related to university research (Audretsch and Acs, 1994). However, the entrepreneurs themselves express doubts as to whether this 'knowledge base' is the primary source of innovation (Macdonald et al., 2007).

As Carter and Collinson (1999) point out, there has been considerable debate over the role of educational attainment in encouraging entrepreneurial activity. Whilst many early studies in the field of entrepreneurship indicated the educational attainment of entrepreneurs to be low, more recent work has begun to recognise that those with higher levels of education will have the abilities and skills required to recognise an opportunity and exploit it successfully (Robinson and Sexton, 1994). For example, research by Delmar and Davidsson (2000) and Arenius and Minniti (2005) found that nascent entrepreneurs tend to be highly educated, whilst Arenius and De Clercq (2005) also showed a positive correlation between education and opportunity recognition.

With increasing interest in entrepreneurship, its impact on the wider economy and growing evidence that education is an important factor in influencing entrepreneurial activity, it is not surprising that the number of entrepreneurship courses has been increasing globally (Kuratko, 2005; Katz, 2003; Vesper and Gartner, 1997). However, the proliferation of such 'interventions' has not been uniform across the school or higher education sectors and the materials and techniques used to 'teach' entrepreneurship are by no main means homogeneous. Indeed, the main critiques of enterprise education are that it tends to follows a traditional didactic format rather than being action-oriented (Sexton and Upton, 1987; Jones-Evans et al., 2000), adopts a corporatist approach to enterprise (Gibb, 1993), and fails to discuss theories that budding entrepreneurs can apply to improve their chances of success (Fiet, 2000). Studies also criticise enterprise education as not being designed for those participating, either relying on skills which are not in place, providing knowledge of factors not required by participants with more experience, and not tailoring education to provide skills required by local business (Laukkanen, 2000). As Rosa (2003) suggests, courses of this type might be expected to have an impact only on the number of individuals intending to start a firm rather than increasing the percentage of nascent entrepreneurs who are successful. Consequently, the 'ivory tower' stereotype of academics continues to exist in many industries, particularly amongst relatively less well-educated owner-managers, leading to a lack of trust in their practicality and their relevance to the real world (Jones-Evans et al., 1999). Courses provided through schools and as work placements with SMEs are less likely to have large influences directly on start-up activity given their low impact on the entrepreneurial skills and knowledge of participants. However, these courses may encourage further involvement in enterprise education at higher levels, and can also help develop an enterprise culture in young people through greater desirability (Peterman and Kennedy, 2003; Birdthistle et al., 2007).

One aspect of which entrepreneurial activity that policymakers may particularly wish to encourage is the adoption of new technology, as this may result in economic growth. It is important to note that one-off, radical introduction of new technology inventions (Schmupeter Mark I innovation) are often limited in geographical, sectoral, financial and temporal contexts (Lajanja and Fontes, 1998; Oakey and Mukhtar, 1999). The majority of innovative behaviours conducted by new technology-based firms are therefore likely to concern technology adoption rather than technology invention (Lajanja and Fontes, 1998). Studies examining the potential of education to enable individuals to successfully reallocate resources in disequilibria have a long history with in a multitude of situations and environments examined (Schultz, 1975). Although less complex than technology invention, in most cases technology adoption requires absorptive capability (Aharoni, 1991), which is likely to involve high levels of skills as well as accumulated human capital in order to search,

select, replicate and adopt technologies developed across the boundaries of firms, research institutions and countries (Lajanja and Fontes, 1998). More specifically Wozniak (1986) shows that human capital is positively associated with early adoption of new technology, and the associated collection of information on new technology prior to adoption (Wozniak, 1993), as human capital reduces the level of uncertainty faced in regard to the payoffs from technology adoption. It is also necessary for some degree of business science knowledge to maximise the benefit of even fairly low level technology adoption (Knol and Stroeken, 2001). Once technology has been adopted human capital is likely to be positively related to the degree that implementation of this new technology is successful (Meyers et al., 1999). It may be possible to provide these more technical entrepreneurship skills through higher education and government training schemes.

