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**The Effectiveness of  
University Technology  
Transfer**

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# The Effectiveness of University Technology Transfer

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## The Effectiveness of University Technology Transfer

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### Abstract

In recent years, there have been numerous studies of the effectiveness of university technology transfer. Such technology transfer mechanisms include licensing agreements between the university and private firms, science parks, incubators, and university-based startups. We review and synthesize these papers and present some pointed recommendations on how to enhance effectiveness. Implementation of these recommendations will depend on the mechanisms that universities choose to stress, based on their technology transfer “strategy.” For example, institutions that emphasize the entrepreneurial dimension of technology transfer must address skill deficiencies in technology transfer offices, reward systems that are inconsistent with enhanced entrepreneurial activity and the lack of training for faculty members, post-docs, and graduate students in starting new ventures or interacting with entrepreneurs. Universities will also have to confront a set of issues related to ethics and social responsibility, as they more aggressively pursue technology commercialization. Finally, we suggest some possible theoretical frameworks for additional research.

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# 1

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## Introduction

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Some university administrators in the U.S. and other industrial nations have asserted that university technology transfer can potentially provide substantial revenue for universities. At the same time, policymakers in these countries have also pointed to the possibility that technology transfer can enhance national and regional economic growth. The key university technology transfer commercialization mechanisms are licensing agreements between the university and private firms, research joint ventures, and university-based startups. These activities can potentially result in financial gains for the university, other benefits to these institutions (e.g., additional sponsored research, hiring of graduate students and post-doctoral fellows), and job creation in the local region. Given the importance of these commercialization mechanisms, many universities and policymakers continually seek guidance on how to evaluate and enhance effectiveness in university technology transfer.

Organizations such as the Association of University Technology Managers (AUTM) in the U.S. and the University Companies Association (UNICO) and the Association for University Research Industry Links (AURIL) in the U.K. have helped to promote technology transfer activity by publishing benchmarking surveys. These surveys have been

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used by scholars to explore key research questions relating to the drivers of effective university technology transfer. While such studies have been useful, the literature remains somewhat embryonic, with many unresolved managerial and policy issues.

In many countries, national governments have provided support for these initiatives via legislation to facilitate technological diffusion from universities to firms (e.g., the Bayh-Dole Act of 1980) and collaborative research (e.g., the National Cooperative Research Act of 1984), subsidies for research joint ventures involving universities and firms (e.g., the European Union's Framework Programmes and the U.S. Commerce Department's Advanced Technology Program (ATP)), and shared use of expertise and laboratory facilities (e.g., the National Science Foundation's Engineering Research Centers, Science and Technology Centers, and Industry-University Cooperative Research Centers). Along these lines, national, state, and regional government authorities have also provided support for science parks and incubators.

The growth in private and public investment in university-based technology initiatives has raised important policy questions regarding the impact of such activities on researchers, universities, firms, and local regions where such investments occur. Given that many of these initiatives are relatively new, university officials and policymakers seek guidance on "best practices." More specifically, they seek evidence on specific organizational practices related to incentives, strategic objectives, and measurement and monitoring mechanisms, which might enhance technology transfer effectiveness. Inductive, qualitative research is also useful in this context, since notions of "effectiveness" are likely to vary across different types of initiatives (e.g., incubators vs. technology transfer offices) and for different players involved in such activities (e.g., university scientists, university administrators, and corporations interacting with the university).

The purpose of this paper is to review and synthesize research on the antecedents and consequences of university-based technology transfer and to explore the implications for practice and future research in this domain. Before presenting a review of the extant literature, it is useful to provide some background information on the rise of university technology transfer.

In the late 1970s, U.S. research universities were often criticized for being more adept at developing new technologies than facilitating their commercialization into the private sector (General Accounting Office, 1998). Furthermore, it was asserted that the long lag between the discovery and commercialization of new knowledge at the university had weakened the global competitiveness of American firms (Marshall, 1985). While such conclusions glossed over the principal mission of research universities as creators of new knowledge, they generated sufficient concern for policymakers to take action. As a consequence, in 1980, the U.S. Congress attempted to remove potential obstacles to university technology transfer by passing the Bayh-Dole Act. Bayh-Dole instituted a uniform patent policy across federal agencies, removed many restrictions on licensing, and allowed universities to own patents arising from federal research grants. The framers of this legislation asserted that university ownership and management of intellectual property would accelerate the commercialization of new technologies and promote economic development and entrepreneurial activity.

