When Does University Research Get Commercialized?  
Creating Ambidexterity in Research Institutions

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ABSTRACT We examine the tensions that make it difficult for a research-oriented university to achieve commercial outcomes. Building on the organizational ambidexterity literature, we specify the nature of the tensions (between academic and commercially-oriented activities) at both organizational and individual levels of analysis, and how these can be resolved. We develop hypotheses linking specific aspects of the organization and the individual researcher to the likelihood of their research projects generating commercial outcomes, and we test them using a novel dataset of 207 Research Council-funded projects, combining objective data on project outcomes with the perceptions of principal investigators. We show that the tension between academic and commercial demands is more salient at the level of the individual researcher than at the level of the organization. Universities show evidence that they are able to manage the tensions between academic and commercial demands, through for example their creation of ‘dual structures’. At the individual level, on the other hand, the tensions are more acute, so that the people who deliver commercial outcomes tend to be rather different to those who are accustomed to producing academic outcomes.

INTRODUCTION

The last ten years has seen an increasing emphasis on the generation of commercial outcomes from university-based research. At the policy level, the commercialization of university research has been viewed as a key driver of national competitiveness, and been consequently supported by a range of initiatives seeking to promote the links between universities and industry (Henderson et al., 1998; Mowery et al., 2002). Many universities have taken great strides in pushing commercial agendas to generate more financial value from their research, by creating new structures and encouraging entrepreneurial activities (Hackett, 2001a; Phan and Siegel, 2006). Some scholars have suggested that...
these changes are bringing about an ‘academic revolution’ towards more entrepreneurial universities, in which commercial outputs become the norm rather than an optional side activity (Etzkowitz et al., 2000; Owen-Smith, 2003).

However, such a transition is likely to be both painful and difficult to achieve, and at the moment the evidence of universities developing commercial capabilities is mixed (Gittelman and Kogut, 2003; Krimsky et al., 1991; Markman et al., 2008; Owen-Smith, 2003; Slaughter and Leslie, 1997; Stern, 2004). At its heart, the challenge essentially involves taking an organization that is equipped for and accustomed to doing one thing (academic research) and at the same time asking it to build a capacity for doing something entirely different (commercialization of technologies and ideas). The extraordinary challenge here is that universities and their faculty are not simply required to switch from one (single-handed) activity to another, but to develop the simultaneous capacity for two activities (academic rigor and commercialization). Thus, tensions arise at the level of the organization as a whole as it strives to manage these two sets of activities at the same time, and also at the level of the individual who has to work out how to balance his or her time between competing demands. As we know from the significant literature on ambidexterity in the wider domain of organization theory, this dual focus is very hard to manage (Duncan, 1976; Gibson and Birkinshaw, 2004; Tushman and O’Reilly, 1997). Much of the research as well as the rhetoric around the ‘entrepreneurial university’ (Etzkowitz, 2003) anticipates research institutions learning to manage these conflicting demands, but reality shows mixed results in terms of adequate university structures and policies as well as career tracks and trainings for individuals. While a considerable stream of research has dealt with the specific results of such a dual focus, such as technology transfer mechanisms and commercialization practices and the subsequent success and failure of commercial projects (Argyres and Liebeskind, 1998; Feldman et al., 2002; Markman et al., 2005a; Phan and Siegel, 2006; Powers and McDougall, 2005a), few researchers have addressed the very roots of this new paradigm, i.e. the ability to combine conflicting demands.

The purpose of this paper is to examine the organizational and individual responses to the dual challenges of academic research and commercialization. We do this through the novel approach of studying how these individual and organizational factors influenced the outcomes of specific research projects, and in particular whether these projects resulted in commercial outputs. Our operational research question is: Why do some research projects generate commercial outputs while others do not? Building on the literature on ambidextrous organizations (Duncan, 1976; Gibson and Birkinshaw, 2004; Tushman and O’Reilly, 1997), we develop several hypotheses linking aspects of the research organization and the individual researcher to the likelihood of their research projects generating commercial outcomes. We test our hypotheses using a unique dataset that combines detailed objective data on university–industry research projects that have received research council funding, combined with the subjective perceptions of the principal investigators leading the projects collected through a separate questionnaire. This paper focuses on research projects within the fields of physical and engineering sciences, which are particularly suitable for the investigation of ambidexterity, since academic researchers involved in this type of research are often required to integrate multiple bodies of knowledge, and to command a good understanding of both fundamental research and
the context of application (Kenney and Goe, 2004; Stokes, 1997; West, 2008; Zucker et al., 2002).

Our research focuses on the first decision point of the process, i.e. the question ‘to-commercialize-or-not-to-commercialize?’ By focusing on this decision, and by comparing projects that generate commercial outcomes (patents, licenses or spin-outs) with those that do not, we are able to provide some important new insights into the early part of the process of commercializing university research.[1] There are, of course, many subsequent steps to the process that are also important, but to a large degree they depend on this critical first decision. To our knowledge, this is the first study to look explicitly at this first-step decision point. To anticipate the findings from our study, we show that the tension between academic and commercial demands is more salient at the level of the individual researcher than at the level of the organization. Universities show evidence of being able to manage the tensions between academic and commercial demands through the creation of dual structures. At the individual level, on the other hand, the tensions are more acute, and people who are accustomed to a traditional academic career are typically less able to deliver commercial outcomes. There are, however, certain exceptions to this general statement. We end by discussing the implications of these findings for research and for policy.

THEORETICAL BACKGROUND

Changes in the Institutional Environment

In recent years, there has been increasing public interest in promoting the commercialization of university-driven research. This has occurred at both the national policy level across countries, and also among the various institutional players associated with research and innovation (Goldfarb and Henrekson, 2003; Gulbrandsen and Smeby, 2005). The trend has been driven by a recognition that research conducted in collaboration with industry can be a potent source of innovation (Chiesa and Piccaluga, 2000; Cohen et al., 2002; Lam, 2005; Mansfield, 1991, 1998), and by changes in governmental policies and legislation such as the 1980 Bayh-Dole Act in the United States (Henderson et al., 1998; Mowery et al., 2002). Consequently, there is a growing amount of governmental and institutional funding available for public-private R&D projects, and an increasing number of universities are founding structures focused on the commercialization of scientific discoveries (Phan and Siegel, 2006). Extant research has recognized this ongoing institutional change and has examined, for example, the trends and drivers of university-born patents and licenses (Chapple et al., 2005; Henderson et al., 1998; Mowery et al., 2002; Siegel et al., 2003; Sine et al., 2003; Thursby and Thursby, 2002), the creation of spin-out companies (Clarysse et al., 2005; Di Gregorio and Shane, 2003) and other means of technology transfer by universities (Argyres and Liebeskind, 1998; Feldman et al., 2002; Markman et al., 2005a; Powers and McDougall, 2005a).