For entrepreneurs running growth businesses courses covering 'succeeding in a rapidly changing world' were found to be ranked highly by entrepreneurs themselves particularly high-tech entrepreneurs (Sexton et al., 1997). However, the applicability of many forms of education and training targeted at increasing innovation is questioned by entrepreneurs themselves (Macdonald et al., 2007). Whilst earlier studies of enterprise education highlighted the importance of identifying opportunities on the technological frontiers for developments in future entrepreneurship courses (Vesper and McMullan, 1988), it is unclear to what extent these calls were heeded. A mainly US survey of business schools found by the mid 1990s undergraduate entrepreneurship courses were mainly based around starting a new venture or small business management with very few found to concentrate on innovation evaluation and technology transfer, and although more graduate course of this ilk existed they were still swamped by more generic new firm courses (Vesper and Gartner, 1997). Even those courses specifically designed to cater for entrepreneurs starting ventures using high technology or in knowledge intensive sectors do not emphasise understanding the continuous process of technology adoption as an important learning objective, although this may be partially encompassed in more general elements designed to help participants deal with the uncertain environment they will face (Garavan and O'Cinneide, 1994).

It appears that whilst earlier work looking for the directions that enterprise education should head in indicated that one aspect that needed to be covered was the use of and influence of new technology, many courses do not appear to specifically cover this element of entrepreneurship. Whilst at the same time enterprise education and training is encouraged and in some cases funded with the express aim of increasing the level of innovation and use of technology in the small business sector. It would seem that the influence of enterprise education on technological adoption within UK SMEs will be uncertain.

It would seem likely that more technical courses such as those provided by higher education establishments and government sponsored organisations would be likely to have a greater impact on technology adoption, than those courses designed to encourage greater interest and participation in entrepreneurial activities at a younger age, such as school based enterprise education and work placements. However, there is still potential for these courses to increase the use of new technology, if as intended these courses not only direct young people towards further sources of small business and enterprise education, but also help a entrepreneurial mindset in those of a younger age.

3. Data and Methodology

The data utilised in the study is drawn from the Global Entrepreneurship Monitor (GEM) surveys for the UK undertaken in 2005, 2006 and 2007. The GEM project is an international study providing comparable data on entrepreneurial activity and attitudes in a number of countries across the world (42 participants in 2007). For an exhaustive description of the

GEM data collection and processing methodology see Reynolds et al. (2005). The survey in the UK takes the form of a stratified random sample collected from the population as a whole and conducted in the form of telephone interviews by a profession survey company IFF. Levie (2007) gives a more in-depth description of the data collection processes utilised within the UK. Whilst the sampling population consists of all adults in the UK, a number of questions are asked to determine whether individuals are actively involved in starting businesses they will own and manage, or currently running businesses as owner-managers. These individuals are asked further questions in relation to their businesses. Although not specifically isolating entrepreneurs for interview the sheer scale of the UK survey (117,395 individuals when combining the surveys of 2005, 2006 and 2007), means that a sub-sample of entrepreneurs can be isolated that is still of usable size.

Those individuals included in the sub-sample studied in this paper consists of those starting new businesses and those who currently are owner-managers of existing businesses. The first group are those undertaking activities to start businesses in which they will be part or whole owners of, and have a managerial role (nascent entrepreneurs). The second group within the sample are those currently managing a business which they are part or whole owners of. Given the expansion of enterprise education has only occurred relatively recently and a vast majority of participants will be younger we limit the sample to those aged between 18 and 45 years of age. The total sample size available when eliminating those not providing data required to control for other characteristics is 3,689.

Given that the paper aims to ascertain the impact of differing sources of enterprise education on the likelihood that business owners will adopt the latest technology within their businesses, we split the sample according to their response to whether the technology or procedures utilised in their ventures will have been available for longer than a certain time period. In order to check for robustness, two periods of time that technology/procedures have been available for are utilised. This allows the isolation of those using relatively new technology (introduced within the last 5 years), and the newest technology (introduced within the last 12 months). The sample includes 783 technology adopting entrepreneurs when using the wider definition and 231 early adopters when using the tighter definition. The binary characteristic of these definitions allow logit estimations to be utilised to determine the impact of enterprise education on technology adoption after controlling for other characteristics of the entrepreneur which may influence the decision.

