‘Content to be sad’ or ‘runaway apprentice’?
The psychological contract and careers of young scientists in the entrepreneurial university

by

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Abstract

Scientific training and career formation are embedded in an interdependent ‘master-apprentice’ relationship between professors and junior scientists. The rise of academic entrepreneurialism with its emphasis on forging links with private firms and research commercialization is altering the relationship between the two parties and transforming the career experience of young scientists. This study uses the lens of social exchange and psychological contract theory to examine the dynamics of the relationship between the two parties and the career behaviour of young scientists. It distinguishes two categories of industrial engagement, collaborative research and commercial ventures, with the former governed by ‘relational’ and the later, ‘transactional’ exchange. The study compares the career experience of young scientists governed by these two types of relationships. It looks at how their psychological contracts evolve as they make the transition from student-learner to postdoctoral researcher, and how they adapt to career uncertainty in an increasingly precarious academic job market. The study finds that those engaged in collaborative research experienced a relational psychological contract and responded to career uncertainty through extended investment. Commitment to the collaborative relationship and an academic career appears to have locked these young scientists in a reciprocal interdependent relationship with their professors. They are the ‘trapped’ postdocs who cannot escape from perennial temporary employment but are ‘content to be sad’. By contrast, those involved in commercialization experienced a transactional turn in the psychological contract, and responded to unfulfilled expectations through career crafting. They are ‘runaway apprentices’ who assert autonomy by developing their own entrepreneurial careers. We argue that the emerging work relationships in the entrepreneurial university hinder the upward mobility of young scientists, but also offer scope for some to redefine their work and careers at the fuzzy boundary between academia and industry. The study contributes to our understanding of the relationship between the psychological contract and individuals’ career behaviour, and sheds new light on the debate about the changing nature of academic careers in an environment where the previously separate organizational fields of science and business increasingly overlap. The evidence is based on individual interviews with 24 doctoral students/postdocs and 16 professors from three UK research universities.
INTRODUCTION

The arrival of the entrepreneurial university has dramatically reshaped academic scientific work over the past two decades (Clark 1998; Etzkowitz 2003). Central to its mission is the development of an organizational capability to translate research results into economic utility by forging close links with industrial firms, and the dual roles of academics as scientist-entrepreneurs. While much has been written about the role of ‘entrepreneurial’ professors (Murray 2004; Stuart and Ding 2006), less is known about the growing number of doctoral and postdoctoral researchers who perform the bulk of bench research and comprise a central component of professors’ scientific human capital (Bozeman and Corley 2004; Lam 2007). These pre-tenured scientists are some of the most highly trained and flexible human resources who play an increasingly critical role in advancing the agenda of the entrepreneurial university. This paper examines the changing work roles and relationships between professors and young scientists as they straddle the institutional sectors of science and business, and its effects on the training and career development of the latter. It adopts a social exchange perspective to examine the dynamics of the relationship between the two parties and its effect on the psychological contract and career behaviour of young scientists. The study focuses on academics in the natural sciences where entrepreneurialism is most fully developed.

The increased utilisation of young scientists as contract researchers is part of a broader transformation in higher education that promotes tighter connection between science and business. Since the early 1990s, the U.K. government has introduced various policies to promote the transfer of knowledge between university and industry, and many of which encourage the use of doctoral students and postdoctoral researchers to staff joint projects (DTI 2000; Lambert 2003). Their role in university-industry interface has also been heightened by growing emphasis on competitive project-based funding and knowledge capitalization. With reduced government core funding, university scientists increasingly act as ‘research entrepreneurs’ to procure funding from external sources (Kurek et al. 2007). Engagement with industry and commercialization of research increasingly form an integral part of their research strategies (Etzkowitz 2003; Lam 2011). Doctoral students and postdocs, with their short-tenure and complementary research skills, provide a flexible workforce for the laboratories and enhance their professors’ capacity to respond to opportunities for external funding and commercialization (Boardman and Ponomariov 2009). They also help to cement professors’ ties with industry and increase the attractiveness of the research group as a partner for private firms (Slaughter et al. 2002). Research shows that professors who pursue industrial applications are more likely to be mentors to their students (Bozeman and Coley 2004), and that having more students/postdocs is associated with the propensity to engage in industrial activities (Boardman and Ponomariov 2009; Oliver 2004).