The institutional changes have created tensions between facilitating the diffusion of new knowledge as a public good and controlling its private ownership and value (Argyres and Liebeskind, 1998; Etzkowitz et al., 2000). Indeed, as Etzkowitz (1998, p. 824) argues, ‘[t]he incorporation of “extension of knowledge” into a compatible relationship with
“capitalization of knowledge” is a profound normative change in science’. Taken together, the developments have led to several pressure points between academia and the commercial sector (Lockett et al., 2003), at both the organizational and individual level.

### Tensions Between Academic and Commercial Demands

It is widely recognized that commercializing academic research is difficult, and the heart of the problem is the inherent tension between academic and commercial demands (Hackett, 2001b; West, 2008). This tension takes several forms. First, universities and industry are likely to prioritize different research goals. Industry usually focuses on less risky research with direct commercial applicability, while government-funded academic research institutions typically undertake projects with longer time horizons and less predictability (Di Gregorio and Shane, 2003). Second, academia traditionally encourages knowledge dissemination and full disclosure of methods and results, whereas the commercial sector actively seeks ownership and tight control of intellectual property (Arrow, 1962; Kremer, 1998; Nelson, 1959). This may be slowly changing through the emergence of open innovation platforms (Chesbrough, 2003), but many of the underlying tensions remain as West’s (2008) study on the commercialization of the Shannon Theory demonstrates. Third, and related to the second point, the academic research community is incentivized to publish its breakthrough ideas as quickly and widely as possible, while commercial interests often seek to delay the publication process and keep some findings hidden (Blumenthal et al., 1996; Dasgupta and David, 1994; Stern, 2004). These contradictory demands create tensions at the organizational level as they make it difficult for universities to set clear priorities in terms of structures, resources and incentives guiding behaviour in one or the other direction.

The tensions are no less profound for individual researchers, and we know from previous research that academic scientists vary significantly in their entrepreneurial involvement (D’Este and Patel, 2007; Louis et al., 1989). First, there is a strong intrinsic sense amongst scholars that academic and commercial activities represent fundamentally different and potentially contradictory endeavours (Bercovitz and Feldman, 2003; Owen-Smith, 2003). As Dasgupta and David (1994) recognized, communities of scientific peers shape the definition of what constitutes a valuable avenue for research, and this makes it risky for a scholar to deviate from the social norm of conducting academically rigorous research in order to seek commercial accomplishments (Bercovitz and Feldman, 2003). Second, commercial activities do not often carry weight in tenure and promotion decisions (Markman et al., 2005b; Owen-Smith and Powell, 2001a). A successful academic career requires significant investment in a specific style of research, paper-writing and network-building, which essentially means little time for pursuing other – commercial – activities (Stephan and Levin, 1992). Third, many scientists lack the competence to undertake commercial activities as they require different skills and abilities than purely academic ones (Clarysse and Moray, 2004; Daniels and Hofer, 1993; Lockett et al., 2003; Shane, 2002). In addition, there may be some reluctance on the part of senior faculty to alter a system that has provided the basis for their own success and recognition (Markides, 2007).
The formidable challenge in addressing these tensions, at the organizational or the individual level, lies in the path-dependence of academic and commercial activities. Organizations are products of their administrative heritage (Bartlett and Ghoshal, 1989), and core competences can easily evolve into ‘core rigidities’ (Leonard-Barton, 1992). Similarly, individuals are bound by their experiences and socialized into specific work environments (Adkins, 1995; Floyd and Wooldridge, 1999). This path-dependency tends to reinforce existing patterns of behaviour and makes universities, and the individuals that work in them, resistant to change.

Reconciling the Tensions

How do these tensions get reconciled in practice? Universities have relatively short and limited experience in managing the tensions between academic and commercial demands. Organizational responses include the establishment of dedicated technology transfer offices (TTOs) with varied resources, capabilities and experience (Kaghan, 2001; Lockett and Wright, 2005; Phan and Siegel, 2006; Powers and McDougall, 2005a; Siegel et al., 2003), as well as the incorporation of supportive policies, activities and incentives designed to legitimize commercial activities (Kaghan, 2001; Lockett and Wright, 2005; Powers and McDougall, 2005b). These current attempts to reconcile newer commercial demands with traditional academic ones fit well with the concept of ambidexterity, as it provides some theoretical guidance on how organizations create structures and systems for managing conflicting demands in their task environments (e.g. Brown and Eisenhardt, 1997; Duncan, 1976; He and Wong, 2004; Tushman and O’Reilly, 1997). In essence, this literature argues for the creation of ‘dual structures’ that allow the different and conflicting demands to be managed at the same time: for example, new business development is often placed in an autonomous unit (Drucker, 1985; Galbraith, 1982) away from the existing lines of business. Although these separate units typically have lateral processes linking them together, the principle of dual structures allows individuals in each unit to work single-mindedly on one set of demands while the challenge of reconciling the conflicting demands is left to a small group of senior executives. In the context of academic institutions, such dual structures could include the creation of a TTO, or the assignment of faculty to different groups or tasks (e.g. clinical, teaching, and entrepreneurial faculty).

While it is widely accepted that dual structures are an important element in the creation of ambidextrous organizations, research has also examined whether it is possible for conflicting demands to be resolved at the level of the individual employee. For example, Adler et al. (1999) identified four approaches individual workers used in a car factory to balance the demands for flexibility and efficiency (switching between different tasks in the course of a day’s work, partitioning of activities so they are done in parallel with different teams, meta-routines for systematizing the creative process, and job enrichment schemes to make workers more innovative in their everyday tasks); and Gibson and Birkinshaw (2004) focused on how organizations can create a supportive context in which individuals wear ‘two hats’ and make their own informed judgments about how they should allocate their time to meet the conflicting demands for alignment and adaptability. These two studies suggest it may be possible for organizations to reconcile conflicting demands at the
individual level. In the university context, for example, this approach would suggest that
individual faculty can switch between academic and commercial endeavours as long as a
supportive context is in place, i.e. when undertaking commercial activities alongside
academic ones is valued, and doing so does not constrain their academic careers. While
not impossible, Adler et al. (1999) and Gibson and Birkinshaw (2004) both acknowledge
that this may be very difficult to achieve on a consistent basis.

