Science Parks and the Performance of New Technology-Based Firms: A Review of Recent U.K. Evidence and an Agenda for Future Research*

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ABSTRACT. Science parks were established to stimulate the formation and development of new technology-based firms (NTBFs). Despite the potential importance of these institutions as a mechanism for generating technological spillovers and employment growth, there has been little systematic analysis of their impact on NTBFs. In this paper, we review some recent evidence comparing the performance of firms located on and off U.K. science parks. This preliminary evidence suggests that the "returns" to being located on a science park are negligible. We conjecture that these results may be due to imprecise estimates of these returns and may also be masking important differences in the returns to different *types* of science parks. In addition, we outline an agenda for additional research on the effects of these institutions on NTBF performance.

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I. Introduction

New technology-based firms (NTBFs) are alleged to play a key role in enhancing entrepreneurship and economic growth. The success of NTBFs located in the vicinity of Stanford and MIT inspired developers in the U.K. to build science parks near universities and higher education institutes (HEIs). Several studies have provided additional justification for such efforts. Acs et al. (1992) and Anselin et al. (1997) report that university research generates local technological spillovers. According to Link and Rees (1990), small firms are more likely to benefit from such spillovers than larger, more established companies. In a similar vein, Harris and Trainor (1995) report that universities stimulate local innovative activity by attracting clusters of R&D intensive firms. The clustering of NTBFs is also assumed to generate additional benefits, such as job creation, technological spillovers, development and diversification of regional economies, enhanced efficiency, and an expansion of exports.

To stimulate the formation of NTBFs, successive British Governments, with the support of universities, HEIs, local governmental authorities, and various financial institutions, have encouraged the development of various property-based incubator initiatives.[1] Science parks represent one type of such an initiative. Despite the potential importance of science parks as a mechanism for generating technological spillovers and employment growth, there has been little systematic analysis of their impact on the performance of NTBFs.

In this short paper, we review some recent U.K. evidence comparing various indicators of the "performance" of firms located on science parks and

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observationally equivalent firms located off science parks. While these results are interesting, they suffer from several empirical limitations that can only be addressed with better data. We identify these limitations and build on this discussion to outline an agenda for further research.

The remainder of this paper is organized as follows. Section II provides a brief history of science parks in the U.K. The following section reviews some empirical evidence relating to the performance of NTBFs located on science parks in the U.K. Section IV examines the shortcomings of these studies and outlines an agenda for additional research.

II. A brief history of science parks in the United Kingdom

According to the United Kingdom Science Park Association (UKSPA (1999)), science parks have three fundamental characteristics. They are designed to foster the formation and growth of innovative firms, provide an environment which enables large companies to develop relationships with small, innovative firms, and promote formal and operational links with "centers of knowledge creation", such as universities, higher education institutes and research institutions. Thus, science parks could provide access to critical human and physical capital for NTBFs, as well as an environment that fosters technology transfer and much-needed business skills.

The first U.K. science parks were established in Cambridge and Heriot-Watt in 1972. By 1989, there were 32, a figure that remained constant until 1993 (UKSPA, 1999). As of 1999, the U.K. had 46 fully operational science parks. Some of this growth can be attributed to the establishment of science parks at institutions that were transformed from polytechnics into "new universities". Key stylized evidence regarding these institutions are as follows. Over 80% of the firms located on science parks have less than 15 employees (UKSPA, 1996). Many of these firms are attempting to commercialize leading-edge technologies, most notably, biotechnology, materials, computers/telecommunications, and technologies with environmental, energy, and industrial applications. The UKSPA (1999) reported that over 50% of science park firms were engaged in R&D or new product design and testing. They also found that these high-tech jobs were helping some local regions retain university and HEI graduates. Finally, the UKSPA noted that approximately 60% of science park firms originated from within a radius of five miles of the science park; 80% were within a radius of thirty miles.

Carter (1989) identified three types of strategies for the creation of a science park in the U.K. The first and least commonly employed approach is a university led and funded strategy, in which a university or HEI establishes a science park and manages it. A second approach is a joint venture strategy, involving the university or HEI and private investors. Under this approach, the unit is managed by a separate legal entity. The third and most commonly employed method is a co-operative venture strategy, in which the partners work together within a flexible and informal framework. This strategy typically results in only limited involvement of the university or HEI and academics in the day-to-day operations of the unit.