Scientific training and career formation are embedded in an interdependent relationship between professors and junior scientists. Professors, as teachers, mentors and collaborators, play a pivotal role in shaping the skills and early careers of junior scientists (Long and McGinnis 1985; Reskin 1979). Industrial engagement may alter the relationships between the two parties and transform young scientists from
‘apprentice learners’ to ‘research workers’ or even ‘business partners’ in commercial ventures. Some authors contend that early career scientists are prone to be exploited as low cost labour in the exchange relationship between university and private business, and could be finding themselves caught between these two powerful institutional settings at the expense of their training and career prospects in an increasingly precarious academic labour market (Harney et al. 2011; Slaughter et al. 2002). This pessimistic view is aligned with the fact that increasingly post-doctoral researchers have become trapped in a sequence of temporary contracts (Laudel and Gläser 2008). Industrial engagement may prolong their dependency and restrict intellectual development which could further diminish their chances of obtaining permanent academic positions (Robin and Cahuzac 2003). Other studies emphasise the dynamic role of early career scientists in facilitating the circulation of knowledge between science and business (Enders and Weert 2004; Mangematin and Robin 2003). Some point out that university-industry collaboration can bring new and varied forms of training to young scientists, and enhance their employability beyond academia (Dany and Mangematin 2004).

However, both arguments have neglected the diverse patterns of industrial engagement and how young scientists may respond differently to the career risks and opportunities entailed. Unlike previous research, this study distinguishes two broad categories of industrial engagement: collaborative research and commercialization. They entail different work relationships between professors as focal links and young scientists as bench researchers. They also provide different learning opportunities for the young scientists involved and incur different levels of scientific and career risks. Collaborative research is an open-science channel of industrial engagement governed by scientific norms of exchange. Involvement of young scientists will not necessarily compromise the mentoring role of professors although prolonged engagement in a support role may hamper their scientific development. Commercial research, by contrast, is governed by the norm of ‘proprietary science’ with the aim of generating specific outputs which can be appropriated for commercial gains. It exposes young researchers to greater scientific career risks, while also creates opportunities for entrepreneurial learning which may have consequential effects on their career orientations (Azoulay et al. 2009).

This study examines the impact of these two types of industrial engagement on the careers of young scientists through the lens of social exchange (Blau 1964; Emerson 1976) and psychological contract theory (Robinson et al. 1994; Rousseau 1995). Social exchange theory posits that norms of exchange influence the relationship between actors. Typically, a distinction is made between relational and transactional exchange. Whilst the former is governed by reciprocity in an open-ended exchange, the latter involves a more specific exchange governed by negotiated rules. Generally, reciprocity gives rise to better work relationships than negotiation because it allows actors to be more trusting of one another and encourages cooperation (Molm et al. 2000). This paper maps these two forms of exchange onto the relationship between young scientists and professors governed by collaborative and commercial links with private firms. Collaborative research is relational-based which can reinforce the mentoring role of professors and generate a cooperative dynamic in their interface with young scientists. Commercialization involves the exploitation of knowledge for financial returns and adds a transactional element to the
relationship. It can undermine trust between the parties involved and create a conflict
dynamic in the relationship.