In sum, the ambidexterity literature offers some useful insights into the structures
and systems organizations put in place to manage conflicting demands, and it provides
a useful perspective on how universities might best cope with the increased demand for
commercial outputs alongside their traditional academic outputs. Specifically, our expec-
tation is that the tension between academic and commercial outputs is resolved more effectively at the level
of the university (or the research department) than at the level of the individual. As already established
in many universities, it is possible to put in place dual structures that focus resources and
efforts around two distinct sets of outputs, but many individuals may lack the motivation
and/or the competence to deliver against the two sets of outputs simultaneously.[2] This
high-level proposition will now be decomposed into a series of operational hypotheses.

HYPOTHESES

As suggested by Phan and Siegel (2006), three levels have to be considered in the decision
to commercialize academic research: the institutional, the organizational and the indi-
vidual. We briefly outlined the important changes in the institutional environment in
the previous section, and we now turn to the main focus of the paper, which is the con-
sideration of organizational and individual level determinants of why some research
projects generate commercial outputs while others do not. Our understanding of these
factors will then allow us to draw some inferences about the extent of (organizational and
individual) ambidexterity in academia.

Organization-Level Determinants of Commercial Outputs

There are important differences between universities on many dimensions. Here we
focus on two such dimensions, and the extent to which they are indicative of ambidex-
tery: the provision of administrative mechanisms that support and assist the commer-
cialization of research projects, and the scientific excellence of the department in which
a particular research project takes place.

Administrative Mechanisms

Although universities follow relatively homogeneous patterns in their organizing prin-
ciples, the recent interest in commercialization has prompted some of them to establish
new structures (Di Gregorio and Shane, 2003; Lockett et al., 2003; Markman et al.,
2005a, 2005b). As described above, the dominant approach to organizational ambidex-
tery is the provision of administrative mechanisms that allow the organization to attend
to dual demands. In the context of a research university, the most well-established ‘dual
structure’ is the Technology Transfer Office (TTO).
Establishment of a TTO. Technology Transfer Offices act as brokers between academia and industry by providing expertise and managing commercialization processes related to technology transfer, patenting, licensing and the creation of start-up companies (Kaghan, 2001; Phan and Siegel, 2006; Powers and McDougall, 2005a). They also typically function as boundary spanners and translators, by bridging cultural and value-related barriers between universities and firms (Kaghan, 2001; Siegel et al., 2003). For these reasons, it can be expected that the existence of a TTO as a dual structure should increase the likelihood of commercial outputs from academic research projects.

Hypothesis 1a: Research projects that take place in universities with a specialized technology transfer office (TTO), have a higher likelihood of a commercial output from the project.

Breadth of TTO support. Previous research has shown that TTOs vary considerably in terms of their focus, resources and capabilities, and that these differences have an impact on the effectiveness of technology transfer (Phan and Siegel, 2006). For example, Lockett and Wright (2005) found that the business development capabilities and expenditure of a TTO have a significant positive relationship on a university’s rate of start-up firm formation, and Powers and McDougall (2005a) showed that start-up formation is positively associated with the university’s organizational resources and financial capital. We therefore suggest that in addition to the existence – or not – of the TTO, the breadth of its support for commercial endeavours should influence the likelihood of commercial outputs.

Hypothesis 1b: The greater the breadth of TTO support in the university where the research project takes place, the higher the likelihood of commercial output from the project.

TTO experience. In addition to their different activities and resources, TTOs also differ in terms of their experience. TTO managers tend to develop routines that help them deal with the heterogeneity and volume of university inventions and different transfer processes, which influence their ability to bridge the gap between academia and commerce (Kaghan, 2001). Indeed, a university’s previous success in technology transfer has been found to be a key determinant of successful start-up formation (O’Shea et al., 2005), and the age of the TTO has been shown to influence both licensing and start-up formation positively (Carlsson and Fridh, 2005). Universities that have invested in TTOs earlier exhibit a longer track-record towards commercial objectives and may be more advanced in the creation of ambidextrous structures. Therefore, we hypothesize that the experience (proxied by age) of the TTO is a significant determinant of commercial outputs from research projects:

Hypothesis 1c: The higher the experience of the TTO in the university where the research project takes place, the higher the likelihood of a commercial output from the project.
Scientific Excellence

The relationship between scientific excellence and commercial output in a university is not self-apparent. Although some researchers have argued that organizations geared towards high-profile academic research may not be able to specialize in commercial activities at the same time (e.g. Slaughter and Leslie, 1997), the majority of existing research has shown a positive relationship between the academic quality of the organization and the likelihood of its involvement with commercial activities (Di Gregorio and Shane, 2003; Gittelman and Kogut, 2003; Owen-Smith, 2003; Owen-Smith and Powell, 2001b; Tornquist and Kallsen, 1994). Our perspective here is that a high level of scientific excellence is the *sine qua non* of commercialization, in that it provides the raw material out of which commercial outputs emerge. Moreover, we see scientific excellence as a non-rivalrous resource at the organizational level, which means that it can be used by universities and departments to legitimize their commercial intentions without damaging their academic credentials. Thus:

**Hypothesis 2**: The higher the scientific excellence of the academic department where the research project takes place, the higher the likelihood of a commercial output from the project.

In sum, research institutions typically respond to the challenge of achieving two disparate goals – academic and commercial outcomes – simultaneously by creating dual structures. A typical way of addressing the ambidexterity problem is to focus on scientific excellence within the traditional academic part of the organization, and on commercial aims through a separate entity such a TTO. These inherent tensions between academia and industry may, however, be much harder to resolve at the individual level, which will be discussed next.

Individual-Level Determinants of Commercial Outputs

Individual Experience

‘Embeddedness’ in academia. A particular characteristic of an academic career is the path dependency it induces through long research pipelines, publication review cycles, and relatively hierarchical social structures. Studies have shown that researchers accumulate human and social capital over time which affects the formation of scientific careers (Bozeman and Corley, 2004), and have suggested an interesting split between younger, more entrepreneurial ‘new-school’ faculty and older, more traditional ‘old-school’ faculty (Owen-Smith and Powell, 2001a).[3] It has been found that researchers who have come through traditional academically-focused career tracks may lack the skills and abilities that are needed for pursuing commercial outputs (cf. Lockett et al., 2003; Shane, 2002). Older, more senior faculty may also fear to alter the current system, which provides the basis for their success (Markides, 2007). Clarysse and Moray (2004) found that entrepreneurs who come out of a pure academic environment only gradually learn to adapt to the needs of business. Other studies have shown that academic inventors often bring a strong knowledge of technology but also focus too much on technical issues.