Firms in the U.K. can obtain services through three main types of science park management agreements (Carter, 1989; Grayson, 1993). The first is the informal team. This is the cheapest and most flexible approach, in which the science park partners divide the various management tasks among themselves, but there is no full-time, on-site management presence. A second type of management agreement involves a single on-site manager. This has the advantage of allowing the development of expertise relating to the specific needs of science park firms. In this instance, the background and experience of the manager are important, especially the balance of technical, financial, and marketing skills. The third type of management agreement is the on-site management company. This entails a formally integrated management structure, including representatives from all investors in the park, which may provide a more secure basis for long-term development.

To enable researchers to focus on the nature of the management function provided by science parks, UKSPA distinguishes between "managed" and "non-managed" science parks.[2] A "managed" science park has a full time, on-site manager (Westhead and Storey, 1994). These managers or "gate-keepers" can legitimize the activities of

entrepreneurs and augment an entrepreneur's commercial, professional and social networks.

III. Assessing the impact of science parks on the performance of NTBFs: Theory and evidence from the United Kingdom

Science parks have numerous objectives, in terms of their impact on *firms* and the *local region*. Objectives relating to firms include facilitating university technology transfer, promoting the formation of NTBFs, encouraging the growth of existing high-tech firms, attracting firms involved in leading-edge technologies, and fostering strategic alliances/networks. Goals relating to regional impacts include economic development, job creation, and enhancement of the image of the location, which is an important objective in regions experiencing industrial decline in the U.K.

One justification for the existence of science parks is that owners of NTBFs could encounter several barriers to successful commercialization, resulting from their small size and inexperience.[3] Developers who designed and manage science parks assert that such obstacles can be surmounted by providing NTBFs with proximity to specialized services; flexible premises (to facilitate growth); shared resources and business services; links with local universities or HEIs; and opportunities for co-operation with other tenants.

Indeed, the marketing of science parks to NTBFs highlights factors that typically influence firm location choices (MacGregor et al., 1986; Galbraith and De Noble, 1988; Gripaios et al., 1989; Sternberg, 1990; Westhead and Batstone, 1998). These include the cost of transportation, real estate, and skilled labor, financial subsidies, site adequacy, the provision of complementary services to overcome an entrepreneur's weaknesses with regard to key business skills, environmental quality, and the presence of a local university. Owner-managers of NTBFs may also value the provision of joint services on science parks, since this can help them reduce overhead costs.

NTBFs that select sponsored environments (Flynn, 1993) can transmit signals to other firms, conferring a reputational advantage or legitimacy for their organizations (Aldrich, 1990). Science park managers (i.e., gate-keepers) can also help reduce uncertainty (and fixed costs) for owner-managers of NTBFs (Johannisson et al., 1994). A gate-keeper could enhance the reputation of fledgling firms with limited social/business networks, which might help them attract additional financial capital and better employees. Moreover, science park managers can foster technology transfer, by promoting linkages between local HEIs and tenant firms.

Finally, there is the issue of the clustering of NTBFs. By reducing uncertainty and transaction costs, as well as enabling owner-managers to exploit commercial and technical information, science parks may provide access to key resources for NTBFs. Furthermore, institutional factors within a science park can provide a context for acquiring tacit knowledge and experience (Thrift, 1996).

In sum, the extant literature suggests that science parks could influence various dimensions of firm performance, broadly defined. Despite growing interest in the science park phenomenon, relatively few studies have been conducted outside the U.K. (see Grayson, 1993; Felsenstein, 1994; Johannisson et al., 1994). More importantly, relatively few studies have examined differences in survival, employment growth, and R&D activity between NTBFs located on science parks and similar NTBFs located off science parks.

There is considerable debate regarding the appropriate method to assess the effectiveness of science parks. It is difficult to generalize results from studies that focus upon a single science park environment (Johannisson et al., 1994). We believe it is inappropriate for researchers to assess the outcomes of the science park phenomenon by solely collecting *perceptual* data from entrepreneurs (and firms) located on a small number of science parks. Such data suffer from several well-known limitations. For example, a sample of entrepreneurs (and firms) located on a single park or a small set of parks may not be representative of the population of all entrepreneurs (and firms) located on science parks. Results from these studies may, therefore, be biased. Furthermore, there is the possibility that client entrepreneurs (and firms) might overestimate the effectiveness of science parks. Several researchers also do *not* identify and gather information from a control

group of observationally equivalent technology-based entrepreneurs (and firms) not located on a science park. A matched control group of respondents not located on a science park enables a researcher to control for confounding (i.e., a variable that obscures the effects of the science park variable) and extraneous variables (i.e., any variable other than the science park variable which might have an effect on the selected dependent variable).