In the aftermath of this landmark legislation, almost all research universities in the U.S. established technology transfer offices (TTOs) to manage and protect their intellectual property. The number of TTOs increased eightfold, to more than 200, resulting in a sixfold increase in the volume of university patents registered (AUTM, 2004). TTOs facilitate commercial knowledge transfers through the licensing to industry of patents or other forms of intellectual property resulting from university research. The Association of University Technology Managers reports that from 1991 to 2004, university revenues from licensing IP have increased over 533%, from USD220 million to USD1.385 billion (AUTM, 2004). The number of firms that utilize university-based technologies has also increased. Finally, the evidence also strongly suggests that venture capitalists are increasingly interested in ventures founded on the basis of basic research (Small Business Administration, 2002).

Our literature review will also encompass the institutional context of university technology transfer, which includes science parks and incubators. We will also discuss the organizational context, including organizational design, processes, and incentives, as well as the roles of

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individual agents, such as scientists and technology transfer officers. Finally, because much of the early research has focused measures of effectiveness and the building of robust theoretical models depended on well specified dependent variables, we review research on measures of technology transfer effectiveness such as licensing revenues, the introduction of new products and services, and new business starts.

The remainder of this review is organized as follows: In the following sections, we present an extensive review of the literature on university technology licensing, selected studies of science parks, and studies of start-up formation at universities. Section II discusses the institutional context of university technology transfer. The following section considers the organizational context of this activity. Section IV contains a discussion of the role of individual agents (i.e., academic and industry scientists, entrepreneurs, managers at firms and universities) in university technology transfer. Section V presents some methodological issues, in the context of a review of studies of licensing and business formation. The following section discusses theoretical implications, while Section VI presents lessons learned for policymakers and university administrators. The final section consists of some tentative conclusions.

## References

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- Aigner, D. J., C. A. K. Lovell, and P. Schmidt (1977), 'Formulation and Estimation of Stochastic Frontier Production Function'. *Journal of Econometrics* **6**, 21–37.
- Association of University Technology Managers (AUTM) (2004), 'The AUTM Licensing Survey, Fiscal Year 2003'. AUTM, Inc: Norwalk, CT.
- Audretsch, D. and E. E. Lehmann (2005), 'University Spillovers and New Firm Location'. *Research Policy* **34**(7), 1058–1075.
- Audretsch, D., E. Lehmann, and S. Warning (2005), 'University spillovers and new firm location'. *Research Policy* **34**(7), 1113–1122.
- Audretsch, D. (2000), 'Is University Entrepreneurship Different?'. mimeo, Indiana University.
- Azagra-Caro, J. M., N. Carayol, and P. Llerena (2006), 'Patent Production at a European Research University: Exploratory Evidence at the Laboratory Level'. *Journal of Technology Transfer* **31**(2), 257–268.
- Battese, G. and T. Coelli (1995), 'A model for technical inefficiency effects in a stochastic frontier production function for panel data'. *Empirical Economics* **20**, 325–332.

62 *References*

- Bercovitz, J., M. 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.
- Bercovitz, J. and M. Feldman (2004), 'Academic Entrepreneurs: Social Learning and Participation in University Technology Transfer'. Mimeo, University of Toronto.
- Blumenthal, D., Campbell, G. Eric, M. Anderson, N. Causino, and K. S. Louis (1997), 'Withholding Research Results in Academic Life Science: Evidence From a National Survey of Faculty'. *Journal of the American Medical Association* **277**(15), 1224–1228.
- Blumenthal, D., Campbell, G. Eric, N. Causino, and K. S. Louis (1996), 'Participation of Life-Science Faculty in Research Relationships With Industry'. *New England Journal of Medicine* **335**(23), 1734–1739.
- Blundell, R., R. Griffith, and J. Van Reenen (1995), 'Dynamic Count Data Models of Technological Innovation'. *Economic Journal* **105**, 333–344.
- Brouwer, M. (2005), 'Entrepreneurship and University Licensing'. *Journal of Technology Transfer* **30**(3), 263–270.
- Campbell, A. F. (2005), 'The evolving concept of value add in university commercialisation'. *Journal of Commercial Biotechnology* **11**(4), 337–345.
- Carlsson, B. and A. Fridh (2002), 'Technology Transfer in United States Universities: A Survey and Statistical Analysis'. *Journal of Evolutionary Economics* **12**, 199–232.
- Chapple, W., A. Lockett, D. S. Siegel, and M. Wright (2005), 'Assessing the Relative Performance of University Technology Transfer Offices in the U.K.: Parametric and Non-Parametric Evidence'. *Research Policy* **34**(3), 369–384.
- Chapple, W., A. Lockett, D. S. Siegel, and M. Wright (2006), 'Assessing the Relative Performance of University Technology Transfer in the U.S. and U.K.: A Stochastic Distance Function Approach'. mimeo.
- Clarke, B. R. (1998), *Creating Entrepreneurial Universities; Organizational Pathways of Transformation*. New York: IAU Press.