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to the detriment of business considerations (Daniels and Hofer, 1993; Lockett et al., 2003). In sum, academic faculty are products of their past in the sense that they cultivate certain skills and values and abandon others as they climb career ladders in a particular environment (Adkins, 1995; Floyd and Wooldridge, 1999).

Consequently, we argue that the greater the researchers’ depth of experience in academic research and the more their competencies, relationships, and ways of thinking are geared to the demands of that career track, the lower the likelihood that they will be able to develop the competencies to produce commercial outputs. This embeddedness is reflected in both the academic position of the principal investigator, as well as the length of time they have spent with pursuing academic interests. For example, a professor is likely to have not only greater experience in academia than a more junior academic, but in addition to that we can expect him/her to have a particular area of expertise, and a reputation associated with that expertise, locking him or her more deeply into a chosen career path than someone who is still finding their way in academia. In addition to a lesser degree of socialization in academia, many of the younger researchers have already been trained with the emerging paradigm of dual demands and are more open towards these developments – or even dependent on raising money from industry to fund their research. Also, more commercially orientated scientists may move on from academia to pursue their careers in more industrial activities (Dietz and Bozeman, 2005; Lam, 2005), which means that the more academically oriented researchers are likely to be in a majority amongst experienced faculty. We thus expect that the relatively more junior academics will be more likely to deliver commercial outputs than more senior ones.

**Hypothesis 3a**: Compared to projects led by professors, projects led by lower-ranking academics will have a higher likelihood of a commercial output.

**Hypothesis 3b**: The less time the principal investigator has spent in academia, the higher the likelihood of a commercial output from the project.

**Industry interaction.** As much as previous academic experience shapes the individual’s competences and experiences, so does previous interaction with industry. As a mirror image of the above, experience with industry engagement can also account for a certain path-dependency in academic careers. Researchers with experience in industry interactions may be in a better position to produce commercial outputs (Gulbrandsen and Smeby, 2005). Therefore, we suggest a positive relationship between previous industry experience and commercial outcomes, as follows:

**Hypothesis 4**: The greater the experience of the principal investigator with industry interaction, the higher the likelihood of a commercial output from the project.

**Individual Scientific Excellence**

We argued above that excellence in scientific inquiry is seen as a foundation for commercialization, and that at the level of the department or university an excellent academic reputation is a non-rivalrous resource that can be used for academic and
commercial outcomes. However, it is not entirely clear that the same arguments can be used at the level of the individual researcher. Considering scientific excellence first, it is straightforward to argue that the excellence of the individual researcher is likely to have a strong positive influence on the quality of the outputs from a research project, which in turn makes it more likely that the outputs have commercial potential. For example, Di Gregorio and Shane (2003) argued that higher quality researchers are more likely to commercialize in order to exploit their inventions than less accomplished ones, and Zucker et al. (2002) suggest that university-firm technology transfer concerning breakthrough biotechnology innovation typically involves ‘star scientists’ (see also Zucker and Darby, 2001; Zucker et al., 2001). Also the paper by West (2008) featured in this issue concludes that star scientists are best suited to commercialize their own knowledge.

But there are also opposing pressures facing an individual researcher that prevent their academic reputation (at an individual level) from being a non-rivalrous resource. As the discussion motivating Hypotheses 3a and 3b suggested, a strong academic reputation can only be gained through a commitment to certain norms of behaviour and through the development of certain path-dependent capabilities; these behaviours and capabilities are not easily set aside, even if the potential for commercial gain presents itself. Scientific excellence, in other words, is closely linked to the embeddedness of an individual within his or her profession, and for that reason it would be expected to reduce the likelihood of commercial outputs.

It is difficult to predict how these opposing pressures will be resolved, and we will return to this issue in the discussion, but our expectation at this stage is for the pressure to conform to professional norms (and to build on existing capabilities) to outweigh the value of profiting from the commercial potential of high-quality scientific outputs. Thus:

**Hypothesis 5**: The lower the scientific excellence of the principal investigator of the research project, the higher the likelihood of a commercial output from the project.

**Motivation to Pursue Commercial Outputs**

The challenge of pursuing dual demands on the individual level is not only a question of supporting structures. An individual’s ability to ‘wear two hats’ is inevitably linked with his/her desire to do so (Gibson and Birkinshaw, 2004). To develop this perspective into a formal hypothesis, it is important to clarify that our focus is on the tension between academic and commercial outputs, and the possibility for individuals to be ambidextrous. So in other words, we are not so concerned about faculty who choose to leave academia to become full-time entrepreneurs; rather, we are concerned with understanding the deliberations of the academic who is seeking to pursue commercial outputs while also continuing to produce academic outputs. Ambidextrous individuals need to satisfy themselves that two conditions have been met: first, they have to have a genuine or intrinsic interest in pursuing commercial outputs; and second, they have to believe that the pursuit of commercial outputs can be achieved without compromising or risking their academic career. In other words, motivation to pursue commercial outputs, in the context of this study, is not just a function of one individual’s utility function, it is also linked with the individual perception of compatibility with his/her
career. In operational terms, this hypothesis is best expressed as an interaction between two variables as follows:

*Hypothesis 6*: The higher (a) the principal investigator’s belief in the compatibility between industry engagement and an academic career, the stronger the relationship between (b) the principal investigator’s interest in applied research and (c) the likelihood of commercial output from the project.

**DATA AND METHODS**

**Sample and Data Collection**

The data for this project examines 207 academic research projects funded by a major research council in the United Kingdom. It provides a unique data set by combining archival data concerning the inputs and outputs of the research projects with independently gathered survey data from the principal investigators of the projects. Our sampling frame is so-called ‘Responsive Mode’ research grants funded by the Engineering and Physical Sciences Research Council (EPSRC) and completed within the years 2003–05. As there is considerable variety in the composition and characteristics of these projects, great care had to be taken in the research design.

The EPSRC is the UK’s premier funding body in the fields of physical sciences and engineering, and it provided us with access to an archival data set concerning a grant scheme called ‘Responsive Mode’, which supports high-quality academic research in fields with a technological orientation. One of its explicit aims is to encourage collaboration between academia and industry, and to fill the ‘middle-ground’ between basic academic research and industry-funded contract research. Although not all projects in this scheme are fully within this middle-ground (e.g. only 47.8 per cent of the projects had an industrial partner), those which are provide a particularly fruitful context for our study, as they are equipped and encouraged to provide both academic and commercial outcomes. In order to capture the middle ground, we focused on academic projects with university–industry interaction (i.e. projects in which industry contributed by providing funding, personnel, equipment or facilities). This procedure ensured a relatively homogeneous sample, in which researchers would feel some pressure to deliver against a second objective (possible commercial outputs), in addition to the academic outputs that are consistently required across all EPSRC projects.