An exchange relationship is underpinned by a psychological contract which is an implicit
understanding of mutual obligations between two parties in a relationship (Rousseau
1995). Mutual obligations are central to the ‘master-apprentice’ relationship between
professors and young scientists in academic research and training (Campbell 2003;
Wade-Benzoni et al. 2006). In physical and experimental sciences, professors are heavily
dependent on junior scientists to do the laboratory bench work. In return for research
assistance, professors help the intellectual development of young scientists and provide
career support. These mutual obligations form the basis of an implicit psychological
contract central to the cooperative relationship between the two parties. A permanent
academic position has been the career goal of most doctoral and postdoctoral researchers.
Those who progress from doctoral to the postdoctoral phase usually see the position as a
bridge towards a tenured academic post. The academic career promise looms large in the
psychological contract held by postdocs. In the past, the majority could expect to obtain
permanent posts after one or two temporary contracts. However, with the emergence of
‘steady state science’ since the early 1990s (Ziman 1994), a growing number of has been
caught in the squeeze of increased supply amid declining job opportunities. Many are
staying longer in ‘apprentice’ positions with limited prospects for career progression
(Stephan and Ma 2005).1 It has become increasingly difficult for professors to reward the
cooperative efforts of young scientists by offering them long-term academic posts.
Industrial engagement can exacerbate the situation and deepen the crisis in career
expectations. Young scientists with prolonged engagement in industrial projects may find
it difficult to build up a track record of research and publications needed for pursuing an
academic career. These developments are likely to have profound effects on the
psychological contracts of young scientists with many experiencing the frustration of
unfulfilled expectations.

Psychological contract theory argues that reciprocal contributions for mutual benefits are
the core of functional exchange relationships and constructive psychological contracts
(Rousseau 1995). Unmet career expectations can be seen by young scientists as
psychological contract breach (Morrison and Robinson 1997) and alters the dynamics of
the exchange relationships with their professors. Rousseau (2000) points out that
psychological contracts change over time and individuals can potentially alter their
expectations in either direction along the relational-transaction continuum. Moreover,
how individuals respond to unmet career expectations may also be influenced by
characteristics of the exchange relationship (Johnson and O'Leary-Kelly 2003; Sturges et
al. 2005). Drawing on these insights, we expect young scientists engaged in collaborative
research and commercial ventures to respond differently to career uncertainty and unmet
expectations. The study compares the career experience of young scientists engaged in
the two types of activities and highlights the effects of the contrasting exchange
relationships on their psychological contracts and career behaviours. It looks at how

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1 Evidence from the U.K. Labour Force Survey for 2001-2010 shows that about 50 percent of academic
staff on fixed term contracts, most of whom would be researchers, were aged 40 or above and 25 percent
were aged over 50.
young scientists’ work role perceptions and career aspirations evolve over time as the relationships with their professors unfold, and how their adaptive responses influence their subsequent career trajectories. The evidence is based on individual interviews with 40 academic scientists, comprising 24 doctoral students/post-docs and 16 professors, from three UK research universities. The analysis also made extensive use of individual CVs for tracking the career trajectories of the young scientists.

The study finds that young scientists engaged in collaborative research experienced a shift in the psychological contract along the relational continuum and responded to career uncertainty through ‘extended investment’ (van Dam 2005). Commitment to the collaborative relationship and an academic career appears to have locked these young scientists in a reciprocal interdependent relationship with their professors. They are the ‘trapped’ postdocs who cannot escape from perennial temporary employment but are ‘content to be sad’, to use a quote from the interviews. By contrast, those who had extensive involvement in commercialization experienced a transactional turn in the psychological contract, and responded to unfulfilled expectations through job crafting and career self-management (King 2004; Wrzesniewski and Dutton 2001). They used the relationships with their professors to acquire commercial knowledge for developing their own entrepreneurial careers: they are ‘runaway apprentices’ who seek independence from their ‘masters’.

The study highlights the agency role of young scientists in shaping their own careers, and contributes to our understanding of the relationship between the psychological contract and individuals’ career behaviour. It also sheds new light on the debate about the changing nature of academic careers in an environment where the previously separate organizational fields of science and business increasingly overlap. It argues that the emerging work relationships in the entrepreneurial university hinder the upward mobility of young scientists, but also offer scope for some to redefine their work and careers at the fuzzy boundary between academia and industry.