Four different sources of enterprise education are examined for their impact on technology adoption, these being: school based business or enterprise education; university based business or enterprise education; formal work placements with SMEs' and government training schemes in business or enterprise skills. Additional controls are also included to account for the impact of: gender; human capital in the form of experience (age and age squared divided by 100), and as general educational attainment (dummies utilised to represent the highest level of qualification achieved); potential of financial constraints (household income bands); risk aversion and familiarity with current UK region (migration status split into three groups life-long residents, in-migrants from other UK regions, and immigrants born overseas). As the characteristics of firms themselves may have a direct influence upon the probability of utilising new technology further controls are also made for: the age of the firm (years since wages were first paid or profits first made); the size of the firm (number of employees); and industry sector of business at the 1-digit Standard Industrial Classification (SIC) level. Finally to control of geographical and temporal differences dummies are included to represent the UK government office regions of residence of the business owners, and year of survey. The proportion of entrepreneurs utilising newer technology by entrepreneurs' and firms' characteristics are reported in Tables 1 and 2, with

Table 3 reporting the proportion of entrepreneurs utilising newer technology by participation in enterprise education.

For each form of the dependant variable size models in total are utilised. The first excludes all of the dummies for enterprise education participation and acts as a base model with which to make comparisons (Model 0). Models 1 to 4 allow a single source of enterprise education to enter the equation, with school based, university based, formal work placements, and government training each entering in turn. Model 5 incorporates all four sources of enterprise education in order to allow for the participation in multiple sources of enterprise education by individuals.

4. Results

i) Broad Definition of Technology Adoption

Initially concentrating the broader measure of technology adoption that of using technology only made available in the last five years (Table 4), the base model (Model 0) is found to only explain a relatively small portion of the variance in technology adoption, with R^2 values indicating around 7 per cent of variance being explained. However, the likelihood ratio test of Model 0 compared to the alternative of a constant probability is significant at the 1 per cent level. The Hosmer-Lemeshow test of goodness of fit is not rejected, so whilst not performing spectacularly the models are suitable.

Concentrating in on the control characteristics of the owner-managers it is found that few of the personal characteristics of the owner-manager have a strong influence on the decision to utilise newer technology. Although only significant at the 10 per cent level it appears that male owner-managers are more likely to utilise newer technology perhaps reflecting a lower level of risk-aversion and greater growth orientation than their female counterparts (Marlow and Carter, 2006).

In terms of human capital, the coefficients on age and age^2/100 suggest that experience increases the probability of technology adoption but at a decreasing rate, but these coefficients are far from significant. The lack of a significant influence from age may reflect the relative youth of the sub-sample. General education appears to play no role on the probability of utilising newer technology within a business. Whilst this at first appears to run contrary to Wozniak's (1986) findings this may reflect the tendency for greater specialisation in UK education at a relatively early age, where individual's with quite different levels of education may possess similar levels of knowledge appropriate to a particular industry sector.

Interestingly financial constraint as measured by the household income of the owner-manager appears to play no role in the adoption of newer technology. However, similar to the gender effect, the potential for lower risk-aversion of those who are more mobile means that in-migrants are more likely to be utilising newer technology in their businesses than life-long residents of a region, although it should be noted that the coefficients are only significant at the 10 per cent level. Similar sized coefficients are found upon the immigrant dummy, but the smaller size of this group means that a lower level of significance is found.

Variables based on the characteristics of the firms themselves appear to explain the adoption of technology better. This is found to be the case particularly for the age of the business. Younger businesses are understandably more likely to be utilising newer technology, as the adoption of this technology involves lower fixed costs associated with the scrapping of existing technology. The use of newer-technology declines as firms age perhaps no longer requiring the same level of efficiency they required when firstly attempting to overcome barriers to entry, or substituting technologically derived efficiency for lower costs based on economies of scale.

The results provide little evidence that economies of scale are utilised in place of efficient newer technology as the coefficients imply that larger firms are more likely to utilise newer technology, although these effects are not significant. Although not reported here for brevity it comes as little surprise that the level of technology adoption varies considerably between industry sectors, with the agriculture sector least likely to be utilising new technology, whilst the business services, and finance, insurance and real estate sectors are more likely to be utilising newer technology.

Moving onto the impact of enterprise education the likelihood of any influence would seem relatively remote with little evidence that more general human capital greatly increases the probability of using newer technology. As discussed in the preceding section it would seem unlikely that enterprise education provided at school or in the form of formal work placements would involve providing the technical skills and knowledge to influence adoption of newer technology. This is born out by the results in Models 1, 3 and 5 where the coefficients are far from significant and in the case of school based education in Models 1 and 5, and formal work placements in Model 5 are actually negative.