In order to gather more information about the principal investigators involved in the research projects, we drew on a survey targeted at the recipients of EPSRC grant scheme during 1999–2003. This survey was conducted independently by one of the authors prior to the archival data collection and did not refer to a specific research project, but to the background, perceptions and motivations of the respondents regarding their interactions with industry. The survey was conducted between March and May 2004; a total of 1528 valid questionnaires were returned, representing a response rate of 35.2 per cent.

We then matched this survey data with the archival data obtained from the final grant reports handed in over the period 2003–05 and retrieved from the EPSRC system. As the length of a typical grant is more than three years, several survey respondents had not
finished their respective projects, and had consequently to be excluded from the sample, or it was impossible to match the person with a particular research grant due to name changes or international moves. The 817 matched cases included collaborative as well as non-collaborative grants. From this matched sample, 236 cases were non-useable, as they did not include data on the individual level-variables central to our study because these survey respondents had not had previous industry engagement (through the focal or previous projects) and had therefore not answered all the sections of the questionnaire. In line with our focus on collaborative research projects, we subsequently omitted all non-collaborative projects which did not show any sign of industry commitment to the project (in the form of money, personnel, facilities or equipment). A comparison between the 207 projects that could be matched with comprehensive data, and all collaborative projects in the EPSRC database, showed that there are no significant differences in terms of their size, personnel and duration.

This rigorous step-wise research design resulted in a unique dataset of 207 collaborative university–industry research projects, in which survey data from the principal investigators of EPSRC funded research projects was combined with archival input and output data from the funding body. In addition, we collected secondary data from the UK’s Research Assessment Exercise (RAE) and the Higher Education Funding Council for England (HEFCE) concerning the research institutions of the principal investigators,[7] and ISI Web of Knowledge concerning citation data for individual principal investigators. Table I provides an overview of the sources of the variables used in the analysis.

**Dependent and Independent Variables**

**Commercial Output**

Our dependent variable ‘commercial output’ was coded as a dichotomous variable. All projects which produced a patent, license, spin-out company or a combination thereof, were identified as having ‘commercial output’ (1). All other projects were assigned as ‘no commercial output’ (0).

**Organization-Level Determinants of Commercial Outputs**

**Administrative mechanisms** included three measures. (1) The first was the establishment of a TTO, which was measured with a dummy variable to indicate whether the university in which the project took place had a Technology Transfer Office or not. (2) Second, the breadth of TTO support assessed the range of support activities that universities provide particularly for spin-outs, which are less common than the more standard and widespread licensing and patenting support activities, and therefore capture the variety better (Clarysse et al., 2005). The variable was constructed by averaging responses to the following HEFCE questionnaire item: ‘Does the HEI [Higher Education Institute] offer support for spin-offs through the following mechanisms either provided by HEI or in collaboration with a partner organization: (i) On-campus incubators, (ii) Other incubators in the locality, (iii) Science-park accommodation, (iv) Seed corn investment’.

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(3) Third, the experience of the TTO was measured as the number of years since it was established using HEFCE data.

**Scientific excellence** was measured using the score attributed to the university department in which the research project took place, by the *Research Assessment Exercise* (RAE) in the UK in 2001, which is the latest major investigation of the scientific standing of UK research. According to a comprehensive examination of research quality, all research departments in UK universities were granted a score (1, 2, 3b, 3a, 4, 5 and 5*) resulting in seven different measurable categories.

**Individual-Level Determinants of Commercial Outputs**

Referring to the **individual experience** of the principal investigator, his/her embeddedness in academia was measured in two ways. First, the principal investigator’s formal position is a dummy variable derived from the EPSRC archival data, in which *Full Professor* is coded ‘1’ and *all other faculty* ‘0’. Second, the PhD age of the principal investigator, derived from the survey, was measured as the number of years spent in academia after the completion of the PhD. Third, the level of previous *industry interaction* by the principal investigator was measured as the number of signed agreements or defined contracts to undertake activities such as joint research projects or research commissioned by industry within 2002–03, i.e. two years prior to the survey.
We collected citation data in order to capture the individual’s scientific excellence. Using the *ISI Web of Science*, we measured the total number of citations referring to the principal investigator’s research, published in peer reviewed journals until year 2003 (i.e. the earliest grant finishing period). This measure reflects the academic influence of these publications as proxy for the quality of the principal investigator’s scientific work. The variable in the model we use is the logged number of citations.

In terms of assessing the principal investigator’s motivation to pursue commercial outputs, we used two variables both derived from the survey. Interest in applied research was measured on a three-item scale, in which respondents had to rate the benefits associated with industry interactions, including: ‘Keeping abreast of problems that industry tries to solve’, ‘Becoming part of a professional network’ and ‘Feedback from industry about technological viability of research in university’. These were measured with a five-point scale ranging from ‘not important’ to ‘extremely important’. The validity of the construct was examined using confirmative factor analysis and indicated an acceptable measure of fit for the factor (p = 0.06; CFI = 0.962). Second, to measure the perceived compatibility of industry involvement and an academic career, we used the following scale items: ‘Collaboration with industry is detrimental to career progression’, ‘The nature of my research is not linked with industry interests or needs’ and ‘Interactions with industry conflict with my teaching and research responsibilities’. All three items were measured on a five-point scale from ‘not at all’ to ‘very much’. For the purpose of our analysis, the items were reverse-coded. Confirmatory factor analysis indicated a good measure of fit for the factor (p = 0.46; CFI = 0.986).

**Control Variables**

As prior studies have shown, the range of collaboration patterns with business across different industries may influence commercialization activities (e.g. Chiesa and Piccaluga, 2000; Meyer-Krahmer and Schmoch, 1998; Shane, 2002). We therefore considered the following control variables. First, we controlled for the science field of the project, as engineering disciplines may differ from fundamental science (see also West, 2008). Second, while all of our selected projects had an industrial partner, some also had collaborations with international academic institutions or institutional partners, such as industry associations. It is also conceivable that money provided by the industrial partner may have a different type of effect than more participative forms of collaboration (i.e. the provision of personnel, equipment or facilities). Therefore, a dummy variable, industry money, was included to indicate whether research money had been dedicated to the project by the partner(s). We also controlled for the principal investigator’s previous grants counting the number of previous (although not necessarily collaborative) research grants the individual had gained from the EPSRC. Moreover, it may also be possible that bigger research institutions and bigger projects simply have more resources to focus on both academic and commercial outcomes, so we also controlled for the duration of the project, the academic staff time spent on the project (in months), and the size of the academic department. Finally, we also added the academic output of the research project measured in terms of the number of peer-reviewed academic publications. This measure was included as a control rather
than an independent variable, because academic publications often take many years to come through, and therefore it does not give a reliable picture of the full academic outcomes of the project.