The paper is structured as follows. The next section develops the conceptual framework for explaining the relationships between professors and young scientists governed by collaborative research and commercial engagement, and the psychological contracts of young scientists. Section three describes the research methods and the interview sample. Section four examines the dynamics of the relationships between young scientists and professors engaged in the two types of activities. It looks at how young scientists’ psychological contracts evolve over time and their responses to unmet career expectations. Section five examines the career transition of the young scientists, and the effects of the two types of activities on their subsequent career trajectories. The paper ends by discussing the theoretical significance and wider implications of the study.
YOUNG SCIENTISTS AND PROFESSORS IN INDUSTRIAL ENGAGEMENT: SOCIAL EXCHANGE AND THE PSYCHOLOGICAL CONTRACT

In the traditional model of academic training, research collaboration between professors and junior scientists often constitutes an extension of the mentoring role of professors and forms an integral part of research training and socialisation (Campbell 2003; Reskin 1979). Industrial engagement, notably research commercialization, may alter the nature and boundary of the collaborative relationship, and transforms the learning and career experience of young scientists. The analysis adopts a social exchange perspective (Blau 1964; Emerson 1976) to explain the dynamics of the relationship between the two parties governed by collaborative and commercial links with private firms. It employs the notion of ‘psychological contract’ (Robinson et al. 1994; Rousseau 1995) to examine young scientists’ perceived mutual obligations between themselves and their professors, and how the accumulation of experience through the relationship, in turn, influences their expectations and adaptive responses to the career risks and opportunities entailed.

Modes of industrial engagement and exchange relationships: collaborative vs. commercial

Social exchange refers to actions that are contingent on rewarding reactions from others (Blau 1964). Exchange can be governed by different principles which constitute a ‘normative definition of the situation that forms among or is adopted by the participants in an exchange relationship’ (Emerson 1976: 351). Social exchange theory posits that the norm of exchange governing an interdependent relationship influences the nature of interaction, flow of resources and how actors use power and respond to risk. Typically, a distinction is made between relational and transactional forms of exchange. While relational exchange is governed by reciprocity rules in an open-ended, long-term exchange relationship, transactional exchange involves a short-term, more specific form of exchange governed by negotiated rules. Resources that are highly particularistic and symbolic (e.g. socio-emotional support and status) are more likely to be exchanged in a relational manner whereas universal and tangible resources (e.g. money and labour) are often exchanged in a more explicit fashion through negotiation (Foa and Foa 1980). Reciprocal exchange allows actors to be more trusting of one another and encourages free flows of resources and cooperation (Gouldner 1960; Molm et al. 2000). By contrast, negotiated arrangements tend to be more quid-pro-quo, and are likely to incite unhelpful power use as actors seek to negotiate better terms and reduce risks (Molm et al. 1999).

Exchange is a dyadic relationship but is subject to the influence and control of the collective. Uehara’s (1990) dual exchange theory suggests that the structure of exchange relations affects the degree of solidarity and nature of reciprocity between parties to the exchange. He distinguishes between generalised exchange and restricted exchange, with the former being subject to a higher degree of collective control and the latter being more dyadically-based. According to Uehara, generalised exchange engenders a higher degree of solidarity because actors place trust in the collective to exert control over individual exchange and thus some of the pressure to track transgression is taken off the individual exchangers themselves. In this context, individuals can be more relaxed and leave the
particulars of the return unspecified at the time of the exchange. By contrast, restricted exchange is characterised by a higher degree of accountability in each partner’s behaviour and is more likely to lead to tension and instability. This is because in a restricted exchange relationship, partners are more inclined to maintain equity in exchange rates between them and to settle inequalities within a short period of time. As a result, conflict over fairness of the exchange frequently occurs and actors may become distrustful of each other.