It is little disappointing that those participating in these 'gateway' forms of enterprise education are not engendered with a more entrepreneurial spirit, so that perhaps not whilst having the skills to better judge the costs and benefits of technology adoption would be more inclined to taking innovative paths. However, the role played by these forms of enterprise education could take the form of developing an entrepreneurial spirit which encourages the uptake of enterprise education at a higher level at either university or through a government sponsored training scheme.

Both university based enterprise education and government training schemes are found to significantly increase the probability that participants will utilise newer technology in their businesses controlling for other influences. Both these significant influences remain present in Model 5 where all four sources of enterprise education are allowed to simultaneously enter the regression.

In terms of the performance of these models, the likelihood ratio tests imply that Model 0 is outperformed by Models: 2 (χ^2 = 5.61 d.f. [1] p-value = 0.018); 4 (χ^2 = 5.06 d.f. [1] p-value = 0.025); and 5 (χ^2 = 10.56 d.f. [4] p-value = 0.032) at the five per cent level. The Hosmer-Lemeshow test for these models appear to be better fits to the data as well with no danger of the null of a good fir being rejected.

It would seem therefore that university based enterprise education and government training schemes do have a positive influence on the level of technological adoption, even entrepreneurs themselves have often criticised university enterprise education in particular (Macdonald et al., 2007). In addition the models of adopting newer technology are also improved by including these variables in the regression.

ii) Narrow Definition of Technology Adoption

The results above of course use quite a broad definition of new technology, and therefore may not accurately represent the influence that enterprise education and other personal or firm characteristics have on the probability of utilising the latest technology, that which has only become available in the last twelve months. Table 5 below presents the result of logistic regressions when using this tighter definition of new technology adopters.

The percentage of the variance explained by the regressions is a little higher than the broad definition with R^2 values indicating around 12 per cent explained by the models. Again the likelihood ratio tests indicate the Models outperform the alternative of constant probability. The Hosmer-Lemeshow statistics imply that models fit the data relatively well.

As with the regressions utilising the broader definition personal characteristics of the entrepreneurs appear to have little influence on the adoption of new technology. There is no longer weak evidence that male owner-managers are more likely to adopt new technology, in fact a negative sign is found on the male dummy, although this is not even significant at the 10 per cent level.

New technology adoption rather than increasing with age is decreasing, which may imply the lower risk-aversion of the young encourages the use of newer riskier technology, however, again this is not significant. Similarly the impact of general formal education is reversed compared to Table 4, but coefficients are very small and far from being significantly different from zero. With the tighter definition of new technology only those entering their current region of habitation from outside the UK are more likely to be utilising new technology in their businesses and even here the coefficients are not significant.

As previously the age of the firm is negatively linked to the probability of being an early adopter of technology. Similar industry sectors are more likely to encourage and discourage early adoption of new technology with the tighter definition. Larger businesses are less likely to use the newest technology although this is not a significant effect.

Addition of the enterprise education variables finds that again school based enterprise education, and formal work placements have no impact on increasing the probability of early adoption, as was the case with the broader definition. However, university based enterprise education is also found to have no significant impact on increasing the probability of using the latest technology. The only source of enterprise education that participation in has a significant impact on the probability of using the newest technology available are government training schemes. The likelihood test implies that Model 4 outperforms Model 0 at the 5 per cent level (χ^2 = 5.75 d.f. [1] p-value = 0.017), but this is not the case when the other sources of enterprise education are also included in the equation (χ^2 = 6.14 d.f. [4] p-value = 0.189).

5. Conclusions

Moves over the last 20 years to develop a more entrepreneurial economies with higher levels of innovative firms capable of competing in the global marketplace have encouraged the expansion of a multitude of entrepreneurial courses at all levels of education. This study has examined the impact of a number of different types of enterprise education on one particular aspect of entrepreneurship, the adoption of new technology, by small business owners.

The results indicated that when examining a broader definition of new technology, participants in those sources of enterprise education more likely to include provision of more technical business skills and knowledge, such as those provided by universities and government training schemes, were more likely to be utilising newer technology. It appeared that ‘gateway’ sources of enterprise education had no significant impact on newer technology usage, and therefore currently only provide a role in encouraging further study in terms of developing innovative activities through this particular mechanism. However, when using a tighter definition of new technology only government training schemes were found to have a significant impact, on early adoption.