**RESULTS**

We begin by presenting some descriptive statistics from our sample. Seventy-nine of the 207 projects (38.2 per cent) produced a commercial output: 40 projects formed a spin-out company and a patent or license, 33 had only a patent or license, and 6 had only a spin-out company. The majority of grants (73 per cent) had received money from industry and the average grant size, including the contribution from industry, was around £222,000. Referring to the characteristics of the principal investigators, two thirds were professors while one third had a lower academic status. For 38 per cent of the grant recipients in our sample, the surveyed project was the first one funded by EPSRC; the remaining researchers had already conducted previous projects with this funding body. Table II presents the descriptive statistics and bivariate correlations of our independent and control variables.

Given our dichotomous dependent variable, we used binary logistic regression analysis to test our hypotheses. Table III gives an overview of the results. Model 1 presents only the control variables, Model 2 includes all the organizational-level variables (Hypotheses 1–2), and in Model 3 we added the variables pertaining to the principal investigator (Hypotheses 3–5). Model 4 presents the interaction effect (Hypothesis 6). Across the four models, we find a significant improvement of pseudo R2 and model fit.\[^9\]

Only one of our control variables, the time academic staff worked on the project, seemed to be significantly associated with commercial output. We did not find a significant association between the academic and commercial output of the project, but this is likely to be at least partly due to the time lag associated with academic publishing, as discussed earlier. The results pertaining to the six hypotheses were robust across the models. In terms of the characteristics of the research institution, the establishment of a TTO showed a positive and significant coefficient (supporting Hypothesis 1a), but we did not find significant results for the breadth of TTO activities or TTO experience, so Hypotheses 1b and 1c were rejected. This may be to the fact that the existence of a dual support structure in itself is key for the decision to commercialize or not, but the breadth of the support mechanisms and the TTO’s experience in administering them may be more relevant in later stages of the commercialization process. The department’s *scientific excellence* was significantly and positively related to commercial output, supporting Hypothesis 2.

In Model 3, in which variables concerning the individual-level drivers of commercialization were added, we found strong support for our hypothesized negative relationships (Hypotheses 3a, 3b) between the principal investigator’s embeddedness in academia and commercial output. In other words, commercial outputs were more likely in projects run by non-professors with less years experience since their PhD. However, the researcher’s level of interaction with industry was not a significant predictor of commercial output, leading us to reject Hypothesis 4. One explanation here may be that it is perhaps not general experience in dealing with industry that matters so much, but rather specific experience, possibly with fewer but stronger relationships.
Table II. Descriptive statistics and bivariate correlations (all correlations > 0.146 are sig. p < 0.05)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. dev.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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<td>2. Institutional collaboration</td>
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<tr>
<td>3. Industry money</td>
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<td>4. Project duration</td>
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<td>0.164</td>
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<td>5. Academic staff time</td>
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<td>6. Department size</td>
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<td>7. Academic output</td>
<td>2.59</td>
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<td>8. Scientific excellence</td>
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<td>0.028</td>
<td>-0.010</td>
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<td>9. TTO</td>
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<td>10. Breadth of TTO support</td>
<td>1.57</td>
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<td>11. TTO experience</td>
<td>12.83</td>
<td>10.68</td>
<td>-0.071</td>
<td>0.053</td>
<td>0.018</td>
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<td>12. Individual scientific exc.</td>
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<td>-0.032</td>
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<td>13. PI position</td>
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<td>0.123</td>
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<td>14. PhD age</td>
<td>22.93</td>
<td>9.64</td>
<td>-0.154</td>
<td>0.097</td>
<td>0.154</td>
<td>0.210</td>
<td>0.048</td>
<td>-0.068</td>
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<td>0.006</td>
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<td>15. Industry interaction</td>
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<td>8.25</td>
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<td>0.076</td>
<td>0.083</td>
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<td>16. Interest in applied research</td>
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<td>17. Compatibility with acad. career</td>
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<td>-0.028</td>
<td>-0.005</td>
<td>-0.003</td>
<td>-0.133</td>
<td>-0.020</td>
<td>-0.024</td>
<td>-0.094</td>
<td>-0.100</td>
<td>-0.092</td>
<td>-0.025</td>
<td>-0.132</td>
<td>0.024</td>
<td>0.109</td>
<td>0.013</td>
<td>0.149</td>
<td>0.227</td>
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Table III. Logistic regression results