- Clarysse, B., M. Wright, A. Lockett, E. van de Elde, and A. Vohora (2005), 'Spinning out new ventures: A typology of incubation strategies from European research institutions'. *Journal of Business Venturing* **20**(2), 183–216.
- Cohen, W. M., R. R. Nelson, and J. P. Walsh (2002), 'Who is Selling the Ivory Tower? Sources of Growth in University Licensing'. *Management Science* **48**(1), 90–104.
- Colyvas, J., M. Crow, A. Geljins, R. Mazzoleni, and R. R. Nelson (2002), 'How do university inventions get into practice?'. *Management Science* **48**(1), 61–72.
- Dai, Y., D. Popp, and S. Bretschneider (2005), 'Institutions and intellectual property: The influence of institutional forces on university patenting'. *Journal of Policy Analysis and Management* **24**(3), 579–598.
- Debackere, K. and R. Veugelers (2005), 'The Role of Academic Technology Transfer Organizations in Improving Industry Science Links'. *Research Policy* **34**(3), 321–342.
- Degroof, J. J. and E. B. Roberts (2004), 'Overcoming Weak Entrepreneurial Infrastructure for Academic Spin-off Ventures'. *Journal of Technology Transfer* **29**(3–4), 327–357.
- Di Gregorio, D. and S. Shane (2003), 'Why Do Some Universities Generate More Start-ups than Others?'. *Research Policy* **32**, 209–227.
- Ensley, M. and K. Hmieleski (2005), 'A comparative study of new venture top management team composition, dynamics, and performance between university-based and independent start-ups'. *Research Policy* **34**(7), 1091–1105.
- Feldman, M., I. Feller, J. Bercovitz, and R. Burton (2002), 'Equity and the Technology Transfer Strategies of American Research Universities'. *Management Science* **48**, 105–121.
- Franklin, S., M. Wright, and A. Lockett (2001), 'Academic and Surrogate Entrepreneurs in University Spin-out Companies'. *Journal of Technology Transfer* **26**(1–2), 127–141.
- Friedman, J. and J. Silberman (2003), 'University Technology Transfer: Do Incentives, Management, and Location Matter?'. *Journal of Technology Transfer* **28**(1), 81–85.

- George, G., S. A. Zahra, and D. R. Wood (2002), 'The Effects of Business-University Alliances on Innovative Output and Financial Performance; A Study of Publicly-Traded Biotechnology Firms'. *Journal of Business Venturing* **17**, 577–609.
- Goldfarb, B. and M. Henrekson (2003), 'Bottom-Up vs. Top-Down Towards the Commercialization of University Intellectual Property'. *Research Policy* **32**(4), 639–658.
- Gong, B. and R. Sickles (1993), 'Finite sample evidence on performance of stochastic frontiers using panel data'. *Journal of Econometrics* **51**, 259–284.
- Grossman, J. H., P. P. Reid, and R. P. Morgan (2001), 'Contributions of Academic Research to Industrial Performance in Five Industry Sectors'. *Journal of Technology Transfer* **26**(1–2), 143.
- Hall, B. H., A. N. Link, and J. T. Scott (2001), 'Barriers Inhibiting Industry from Partnering with Universities: Evidence from the Advanced Technology Program'. *Journal of Technology Transfer* **26**(1–2), 87.
- Harmon, B., A. Ardishvili, R. Cardozo, and T. Elder (1997), 'Mapping the university technology transfer process'. *Journal of Business Venturing* **12**(6), 423–424.
- Jensen, R., J. G. Thursby, and M. C. Thursby (2003), 'The Disclosure and Licensing of University Inventions: The Best We Can Do With the S\*\*t We Get to Work With'. *International Journal of Industrial Organization* **21**(9), 1271–1300.
- Jensen, R. and M. Thursby (2001), 'Proofs and Prototypes for Sale: The Licensing of University Inventions'. *American Economic Review* **91**(1), 240–259.
- Lach, S. and M. Schankerman (2004), 'Royalty Sharing and Technology Licensing in Universities'. *Journal of the European Economic Association* **2**(2–3), 252–264.
- Leitch, C. M. and R. T. Harrison (2005), 'Maximising the potential of university spin-outs: the development of second-order commercialisation activities'. *R&D Management* **35**(3), 257–272.
- Lerner, J. (2005), 'The University and the Start-Up: Lessons from the Past Two Decades'. *Journal of Technology Transfer* **30**(1–2), 49.