A study does have a number of limitations including the fact that the data source is entirely from the UK, enterprise education courses do differ between countries and therefore the findings may not be generalisable to other countries. Secondly the categories of enterprise education are relatively broad and do not differentiate for example between students taking courses based around business, and those from other faculties such as engineering or science students taking courses aimed at helping commercialise inventions and innovations developed through their major subjects. Thirdly experience can only be crudely measured

through age, whilst previous work experience may obviously have an important impact particularly where this is in the same industry as their current business.

It is worrying that given the large amount of money spent on enterprise initiatives to aid the development of aspiring entrepreneurs that sources such as university education appear to have little impact in developing technologically innovative business-owners. This implies that some of the worries set out in previous literature in relation to the form that enterprise education takes may be justified. It also brings into question whether public money is being wasted in initiatives which are aimed at boosting greater new technology use and innovation, but utilise courses where it is rare for these elements to be explicitly dealt with.

Although the limitations outlined above must be considered, it does seem that before more public money is spent for little reward, it may be necessary to reassess and identify what the aims of enterprise education are for society as a whole. If as is often stated, the enhancement of small business in the UK through greater innovation and use of technology remains the aim then this should mean concentrating funding on those schemes where technology and innovation play an important role. In areas or regions of the country where no such existing courses are present this should mean the development of new courses, which fit the criteria.

References

Ács, Z.J. and Audretsch, D.B. (2003) 'Innovation and technological change'. In Z.J. Ács and D. B. Audretsch (eds.), *Handbook of Entrepreneurship Research*, Boston: Kluwer Academic Publishers, 55–79.

Aharoni, Y. (1991) 'Education and technology transfer: an recipient point of view'. In T. Agmon and M. von Glinow (eds), Technology Transfer in International Business, New York: Oxford University Press (US), 79-102.

Arenius, P. and De Clercq, D. (2005) 'Network-based approach on opportunity recognition', *Small Business Economics*, 24 (3), 249-265.

Arenius, P. and Minniti, M. (2005) 'Perceptual variables and nascent entrepreneurship', *Small Business Economics*, 24 (3), 233-247.

Audretsch, D.B. and Acs, Z.J. (1994) 'New-firm startups, technology, and macroeconomic fluctuations', *Small Business Economics*, 6 (6), 439-449.

Birdthistle, N. Hynes, B. and Fleming, P. (2007) 'Enterprise education programmes in secondary schools in Ireland: a multi-stakeholder perspective', *Education & Training*, 49 (4), 265-276.

Carter, S. and Collinson, E. (1999) 'Entrepreneurship education: Alumni perceptions of the role of higher education institutions', *Journal of Small Business and Enterprise Development*, 6 (3), 229-239.

Cefis, E. and Marsili, O. (2006) 'Survivor: the role of innovation in firms' survival', *Research Policy*, 35 (5), 626-641.

Delmar, F. and Davidsson, P. (2000) 'Where do they come from? Prevalence and characteristics of nascent entrepreneurs', *Entrepreneurship and Regional Development*, 12 (1), 1-23.

Fiet, J.O. (2000) 'The theoretical side of teaching entrepreneurship', *Journal of Business Venturing*, 16 (1), 1-24.

Garavan, T.N. and O'Cinneide, B. (1994) 'Entrepreneurship education and training programmes: a review and evaluation – part 2', *Journal of European Industrial Training*, 18 (11), 13-21.

Gibb, A.A. (1993) 'The enterprise culture and education: understanding enterprise education and its links with small business entrepreneurship and wider educational goals', *International Small Business Journal*, 11 (3), 11-34.

Gorman, G. Hanlon, D. and King, W. (1997) 'Some research perspectives on entrepreneurship education, enterprise education, and education for small business management: a ten year literature review', International Small Business Journal, 15 (3), 56-77.

Jones-Evans, D. Klofsten, M. Andersson, E. and Pandya, D. (1999) 'Creating a bridge between university and industry in small European countries: the role of the Industrial Liaison Office. *R&D Management* 29 (1), 47-56.

Jones-Evans, D. Williams, W. and Deacon, J. (2000) 'Developing entrepreneurial graduates: an action-learning approach', *Education and Training*, 42 (4/5), 282–288.