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<tr>
<th>Model</th>
<th>Hypotheses</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
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<tr>
<td></td>
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<td>B</td>
<td>S.E.</td>
<td>B</td>
<td>S.E.</td>
</tr>
<tr>
<td></td>
<td>(Constant)</td>
<td>-0.368</td>
<td>1.136</td>
<td>-2.545</td>
<td>1.755</td>
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<td>Controls</td>
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<tr>
<td>Science fields</td>
<td>n.s</td>
<td>0.113</td>
<td>0.627</td>
<td></td>
<td>n.s</td>
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<td>International collaboration</td>
<td>0.047</td>
<td>0.627</td>
<td>-0.002</td>
<td>0.639</td>
<td>0.001</td>
</tr>
<tr>
<td>Institutional collaboration</td>
<td>0.047</td>
<td>0.627</td>
<td>-0.002</td>
<td>0.639</td>
<td>0.001</td>
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<tr>
<td>Industry money</td>
<td>-0.132</td>
<td>0.367</td>
<td>-0.036</td>
<td>0.374</td>
<td>0.077</td>
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<td>Previous grants</td>
<td>-0.070**</td>
<td>0.030</td>
<td>-0.076**</td>
<td>0.031</td>
<td>-0.089***</td>
</tr>
<tr>
<td>Duration</td>
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<td>0.023</td>
<td>-0.017</td>
<td>0.023</td>
<td>0.001</td>
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<tr>
<td>Academic staff time</td>
<td>0.019**</td>
<td>0.008</td>
<td>0.020***</td>
<td>0.008</td>
<td>0.021**</td>
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<td>Department size</td>
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<td>0.126</td>
<td>-0.045</td>
<td>0.132</td>
<td>-0.101</td>
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<td>Academic output</td>
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<td>0.050</td>
<td>-0.014</td>
<td>0.052</td>
<td>0.003</td>
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<tr>
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<tr>
<td>TTO</td>
<td>H1a+</td>
<td>0.903**</td>
<td>0.470</td>
<td>10.225**</td>
<td>0.512</td>
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<tr>
<td>Breadth of TTO support</td>
<td>H1b+</td>
<td>-0.287</td>
<td>0.470</td>
<td>-0.359</td>
<td>0.294</td>
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<td>Experience of TTO</td>
<td>H1c+</td>
<td>0.021</td>
<td>0.015</td>
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<td>Scientific excellence</td>
<td>H2+</td>
<td>0.370**</td>
<td>0.190</td>
<td>0.512**</td>
<td>0.206</td>
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<td>Individual-level determinants</td>
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<tr>
<td>PI position</td>
<td>H3a-</td>
<td>-10.341***</td>
<td>0.462</td>
<td>-10.334***</td>
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<td>PhD age</td>
<td>H3b-</td>
<td>-0.061***</td>
<td>0.023</td>
<td>-0.062***</td>
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<td>Industry interaction</td>
<td>H4+</td>
<td>0.000</td>
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<td>Individual scientific excellence</td>
<td>H5-</td>
<td>0.165**</td>
<td>0.069</td>
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<tr>
<td>Compatibility with academic career</td>
<td>0.297</td>
<td>0.186</td>
<td>0.390*</td>
<td>0.199</td>
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<td>Compatibility × compatibility</td>
<td>H6+</td>
<td>0.410**</td>
<td>0.167</td>
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<td>Cox &amp; Snell R square</td>
<td>0.106</td>
<td>0.141</td>
<td>0.228</td>
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<tr>
<td>Nagelkerke R square</td>
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<td>0.192</td>
<td>0.309</td>
<td>0.338</td>
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<td>Model chi square</td>
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<td>59.248</td>
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<td>Significance</td>
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<td>0.008</td>
<td>0.000</td>
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<tr>
<td>Classification correct</td>
<td>68.6%</td>
<td>69.1%</td>
<td>72.5%</td>
<td>73.4%</td>
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</tr>
<tr>
<td>N = 207</td>
<td></td>
<td></td>
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</table>

* Regression results controlling for science fields; all coefficients were non-significant.
* p < 0.1; ** p < 0.05; *** p < 0.01.
Hypothesis 5 argued for a negative relationship between the principal investigator’s scientific excellence and commercial outputs from the project, but in fact we found a significant positive relationship. In other words, those faculty with the highest levels of citations to their work were also the most likely to achieve commercial outcomes from their research projects. In one respect this seems unsurprising, because high quality academic outputs provide good ‘raw material’ for commercial outputs, but it goes against the overall logic of the paper, and also against the findings for Hypotheses 3a and 3b. We return to this issue in the discussion.

Finally, in terms of the motivation of the principal investigator, the interaction effect between interest in applied research and perceived compatibility with the researcher’s academic career was significant and positive, thereby supporting Hypothesis 6.

DISCUSSION AND CONCLUSIONS

Let us briefly summarize the findings from this study. Our organizational level findings show that it is possible to achieve ambidexterity at the level of the university through the combination of excellence in scientific research and the provision of a dual structure to facilitate the commercialization of academic inventions. The context of our study, engineering and physical sciences, was purposefully chosen to cover the middle ground between ‘blue-skies’ and ‘applied’ research in order to gain insights into a field where the dual demands of academic and commercial research are more relevant than in other disciplines. While technology commercialization as a derivative of academic research has become an essential characteristic of engineering research and academic institutions that host this research (Etzkowitz et al., 2000; Kenney and Goe, 2004; Phan and Siegel, 2006; Stern, 2004; Stokes, 1997) this trend is less pronounced in other fields, such as management studies. But recently the debate around ‘rigour and relevance’ has also been re-heated in our discipline (e.g. Academy of Management Journal, 2007; Ghoshal, 2005; Rynes et al., 2001; Simon, 1967; Squires, 2001; Whitley, 1984). Given this background, the importance of scientific excellence as a non-rivalrous good, which is highlighted in our results, is even more important and may provide interesting and novel insights for universities as well as policy makers. Our result concerning the importance of a TTO confirms prior research, but the finding that the breadth of support and the experience of the TTO are not significant predictors of commercial outcomes is more surprising. It may be that they are not as important for the initial decision to commercialize as they are for the success of the later stages of the process, but the result also leaves room for speculation whether the existence of a TTO has merely a signalling effect for the university’s commercial intentions or whether it actually provides evidence for a successful commercial track record.\[10\]

While the organizational level results are interesting, our key contribution comes from the counter-intuitive individual level results. Building on the organizational ambidexterity literature, we argued that individuals would struggle to become ambidextrous: that is, they would typically follow either a traditional academic publishing career, or a trajectory that was more open to producing commercial outputs, but not both. However our results suggested a rather more nuanced story. The ‘embeddedness’ of the principal investigator in academia (in terms of his/her seniority and years in the profession) was
significantly and negatively associated with the likelihood of a project generating a commercial output, but the scientific excellence of the principal investigator (in terms of citations to his/her work) was positively and significantly associated with the generation of commercial outputs. Taken together, these findings suggest it is possible for individuals to be ambidextrous (see also the findings presented by West, 2008). That is, the projects with younger, less senior, and higher-cited principal investigators produce the highest proportion of commercial outputs.[11] These are potentially the equivalent of the ‘star scientists’ identified by Zucker and Darby (2001) (see also Zucker et al., 2001, 2002) in the biotechnology field, who by virtue of their all-round excellence are able to rise above the normative boundaries that constrain the behaviour of other faculty. But while such ambidextrous people clearly exist, they also appear to be in the minority: the strong support for Hypotheses 3a and 3b adds support to our broad proposition that most individuals choose one trajectory or the other, but not both. The support for Hypothesis 6 also adds weight to this argument. In addition to the researcher’s track record, his or her motivation to engage in commercialization is vital. Faculty who are both motivated to pursue commercial activity and who believe it will not harm their academic careers is more likely to generate commercial outputs.