- Link, A. N. and K. R. Link (2003), 'On the growth of U.S. science parks'. *Journal of Technology Transfer* **28**, 81–85.
- Link, A. N. and J. T. Scott (2003), 'The growth of Research Triangle Park'. *Small Business Economics* **20**, 167–175.
- Link, A. N. and J. T. Scott (2005), 'Opening the Ivory Tower's Door: An Analysis of the Determinants of the Formation of U.S. University Spin-Off Companies'. *Research Policy* **34**(3), 1106–1112.
- Link, A. N. and J. T. Scott (2006), 'U.S. University Research Parks'. *Journal of Productivity Analysis* **25**(1), 43–55.
- Link, A. N. and D. S. Siegel (2005), 'Generating Science-Based Growth: An Econometric Analysis of the Impact of Organizational Incentives on University-Industry Technology Transfer'. *European Journal of Finance* **11**(3), 169–182.
- Lockett, A., M. Wright, and S. Franklin (2003), 'Technology Transfer and Universities' Spin-out Strategies'. *Small Business Economics* **20**, 185–201.
- Lockett, A. and M. Wright (2005), 'Resources, Capabilities, Risk Capital and the Creation of University Spin-Out Companies,' Technology Transfer and Universities' Spin-out Strategies'. *Research Policy* **34**(7), 1043–1057.
- Louis, K. S., D. Blumenthal, M. E. Gluck, and M. A. Stoto (1989), 'Entrepreneurs in Academe: An Exploration of Behaviors Among Life Scientists'. *Administrative Science Quarterly* **34**, 110–131.
- Louis, K., L. M. Jones, M. S. Anderson, D. Blumenthal, and E. G. Campbell (2001), 'Entrepreneurship, Secrecy, and Productivity: A Comparison of Clinical and Non-Clinical Life Sciences Faculty'. *Journal of Technology Transfer* **26**(3), 233–245.
- Markman, G., P. Gianiodis, and P. Phan (2006), 'An Agency Theoretic Study of the Relationship Between Knowledge Agents and University Technology Transfer Offices'. *Rensselaer Polytechnic Working Paper*, Troy, NY.
- Markman, G., P. Phan, D. Balkin, and P. T. Gianiodis (2005a), 'Entrepreneurship and University-Based Technology Transfer'. *Journal of Business Venturing* **20**(2), 241–263.

66 *References*

- Markman, G., P. Phan, D. Balkin, and P. T. Gianiodis (2005b), 'Innovation Speed: Transferring University Technology to Market'. *Research Policy* **34**(7), 1058–1075.
- Markman, G., P. Phan, D. Balkin, and P. Gianiodis (2004), 'Entrepreneurship From the Ivory Tower: Do Incentive Systems Matter?'. *Journal of Technology Transfer* **29**(3–4), 353–364.
- Marshall, E. (1985), 'Japan and the economics of invention'. *Science* **April 12**, 157–158.
- Medda, G., C. Piga, and D. S. Siegel (2005), 'University R&D and Firm Productivity: Evidence from Italy'. *Journal of Technology Transfer* **30**(1–2), 199–205.
- Medda, G., C. Piga, and D. S. Siegel (2006), 'Assessing the Returns to Collaborative Research: Firm-Level Evidence from Italy'. *Economics of Innovation and New Technology* **15**(1), 37–50.
- Meeusen, W. and J. Van den Broeck (1977), 'Efficiency estimation from Cobb-Douglas production functions with composed errors'. *International Economic Review* **18**, 435–444.
- Merges, R. and R. R. Nelson (1990), 'On the complex economics of patent scope'. *Columbia Law Review* **90**(4), 839–916.
- Mian, S. A. (1994), 'US University-Sponsored Technology Incubators: An Overview of Management, Policies and Performance'. *Technovation* **14**(8), 515–528.
- Mian, S. A. (1996), 'Assessing Value-Added Contributions of University Technology Business Incubators to Tenant Firms'. *Research Policy* **25**(3), 325–335.
- Mian, S. A. (1997), 'Assessing and Managing the University Technology Business Incubator: An Integrative Framework'. *Journal of Business Venturing* **12**(4), 251–285.
- Moray, N. and B. Clarysse (2005), 'Institutional change and resource endowments to science-based entrepreneurial firms'. *Research Policy* **34**(7), 1010–1027.
- Mowery, D. C., R. R. Nelson, B. Sampat, and A. A. Ziedonis (2001), 'The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980'. *Research Policy* **30**, 99–119.