Katz, J.A. (2003) 'The chronology and intellectual trajectory of American entrepreneurship education', *Journal of Business Venturing*, 18 (2), 283-300.

Knol, W.H.C. and Stroeken, J.H.M. (2001) 'The diffusion and adoption of information technology in small- and medium-sized enterprises though IT scenarios', *Technology Analysis and Strategic Management*, 13 (2), 227-246.

Kuratko, D.F. (2005) 'The emergence of entrepreneurship education: development, trends, and challenges', *Entrepreneurship, Theory and Practice*, 29 (5), 577-597.

Laranja, M. and Fontes, M. (1998) 'Creative adaptation: the role of new technology based firms in Portugal', *Research Policy* 26, 1023-1036.

Laukkanen, M. (2000) 'Exploring alternative approaches in high-level entrepreneurship education: creating micro-mechanisms for endogenous regional growth', *Entrepreneurship and Regional Development*, 12 (1), 25-47.

Macdonald, S. Assimakopoulos, D. and Anderson, P. (2007) 'Education and training for innovation in SMEs: a tale of exploitation', *International Small Business Journal*, 25 (1), 77-95.

Marlow, S. and Carter, S. (2006) *'If you don't ask you don't get!' Women, Self-employment and Finance'*. Paper presented at the Warwick Business School Small Firm Finance Conference, Warwick, May

Marsh, R. (1996) 'Innovation in small and medium sized enterprises, 1995 survey', *Economic Trends*, 516 (October), 24-41.

Meyers, P.W. Sivakumar, K. and Nakata, C. (1999) 'Implementation of industrial process innovations: factors, and marketing implications', *Journal of Product Innovation Management*, 16 (3), 295-311.

Oakey, R. and Mukhtar, S. (1999) 'United Kingdom high-technology small firms in theory and practice: A Review of Recent trend', *International Small Business Journal* 17 (2), 48-64.

Peterman, N.E. and Kennedy, J. (2003) 'Enterprise Education: Influencing Students' Perceptions of Entrepreneurship', *Entrepreneurship Theory and Practice*, 28 (2), 129–144.

Robinson, P.B. and Sexton, E.A. (1994) 'The effect of education and experience on self-employment success', *Journal of Business Venturing*, 9(2), 141-156.

Rosa, P. (2003) ''Hardly likely to make the Japanese tremble' - the businesses of recently graduated university and college 'entrepreneurs'', *International Small Business Journal*, 21 (4), 435–459

Schultz, T. W. (1975) 'The value of the ability to deal with disequilibria', *Journal of Economic Literature*, 13 (3), 827-846.

Sexton, D.L. and Upton, N.B. (1987) 'Evaluation of an innovative approach to teaching entrepreneurship', *Journal of Small Business Management*, 25 (1), 35-43.

Sexton, D.L. Upton, N.B. Wacholtz, L.E. and McDougall, P.P. (1997) 'Learning needs of growth-oriented entrepreneurs', *Journal of Business Venturing*, 12 (1), 1-8.

Thurik, R. (2008) 'Entreprenomics: entrepreneurship, economic growth and policy'. In Z.J. Ács, D. B. Audretsch and R. Strom (eds.), *Entrepreneurship Growth and Public Policy*, Cambridge: Cambridge University Press.

Van Stel, A. Carree, M. and Thurik, R. (2005) 'The effect of entrepreneurial activity on national economic growth', Small Business Economics, 24 (3), 311-321.

Vesper, K.H. and Gartner, W.B. (1997) 'Measuring progress in entrepreneurship education', *Journal of Business Venturing*, 12 (5), 403-421.

Vesper, K.H. and McMullan, W.E. (1988) 'Entrepreneurship: today courses, tomorrow degrees?', *Entrepreneurship Theory and Practice*, 13 (1), 7-13.

Wozniak, G.D. (1986) 'Human capital, information, and the early adoption of new technology', *Journal of Human Resources*, 22 (1), 101-112.

Wozniak, G.D. (1993) 'Joint information acquisition and new technology adoption: late verses early adoption', *Review of Economics and Statistics*, 72 (3), 438-445.