The first step in overcoming some of these limitations is to construct a longitudinal data set consisting of performance indicators for NTBFs located on parks and a control group of NTBFs that are not located on parks. Such data were collected in the U.K. by Monck et al. (1988), based on a comprehensive survey conducted in 1986.[4] These data were subsequently updated and extended to 1992 by Westhead and Storey (1994). To facilitate generalization, interviews were conducted with a representative sample of firms located in *numerous* science parks. Also, structured questionnaires were implemented in 1986 and 1992 to gather information from owner-managers of science park firms. In-person interviews with the owner-managers of science park firms were conducted (in 1986 and 1992), in order to ensure a high response rate and to collect more accurate information. In order to control (albeit, imperfectly) for sample selection bias, data were collected in both years from observationally equivalent firms (i.e., a control group of similar firms that are not located on a science park). Samples of science park and off-park firms were matched, in 1986, along the following dimensions: age of firm, main industrial activity, ownership status, and standard region location.[5]

An initial analysis of the data from the 1986 and 1992 samples was presented in Westhead and Storey (1994). The authors found an insignificant difference between the closure rates of firms located on science parks and similar firms not located on science parks (32% compared with 33%).[6] This result was confirmed by Westhead et al. (1995) using multivariate logistic regression analysis. They concluded that sponsored science park environments did not significantly increase the probability of business survival.[7] Another dimension of performance is job creation. Using the longitudinal data described earlier, Westhead and Cowling (1995) found that the mean employment growth rates of firms located on parks and those not located on parks period were virtually identical.[8]

There has also been some analysis of the importance of links with an HEI. Westhead and Storey (1995) compared survival rates over the 1986 to 1992 period for NTBFs on science parks with and without HEI links. The authors reported a higher survival rate among firms with an HEI link (72%) than firms without such a link (53%). This difference was highly statistically significant.

Westhead (1997), in addition, examined differences in R&D "outputs" and "inputs" of NTBFs located on science parks and similar NTBFs located off science parks. R&D input measures include the percentage of scientists and engineers in total employment, the level and intensity of R&D expenditure, and information on the thrust and nature of the research undertaken by the firm. Proxies for R&D outputs are counts of patents, copyrights, and new products or services. Westhead reports that science park firms tend to be more R&D intensive than off-park firms, although once again, these differences are not statistically significant. He also finds insignificant differences between science park and non-science park firms, along all dimensions of R&D output.

IV. An agenda for additional research

The existing evidence suggests that the "returns" to location on an U.K. science park are negligible. That is, it appears that there are no statistically significant differences in various dimensions of performance between NTBFs located on science parks and observationally equivalent NTBFs located off science parks. These results should be interpreted with caution because they are based on a small sample of firms and, generally, only univariate statistical tests were conducted. Additional data and a more sophisticated econometric framework might yield different results.

More importantly, additional dimensions of the performance of NTBFs on science parks should be measured. We believe that there are four critical research questions:

- Do firms located on a science park have higher research productivity than observationally equivalent firms not located on a science park?
- Do the "returns" to location on a science park vary according to the type of park (e.g., a university science park)?
- Do the "returns" to location on a science park vary according to the type of entrepreneur who locates on a park?
- How does activity on a university science park affect other dimensions of university technology transfer (e.g., licensing agreements and other university-based start-ups)?

Despite the potential importance of science parks as a mechanism for generating technological spillovers, there has been no systematic analysis of their impact on the research productivity of firms. Productivity measures (for firms located on and off science parks) can be constructed using the data on R&D inputs and outputs presented in Westhead (1997). These productivity estimates could be calculated using parametric methods, such as stochastic frontier analysis (Siegel et al., 1999), or non-parametric methods, such as data envelopment analysis (Thursby and Kemp, 2001). One could also extend this framework by both assessing and "explaining" relative productivity (i.e., regressing these measures of relative efficiency on a set of park and environmental characteristics, in order to determine why some science parks are more effective at enhancing the research productivity of client firms). These findings would allow researchers to determine whether science parks are indeed effectively targeting innovation market failures.