- Mustar, P., M. Renault, M. G. Colombo, E. Piva, M. Fontes, A. Lockett, M. Wright, B. Clarysse, and N. Moray (2006), 'Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy'. *Research Policy* **35**(2), 289–000.
- Nelson, R. R. (2001), 'Observations on the Post Bayh-Dole Rise of Patenting at American Universities'. *Journal of Technology Transfer* **26**(1–2), 13–19.
- Nerkar, A. and S. Shane (2003), 'When Do Startups that Exploit Academic Knowledge Survive?'. *International Journal of Industrial Organization* **21**(9), 1391–1410.
- Niclaou, N. and S. Birley (2003), 'Social Networks in Organizational Emergence: The University Spinout Phenomenon'. *Management Science* **49**(12), 1702–1725.
- O'Shea, R., T. Allen, and A. Chevalier (2005), 'Entrepreneurial Orientation, Technology Transfer, and Spin-off Performance of U.S. Universities'. *Research Policy* **34**(7), 994–1009.
- Owen-Smith, J. and W. W. Powell (2001), 'To Patent or Not: Faculty Decisions and Institutional Success at Technology Transfer'. *Journal of Technology Transfer* **26**(1–2), 99–114.
- Owen-Smith, J. and W. W. Powell (2003), 'The expanding role of university patenting in the life sciences: Assessing the importance of experience and connectivity'. *Research Policy* **32**(9), 1695–1711.
- Parker, D. D. and D. Zilberman (1993), 'University technology transfers: Impacts on local and US economies'. *Contemporary Policy Issues* **11**(2), 87.
- Perez, M. P. and A. M. Sanchez (2003), 'The development of university spin-offs: early dynamics of technology transfer and networking'. *Technovation* **23**(10), 823–831.
- Powell, W. W. and J. Owen-Smith (1998), 'Universities and the market for intellectual property in the life sciences'. *Journal of Policy Analysis and Management* **17**(2), 253–277.
- Powers, J. B. and P. McDougall (2005a), 'University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship'. *Journal of Business Venturing* **20**(3), 291–311.

- Powers, J. B. and P. McDougall (2005b), 'Policy orientation effects on performance with licensing to start-ups and small companies'. *Research Policy* **34**(7), 1028–1042.
- Poyago-Theotoky, J., J. Beath, and D. S. Siegel (2002), 'Universities and Fundamental Research: Reflections on the Growth of University-Industry Partnerships'. *Oxford Review of Economic Policy* **18**(1), 10–21.
- Renault, C. S. (2006), 'Academic Capitalism and University Incentives for Faculty Entrepreneurship'. *Journal of Technology Transfer* **31**(2), 227–239.
- Roberts, E. and D. E. Malone (1996), 'Policies and Structures for Spinning Off New Companies from Research and Development Organizations'. *R&D Management* **26**, 17–48.
- Roberts, E. (1991), *Entrepreneurs in High Technology, Lessons from MIT and Beyond*. Oxford University Press.
- Rogers, E. M., Y. Yin, and J. Hoffmann (2000), 'Assessing the Effectiveness of Technology Transfer Offices at U.S. Research Universities'. *The Journal of the Association of University Technology Managers* **12**, 47–80.
- Rothaermel, F. and M. C. Thursby (2005), 'Incubator Firm Failure or Graduation? The Role of University Linkages'. *Research Policy* **34**(3), 1076–1090.
- Scott, S. (2002), 'Selling University Technology: Patterns From MIT'. *Management Science* **48**(1), 122–138.
- Shane, S. and T. Stuart (2002), 'Organizational Endowments and the Performance of University Start-ups'. *Management Science* **48**(1), 154–171.
- Sharmistha, B.-S., L. Hall, and L. Petryshyn (2001), 'A study of university-industry linkages in the biotechnology industry: Perspectives from Canada'. *International Journal of Biotechnology* **3**(3–4), 390–410.
- Siegel, D. S., D. A. Waldman, L. Atwater, and A. N. Link (2003a), 'Commercial Knowledge Transfers from Universities to Firms: Improving the Effectiveness of University-Industry Collaboration'. *Journal of High Technology Management Research* **14**, 111–133.