These findings offer important implications for both theory and practice. At a theoretical level, we showed that the concept of ambidexterity (as used in organization theory) can enhance our understanding of the pressures behind technology commercialization and provide guidance as universities and their employees seek to develop the capacity to deliver academic and commercial outputs. Also, consistent with the dominant point of view in the ambidexterity literature, we showed that universities reconcile the tensions between conflicting demands through the creation of dual structures at the level of the university or research department. At the individual level we provide evidence that there is a new generation of researchers who are potentially comfortable with the dual demands of academia and industry, which may well be a reflection of the changing institutional environment discussed in the introductory part of the paper. However, we also show that this does not mean all young new-school (Owen-Smith and Powell, 2001a) researchers are capable of producing both high-quality academic research and commercial outputs. It rather implies that the fundamental importance of scientific excellence remains as imperative as ever, and that young star scientists (cf. Zucker et al., 2002) are leading the academic ‘revolution’. For the majority of academics, reconciling the dual tensions remains very difficult, as researchers are bound by existing path-dependent patterns of behaviour making them resistant to change.

In terms of practical implications, the research highlights some of the specific options universities have if they want to increase the volume of commercial outputs from their research projects. Most obviously, they can develop TTOs and other mechanisms for promoting and supporting commercialization. More subtly, they can make it clear that the development of commercial outputs is a legitimate activity, and that it does not compromise a researcher’s ability to further his or her academic career. Our results make it a key priority for universities to seek and promote young ambidextrous high achievers, not only to benefit from their own research but also because their success will encourage others to seek achievement in both domains. We
can also speculate that universities might benefit from providing incentives, support and training for some of their established researchers who are locked into academic research trajectories.

From a policy perspective, the study raises some interesting questions about the types of researchers and institutions that might be targeted by research councils. For example, if a research council is seeking to develop both academic and commercial outputs, seniority and strong prior experience in academia are warning signs. It is often said that you cannot teach an old dog new tricks, and the findings from this research are certainly consistent with this aphorism. A better strategy may be to target young high achievers or – as young stars are not many – target young researchers who exhibit high potential, in order to increase the number of ambidextrous researchers producing both academic and commercial outcomes.

Our study does not come without limitations. We chose our sample of research projects very carefully, focusing on collaborative research projects with certain pressures to deliver against two objectives: academic as well as commercial. But of course this creates non-trivial concerns about the generalizability of the findings. We would expect these findings to apply to other contexts where research projects have the potential for both academic and commercial outputs, but a setting where research projects were focused much more on basic research or on purely commercial outputs would likely exhibit rather different characteristics. With regard to generalizability to other countries, the UK is among the most advanced countries in terms of public policy towards commercialization (OECD, 2002) so we would expect to see similar findings in other commercially-responsive countries where government-funded research councils support university research projects.

Three other limitations are worth noting. First, our broad measure of commercial outputs did not allow us to reveal potential differences between the conditions leading to patenting, licensing and spin-out activities (see also Note 1). While these activities clearly need different forms of management when they are being developed into profitable ventures, it made sense to group them together as early indicators of commercial outputs from academic research projects. Future research might, however, usefully look at the different conditions that give rise to each different activity. Second, we wanted to develop a high-quality measure of academic outputs to parallel our measure of commercial outputs associated with the project, but this was impossible with this particular body of data. We included the academic output from the research project at the end of the funding period in our model, but we would have to wait several years to assess the quality and impact of this research (e.g. through citations). This is certainly a direction where this research can be extended in the future. Third, it was not possible to control for the number of researchers who have left academia after the completion of successful research projects to become entrepreneurs.

In conclusion, the purpose of this paper was to investigate the conditions under which academic research projects generated commercial outcomes. Building on the concept of organizational ambidexterity, we showed that the tensions between academic and commercial research outputs can be managed relatively effectively at the level of the university through the creation of dual structures such as TTOs. At the level of the individual researcher, on the other hand, the tensions are more acute, and academics who deliver
commercial outcomes tend to be rather different to those who are accustomed to a traditional academic career.

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NOTES

[1] We acknowledge that a differentiation between different types of outcomes (i.e. patents, licenses and spin-outs) is important, particularly in the later stages of commercialization. However, our research looks at the first decision point of the process, i.e. the question of whether to commercialize or not, rather than the actual mechanism of commercialization. The choice of mechanism is typically motivated by either the availability of a particular type of support, or political factors (as also pointed out by the Lambert Report on UK Science Commercialization), but is less likely to influence the decision of whether to commercialize in the first place.

[2] It is important to underline that a significant number of individuals do actually pursue academic and commercial activities. However, their efforts in this regard are often facilitated by the institution-level creation of dual structures. For example, at business schools it is common for faculty to ‘sell’ some of their time to an executive development operation or to pursue a contract research project through a Research Centre, both of which are typically formalized activities that the school has decided to make legitimate.

[3] While more hybrid forms of academic careers are starting to emerge (Dietz and Bozeman, 2005; Lam, 2005; Owen-Smith, 2003; Owen-Smith and Powell, 2001a), the typical categories researchers fall into are those of more traditional ‘old school’ and younger, more entrepreneurial ‘new school’.

[4] We wish to thank an anonymous reviewer for pointing this out to us.

[5] It is important to note that the EPSRC does not fund ‘contract research’, where there is a clear commercial outcome envisaged at the start of the project.

[6] It is worth clarifying that this approach does not mean we are sampling on the dependent variable. The existence of interaction with industry (the sampling criterion) is very different from the existence of a commercial output (the dependent variable).

[7] Data for the scores from the UK Research Assessment Exercise were obtained from http://www.hero.ac.uk; while data on higher education institutions were obtained from the Higher Education Business and Community Interaction Survey (HEBCI): http://www.hefce.ac.uk.

[8] The total funding of the research project (in GB pounds) was used as an alternative measure. However, due to a relatively high correlation with the other independent variables capturing the size dimension, it was removed from the final regression analysis. The results remain robust if total funding is added into the equation.

[9] In order to verify the robustness of our results, we conducted a post-hoc analysis excluding those projects which reported only a patent/license but no spinout company as commercial output and found that our hypotheses tests produce robust results. To provide further evidence that our sampling approach does not introduce a bias, we tested our model based on all projects that could be matched between the two datasets (n = 817), regardless of whether they were collaborative or not. Although the test could only be performed on a smaller number of hypotheses as several of the individual level variables were not available in this dataset due to blank sections in the survey, these results provided further support for our key individual-level finding that less experienced researchers have a higher likelihood to produce commercial outputs.

[10] We wish to thank an anonymous reviewer for this suggestion.

[11] We tested for interaction effects between the Scientific Excellence and ‘Embeddedness’ in academia variables, but none were significant.
REFERENCES