It is conceivable that existing evidence could be masking important differences in the returns to different *types* of science parks. In this regard, it might be useful to develop a taxonomy of science parks. For instance, we believe that it may be important to distinguish between "managed" and "non-managed" parks. In the U.K., many science parks have been established in depressed regions, which do not have a culture conducive to the development of NTBFs. Some owner-managers of firms in these regions have chosen to locate their firm on a "managed" park, in order to have access to critical resources and establish the legitimacy of their ventures. Not surprisingly, the existing evidence indicates that business closure rates on "non-managed" science parks were lower than those reported on "managed" parks (Westhead and Batstone, 1999). This finding implies that science parks placing a greater emphasis on increasing the supply of technology-based entrepreneurs in such depressed environments will have high levels of business turbulence. In contrast, owners of "non-managed" science parks who place a greater emphasis on developing, rather than incubating, new firms may inevitably have clients firms with lower closure rates.

Additional research should be undertaken to determine whether a particular science park strategy (i.e., university led and funded, joint venture strategy, or co-operative venture strategy) or management agreement (i.e., informal teams, single science park manage on-site or on-site management company) is associated with a wider range of benefits. A science park location and a proactive gate-keeper may develop an environment that engenders trust between science park tenants, the local HEI and other local firms not located on a science park. The effectiveness of intermediaries (Perry, 1996), such as science park mangers, in the commercialization process and the linking of science park firms with HEIs, other tenants on the park, as well as firms located off-park, needs to be carefully monitored.

Another potential source of heterogeneity in the social returns to science parks involves the match between the attributes of the entrepreneur and the park. In this regard, it might also be useful to conduct a large scale, stratified survey of entrepreneurs who choose to locate their firms on a science park. Studies suggest (Westhead, 1995) that there are different *types* of entrepreneurs (e.g., "portfolio" and "serial" entrepreneurs (Westhead and Wright, 1998) and "surrogate" entrepreneurs (Franklin et al., 2001), which could have performance implications for the NTBFs they manage.

We believe that the relationship between university science parks and other aspects of university-industry technology transfer warrants further attention. For instance, researchers could examine the relationship between activity on a university science park and licensing of university-based

technologies to firms, university patenting, sponsored research, co-authoring between academic and industry scientists, university-based start-ups, and hiring of engineering and science graduates. This would contribute to the debate on the most effective mechanisms for transferring technology from universities to firms (Siegel et al., 1999; Bray and Lee, 2000). In particular, it may offer insights into the most appropriate modes for enhancing the performance of university spin-out companies (Franklin et al., 2001).

To address the four proposed research questions, scholars should employ both a mix of quantitative and qualitative methods and a combination of archival and survey data. As noted in Siegel (2000), there is a precedent for using both approaches in assessing the performance of U.S. public-private technology partnerships, such as the Small Business Innovation Research (SBIR) program. SBIR was designed to stimulate the formation and growth of NTBFs. A recent book by Wessner (2001) compiles an impressive set of statistical analyses and case studies, which illustrate how SBIR has addressed innovation market failure for small firms and spurred innovative and entrepreneurial activity.[9] We are just beginning to understand the managerial and policy implication of science parks.

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Notes

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[1] Universities and HEIs have supported science parks to ensure that their research is more relevant to industry, to secure more prestige, private sector funding, and rental income, and to provide job opportunities for HEI employees and students.

[2] The UKSPA identified the following parks as "non-managed": Aberdeen, Aberystwyth, Cambridge, Highfields (Nottingham), Listerhills (Bradford) and Loughborough (Westhead and Storey (1994)).

[3] Developers have assumed that science park tenants who want their businesses to compete in international markets are especially concerned with image (Massey et al. (1992)).

[4] The 1986 survey of Science park firms conducted by Monck et al. (1988) (also see Massey et al., 1992) and the 1992 survey conducted by Westhead and Storey (1994) adopted the following UKSPA definition of a science park as a property-based initiative which included the following features: has formal and operational links with a University, other HEI or Research Centre; is designed to encourage the formation and growth of knowledge based businesses and other organizations normally resident on site; and has a management function which is actively engaged in the transfer of technology and business skills to the organizations on site (Monck et al., 1988, p. 64).

[5] A cost-benefit analysis of property-led economic development policies pursued by local authorities and development agencies was beyond the scope of the study.

[6] The definition of closure was: "An independent business is regarded as a closure if, in 1992, it is no longer identifiable as a trading business. An independent business which moves locations but continues as a trading business is *not* regarded as a closure. If the business is a subsidiary or a branch plant then it is regarded as having ceased if it no longer trades at its previous location" (Westhead and Storey, 1994, p. 25).