- Siegel, D. S., D. A. Waldman, L. Atwater, and A. N. Link (2004), 'Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies'. *Journal of Engineering and Technology Management* **21**(1–2), 115–142.
- Siegel, D. S., D. A. Waldman, and A. N. Link (2003b), 'Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study'. *Research Policy* **32**(1), 27–48.
- Siegel, D. S., P. Westhead, and M. Wright (2003c), 'Assessing the Impact of Science Parks on the Research Productivity of Firms: Exploratory Evidence from the United Kingdom'. *International Journal of Industrial Organization* **21**(9), 1357–1369.
- Small Business Administration (2002), 'The influence of R&D expenditures on new firm formation and economic growth'. Maplewood, New Jersey: BJK Associates.
- Smilor, R. and J. Matthews (2004), 'University venturing: Technology transfer and commercialisation in higher education'. *International Journal of Technology Transfer and Commercialisation* **3**(1), 111–128.
- Thursby, J. G., R. Jensen, and M. C. Thursby (2001), 'Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities'. *Journal of Technology Transfer* **26**, 59–72.
- Thursby, J. G. and S. Kemp (2002), 'Growth and productive efficiency of university intellectual property licensing'. *Research Policy* **31**, 109–124.
- Thursby, J. G. and M. C. Thursby (2002), 'Who is Selling the Ivory Tower? Sources of Growth in University Licensing'. *Management Science* **48**, 90–104.
- Thursby, J. G. and M. C. Thursby (2004), 'Are Faculty Critical? Their Role in University Licensing'. *Contemporary Economic Policy* **22**(2), 162–178.
- Thursby, J. G. and M. C. Thursby (2005), 'Gender Patterns of Research and Licensing Activity of Science and Engineering Faculty'. *Journal of Technology Transfer* **30**(4), 345–353.

70 *References*

- Tushman, M. and P. Anderson (1986), 'Technological discontinuities and organizational environments'. *Administrative Science Quarterly* **31**, 439–465.
- Van Dierdonck, R., K. Debackere, and M. A. Rappa (1991), 'An Assessment of Science Parks: Towards a Better Understanding of Their Role in the Diffusion of Technological Knowledge'. *R and D Management* **21**(2), 109.
- Vedovello, C. (1997), 'Science parks and university-Industry interaction: Geographical proximity between the agents as a driving force'. *Technovation* **17**(9), 491–502.
- Vohora, A., M. Wright, and A. Lockett (2004), 'Critical junctures in the development of university high-tech spinouts companies'. *Research Policy* **33**(1), 147–175.
- 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., 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 D. J. Storey (1994), *An Assessment of Firms Located On and Off Science Parks in the United Kingdom*. London: HMSO.
- Wright, M., S. Birley, and S. Mosey (2004a), 'Entrepreneurship and University Technology Transfer'. *Journal of Technology Transfer* **29**(3–4), 235–246.
- Wright, M., A. Lockett, B. Clarysse, and M. Binks (2006), 'University spin-out companies and venture capital'. *Research Policy* (in press).
- Wright, M., A. Lockett, N. Tiratsoo, C. Alferoff, and S. Mosey (2004b), 'Academic Entrepreneurship, Knowledge Gaps and the Role of Business Schools'. *mimeo*, University of Nottingham.
- Zucker, L. G., M. R. Darby, and J. Armstrong (1998a), 'Geographically Localized Knowledge: Spillovers or Markets?'. *Economic Inquiry* **36**(1), 65–86.

- Zucker, L. G., M. R. Darby, and J. Armstrong (2000), 'University Science, Venture Capital, and the Performance of U.S. Biotechnology Firms'. mimeo, UCLA.
- Zucker, L. G., M. R. Darby, and M. B. Brewer (1998b), 'Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises'. *American Economic Review* **88**(1), 290–306.
- Zucker, L. G. and M. R. Darby (2001), 'Capturing Technological Opportunity Via Japan's Star Scientists: Evidence from Japanese Firms' Biotech Patents and Products'. *Journal of Technology Transfer* **26**(1-2), 37–58.