---

[i] *Although data used in this work are collected by the GEM consortium, their analysis and interpretation are the sole responsibility of the authors.*

Binary logistic regression of utilisation of technology and processes introduced in last the five years

		Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
Male		0.1575 (0.085)	0.1576 (0.085)	0.1591 (0.082)	0.1576 (0.085)	0.1676 (0.068)	0.1684 (0.067)
Age		0.0151 (0.816)	0.0141 (0.827)	0.0190 (0.768)	0.0149 (0.817)	0.0116 (0.857)	0.0122 (0.851)
$Age^2/100$		-0.0631 (0.515)	-0.0622 (0.522)	-0.0670 (0.490)	-0.0627 (0.519)	-0.0586 (0.546)	-0.0609 (0.532)
Educational Attainment (base category: secondary qualifications)	Some Secondary	0.0680 (0.730)	0.0661 (0.737)	0.0980 (0.619)	0.0687 (0.727)	0.0824 (0.676)	0.0985 (0.618)
	Post Secondary	-0.0401 (0.771)	-0.0394 (0.775)	-0.0644 (0.641)	-0.0405 (0.769)	-0.0432 (0.754)	-0.0623 (0.652)
	Graduate Experience	-0.0080 (0.936)	-0.0067 (0.947)	-0.0441 (0.664)	-0.0081 (0.935)	-0.0092 (0.927)	-0.0394 (0.699)
Household Income (base category: middle third)	Lower Third	-0.1381 (0.264)	-0.1387 (0.262)	-0.1340 (0.279)	-0.1383 (0.264)	-0.1419 (0.252)	-0.1394 (0.261)
	Upper Third	-0.1490 (0.130)	-0.1488 (0.130)	-0.1497 (0.128)	-0.1490 (0.130)	-0.1401 (0.155)	-0.1409 (0.153)
Migration Status (base category: life-long residents)	In-Migrants	0.1647 (0.082)	0.1650 (0.081)	0.1711 (0.071)	0.1647 (0.082)	0.1600 (0.091)	0.1685 (0.076)
	Immigrants	0.1393 (0.359)	0.1405 (0.355)	0.1235 (0.417)	0.1395 (0.358)	0.1256 (0.408)	0.1155 (0.449)
Age of Firm, years since wages paid (base category: not yet)	3 years or less	**-0.4669** (0.000)	**-0.4672** (0.000)	**-0.4547** (0.000)	**-0.4667** (0.000)	**-0.4503** (0.000)	**-0.4417** (0.000)
	4 to 12 years	**-0.8751** (0.000)	**-0.8762** (0.000)	**-0.8651** (0.000)	**-0.8751** (0.000)	**-0.8580** (0.000)	**-0.8547** (0.000)
	13 years or more	**-1.0269** (0.000)	**-1.0272** (0.000)	**-1.0258** (0.000)	**-1.0268** (0.000)	**-1.0158** (0.000)	**-1.0180** (0.000)
Size of Firm, number of employees (base category: no employees)	1 to 5 Employees	0.1525 (0.301)	0.1518 (0.303)	0.1441 (0.329)	0.1524 (0.301)	0.1535 (0.298)	0.1421 (0.336)
	6 to 19 Employees	0.2621 (0.243)	0.2620 (0.244)	0.2532 (0.260)	0.2620 (0.244)	0.2531 (0.260)	0.2448 (0.277)
	20 or more Employees	0.2050 (0.511)	0.2060 (0.509)	0.1796 (0.566)	0.2049 (0.512)	0.1883 (0.547)	0.1691 (0.589)
Enterprise Education	School based		-0.0265 (0.820)				-0.1246 (0.311)
	University based			**0.2222** (0.017)			**0.2277** (0.021)
	Work placement				0.0069 (0.937)		-0.0371 (0.683)
	Government training					**0.2228** (0.023)	**0.2027** (0.043)
N		3689	3689	3689	3689	3689	3689
LR d.f. p-value		272.41 [38] (0.000)	272.46 [39] (0.000)	278.02 [39] (0.000)	272.42 [39] (0.000)	277.47 [39] (0.000)	282.97 [42] (0.000)
R^2		0.0714	0.0714	0.0729	0.0714	0.0728	0.0742
Hosmer-Lemeshow		12.2 (0.143)	13.65 (0.091)	5.87 (0.662)	11.37 (0.181)	7.88 (0.446)	4.18 (0.841)