[7] Westhead et al. (1995) used multivariate logistic regression analysis to identify the determinants of survival for technology-based firms in the Monck et al. (1988) samples between 1986 and 1992. A science park location was not found to be a significant determinant of business survival. They found that younger businesses and those competing against small firms were significantly less likely to survive. However, "team start" businesses owned by more than one shareholder and those that had a founder with a bachelor's degree or more were significantly more likely to survive.

[8] Responses to the "follow-on" survey were examined for non-response bias (Westhead and Storey, 1994, pp. 33–39). No marked differences between the 1986 and 1992 "follow-on" survey returns were recorded with regard to ownership characteristics, sectoral or geographical coverage or the age of the surveyed organizations.

[9] Please refer to Audretsch et al. (2001), Audretsch et al. (2001), and Link and Scott (2001). Similar methods have been used to evaluate the Advanced Technology Program (ATP) in the U.S (see Wessner, 1999).

References

Acs, Z. J., D. B. Audretsch and M. P. Feldman, 1992, 'Real Effects of Academic Research: Comment', *American Economic Review* **82**, 363–367.

Aldrich, H. E., 1990, 'Using an Ecological Perspective to Study Organizational Founding Rates', *Entrepreneurship Theory and Practice* **14**, 7–24.

Anselin, L, A. Varga and Z. Acs., 1997, 'Local Geographic Spillovers between University Research and High Technology Innovations', *Journal of Urban Economics* **42**, 422–448.

Audretsch, D. B., A. N. Link and J. T. Scott, 2001,

'Public/Private Technology Partnerships: Evaluating SBIR Supported Research', *Research Policy*, forthcoming.

Audretsch, D. B., J. Weigand and C. Weigand, 2001, 'Does the Small Business Innovation Research Program Foster Entrepreneurial Behavior? Evidence from Indiana', in Charles Wessner (ed.), *The Small Business Innovation Research Program (SBIR): An Assessment of the Department of Defense Fast Track Initiative*, Washington, D.C.: National Academy Press, pp. 160–193.

Bercovitz, J., H. Feldman, I. Feller and R. Burton, 2001, 'Organizational Structure as Determinants of Academic Patent and Licensing Behavior: An Exploratory Study of Duke, Johns Hopkins, and Pennsylvania State Universities', *Journal of Technology Transfer* **26**, 21–35.

Bray, M. J. and J. N. Lee, 2000, 'University Revenues from Technology Transfer: Licensing Fees vs. Equity Positions', *Journal of Business Venturing* **15**, 385–392.

Carter, N., 1989, *Science Parks Development and Management*, London: The Estates Gazette Limited.

Felsenstein, D., 1994, 'University-Related Science Parks – "Seedbeds" or "Enclaves" of Innovation?', *Technovation* **14**, 93–110.

Flynn, D. M., 1993, 'A Critical Exploration of Sponsorship, Infrastructure, and New Organizations', *Small Business Economics* **5**, 129–156.

Franklin, S., M. Wright and A. Lockett, 2001, 'Academic and Surrogate Entrepreneurs in University Spin-out Companies', *Journal of Technology Transfer* **26**, 127–141.

Galbraith, C. and A. F. De Noble, 1988, 'Location Decisions by High Technology Firms: A Comparison of Firm Size, Industry Type and Institutional Form', *Entrepreneurship Theory and Practice* **13**, 31–47.

Grayson, L., 1993, *Science Parks: An Experiment in High Technology Transfer*, London: The British Library.

Gripaios, P., B. Bishop, R. Gripaios and C. Herbert, 1989, 'High Technology Industry in a Peripheral Area: The Case of Plymouth', *Regional Studies* **23**, 151–157.

Harris, R., and M. Trainor, 1995, 'Innovations and R&D in Northern Ireland Manufacturing: A Schumpeterian Approach', *Regional Studies* **29**, 593–604.

Johannisson, B., O. Alexanderson, K. Nowicki and K. Senneseth, 1994, 'Beyond Anarchy and Organization: Entrepreneurs in Contextual Networks', *Entrepreneurship and Regional Development* **6**, 329–356.

Link, A. N., and J. Rees, 1990, 'Firm Size, University-Based Research, and the Returns to R&D', *Small Business Economics* **2**, 25–32.

Link, A. N. and J. T. Scott, 2001, 'Estimates of the Social Returns to Small Business Innovation Research Projects', in Charles Wessner (ed.), *The Small Business Innovation Research Program (SBIR): An Assessment of the Department of Defense Fast Track Initiative*, Washington, D.C.: National Academy Press, pp. 275–290.

MacGregor, B. D., R. J. Langridge, J. Adley and B. Chapman, 1986, 'The Development of High Technology Industry in Newbury District', *Regional Studies* **20**, 433–448.

Massey, D., P. Quintas and D. Wield, 1992, *High Tech Fantasies: Science Parks in Society, Science and Space*, London: Routledge.

Monck, C. S. P., R. B. Porter, P. Quintas, D. J. Storey and P. Wynarczyk, 1988, *Science Parks and the Growth of High Technology Firms*, London: Croom Helm.

Perry, M., 1996, 'Network Intermediaries and Their Effectiveness', *International Small Business Journal* **14**, 72–80.

Siegel, D. S., 2000, 'Strategic Research Partnerships and Economic Performance: Data Considerations', *Paper presented at the National Science Foundation Workshop on Strategic Research Partnerships*, Arlington, VA, October 13, 2000.

Siegel, D. S., J. G. Thursby, M. C. Thursby and A. A. Ziedonis, 2001, 'Organizational Issues in University-Industry Technology Transfer: An Overview of the Symposium Issue', *Journal of Technology Transfer* **26**, 5–11.

Siegel, D. S., D. Waldman and A. Link, 1999, Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study. NBER Working Paper #7256, July 1999.

Sternberg, R., 1990, 'The Impact of Innovation Centres on Small Technology-Based Firms: The Example of the Federal Republic of Germany', *Small Business Economics* **2**, 105–118.

Thrift, N., 1996, *Spatial Formations*, London: Sage.

Thursby, J. G. and S. Kemp, 2001, 'Growth and Productive Efficiency of University Intellectual Property Licensing', *Research Policy*, forthcoming.

UKSPA, 1996, *UKSPA 96: The United Kingdom Science park Association Annual Report 1996*, Birmingham: The United Kingdom Science Park Association.

UKSPA, 1999, *15th Anniversary 1984–1999*, Birmingham: The United Kingdom Science Park Association.

Wessner, C. W. (ed.), 1999, *The Advanced Technology Program: Challenges and Opportunities*, Washington, D.C.: National Academy Press.

Wessner, C. W. (ed.), 2001, *The Small Business Innovation Research Program (SBIR): An Assessment of the Department of Defense Fast Track Initiative*, Washington, D.C.: National Academy Press.

Westhead, P., 1995, 'Survival and Employment Growth Contrasts Between Types of Owner-Managed High-Technology Firms', *Entrepreneurship Theory and Practice* **20**, 5–27.

Westhead, P., 1997, 'R&D 'Inputs' and 'Outputs' of Technology-Based Firms Located On and Off Science Parks', *R&D Management* **27**, 45–62.

Westhead, P. and S. Batstone, 1998, 'Independent Technology-Based Firms: The Perceived Added Value of a Science Park Location', *Urban Studies* **35**, 2197–2219.

Westhead, P. and S. Batstone, 1999, 'Perceived Benefits of a Managed Science Park Location for Independent Technology-Based Firms', *Entrepreneurship and Regional Development* **11**, 129–154.

Westhead, P., and M. Cowling, 1995, 'Employment Change in Independent Owner-Managed High-Technology Firms in Great Britain', *Small Business Economics* **7**, 111–140.

Westhead, P. and D. J. Storey, 1994, *An Assessment of Firms Located On and Off Science Parks in the United Kingdom*, London: HMSO.

Westhead, P. and D. J. Storey, 1995, 'Links Between Higher Education Institutions and High Technology Firms', *Omega, International Journal of Management Science* **23**, 345–360.

Westhead, P., D. J. Storey and M. Cowling, 1995, 'An Exploratory Analysis of the Factors Associated with the Survival of Independent High-Technology Firms in Great Britain', in F. Chittenden, M. Robertson and I. Marshall (eds.), *Small Firms: Partnerships for Growth*, London: Paul Chapman, pp. 63–99.

Westhead, P. and M. Wright, 1998, 'Novice, Portfolio and Serial Founders: Are They Different?', *Journal of Business Venturing* **13**, 173–204.