Binary logistic regression of utilisation of technology and processes introduced in the last year

		Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
Male		-0.0597 (0.696)	-0.0598 (0.695)	-0.0584 (0.702)	-0.0596 (0.696)	-0.0363 (0.813)	-0.0357 (0.816)
Age		-0.0406 (0.691)	-0.0412 (0.686)	-0.0388 (0.704)	-0.0407 (0.690)	-0.0495 (0.628)	-0.0497 (0.628)
$Age^2/100$		0.0458 (0.768)	0.0461 (0.766)	0.0441 (0.776)	0.0462 (0.766)	0.0583 (0.708)	0.0563 (0.717)
Educational Attainment (base category: secondary qualifications)	Some Secondary	0.3323 (0.290)	0.3292 (0.295)	0.3479 (0.269)	0.3332 (0.289)	0.3737 (0.236)	0.3707 (0.241)
	Post Secondary	-0.0467 (0.837)	-0.0460 (0.840)	-0.0579 (0.799)	-0.0472 (0.836)	-0.0520 (0.819)	-0.0548 (0.810)
	Graduate Experience	-0.0603 (0.724)	-0.0590 (0.730)	-0.0765 (0.657)	-0.0604 (0.723)	-0.0559 (0.743)	-0.0625 (0.717)
Household Income (base category: middle third)	Lower Third	0.1921 (0.317)	0.1912 (0.320)	0.1923 (0.317)	0.1918 (0.318)	0.1816 (0.345)	0.1809 (0.347)
	Upper Third	0.1233 (0.466)	0.1242 (0.463)	0.1233 (0.466)	0.1232 (0.467)	0.1275 (0.452)	0.1299 (0.444)
Migration Status (base category: life-long residents)	In-Migrants	-0.0391 (0.809)	-0.0386 (0.812)	-0.0363 (0.823)	-0.0390 (0.810)	-0.0466 (0.774)	-0.0439 (0.787)
	Immigrants	0.3583 (0.119)	0.3589 (0.119)	0.3511 (0.127)	0.3585 (0.119)	0.3340 (0.147)	0.3301 (0.153)
Age of Firm, years since wages paid (base category: not yet)	3 years or less	**-0.7945** (0.000)	**-0.7952** (0.000)	**-0.7895** (0.000)	**-0.7942** (0.000)	**-0.7607** (0.000)	**-0.7605** (0.000)
	4 to 12 years	**-1.8782** (0.000)	**-1.8799** (0.000)	**-1.8740** (0.000)	**-1.8780** (0.000)	**-1.8513** (0.000)	**-1.8536** (0.000)
	13 years or more	**-2.0448** (0.000)	**-2.0453** (0.000)	**-2.0452** (0.000)	**-2.0448** (0.000)	**-2.0315** (0.000)	**-2.0335** (0.000)
Size of Firm, number of employees	1 to 5 Employees	-0.0487 (0.845)	-0.0503 (0.840)	-0.0518 (0.836)	-0.0488 (0.845)	-0.0524 (0.834)	-0.0589 (0.814)
	6 to 19 Employees	-0.6262 (0.197)	-0.6268 (0.197)	-0.6311 (0.194)	-0.6262 (0.197)	-0.6493 (0.181)	-0.6537 (0.178)
	20 or more Employees	-0.3916 (0.527)	-0.3913 (0.528)	-0.4002 (0.518)	-0.3917 (0.527)	-0.4196 (0.498)	-0.4227 (0.495)
Enterprise Education	School based		-0.0364 (0.850)				-0.1008 (0.620)
	University based			0.0994 (0.528)			0.0677 (0.687)
	Work placement				0.0067 (0.964)		-0.0348 (0.822)
	Government training					**0.3867** (0.015)	**0.3891** (0.016)
N		3689	3689	3689	3689	3689	3689
LR d.f. p-value		209.69 [38] (0.000)	209.73 [39] (0.000)	210.09 [39] (0.000)	209.69 [39] (0.000)	215.44 [39] (0.000)	215.83 [42] (0.000)
R^2		0.1214	0.1214	0.1216	0.1214	0.1247	0.125
Hosmer-Lemeshow		6.74 (0.565)	6.27 (0.617)	5.7 (0.681)	6.73 (0.566)	2.47 (0.963)	2.51 (0.961)