Building on the above insights, we postulate that the norms and structures of exchange governing the relationship between professors and young scientists differ between collaborative research and commercial ventures. Collaborative research is governed by an established academic framework and scientific norms of exchange. Its primary goal is to produce outputs that are of industrial relevance but which can be adapted for publications by the researchers involved. It is a relational-based, generalised exchange relationship which builds on the free flow of knowledge resources between the parties involved. In most cases, private firms engage in collaborative research with academic researchers in order to gain access to evolving new knowledge. Academics are usually given a high degree of autonomy in conducting the research. Involvement of young scientists will not necessarily undermine the teaching/mentoring role of professors especially if the collaboration forms an integral part of their scientific training (Bozeman and Corley 2004). On the contrary, the provision of funding resources and the role of professors in brokering the relationship with industrial sponsors (Salminen-Karlsson and Wallgren 2008) may serve to reinforce the mentoring exchange and generate a cooperative dynamic in the relationship.

Commercial research, by contrast, is governed by the norm of ‘proprietary science’ with the aim of generating specific outputs which can be appropriated for financial gains. Industrial sponsors often exert a direct influence on the research conducted and may restrict the opportunities for open dissemination and production of publications. The exchange relationship is more restricted and it involves the flow of financial resources in addition to knowledge. Commercial engagement adds a transactional element to the master-apprentice relationship between professors and young scientists. It also entails more complex role relationships between them (MacDonald and Williams-Jones 2009). The role of the professor as business person/entrepreneur may not be compatible with that of teacher/mentor. Serious conflicts of interest may occur when students/researchers are employed to work in a spin-off company formed by a professor (Sugarman 2005). In research commercialization, disputes over ownership of intellectual property and distribution of benefits are not uncommon (Mars et al. 2008). Further, unlike collaborative research where the relationship between the two parties is governed by academic norms and subject to peer sanction, the interface between them in commercial ventures occurs at the boundary of science and business, moving away from the safeguards of the established academic framework. The exchange relationship in commercial ventures is more dyadically-based and prone to tension.

Molm et al (1999) argue that power use will be greater when exchange is negotiated than when it is reciprocal. This is because efforts to negotiate better terms and reduce risks
incite the use of power by actors. The mutual dependency between professors and young researchers provides the structural basis for their power over each other where the less dependent partner, the professor, has a structural power advantage (Emerson 1962). This structural potential is more likely to become manifest in commercial than in collaborative research. Commercial engagement, therefore, has greater potential to undermine trust between young scientists and professors, and create a conflict dynamic in the relationship.

**Mutual obligations and the psychological contract: from training to work**

The relationship between young scientists and professors builds on the collaborative projects undertaken, and entails mutual promises and obligations made and accepted by the parties. How each party perceive these obligations and the mutual expectations regarding the terms of the exchange relationship can be conceptualised as the psychological contract (Rousseau 1995). Researchers have emphasised that psychological contracts are held by employees representing their perceptions of mutual obligations between them and their organizations or employers (Morrison and Robinson 1997; Rousseau 1989). In this paper, the concept is employed to examine the perceptions and expectations of young scientists regarding training and career development in their exchange relationships with the professors.

Psychological contracts can take different form. A common approach is to distinguish between psychological contracts that are largely relational in nature and those that are largely transactional (Rousseau 1995, 2000). A ‘relational’ contract entails broad, open-ended obligations which involve the exchange of not only monetizable elements, but also socioemotional elements such as loyalty and support. A transactional contract is composed of specific and monetizable obligations entailing limited involvement of the parties. In between these two polar types, ‘balanced’ and ‘transitional’ psychological contracts are also possible. A balanced psychological contract is characterised by an open-ended relationship with specific obligations that are subject to change over time. A ‘transitional’ psychological contract is characterised by uncertainty and an eroding exchange relationship. Previous research suggests that ‘relational’ and ‘balanced’ psychological contracts offer higher degree of stability (Lester et al. 2007) and are positively correlated with employee satisfaction (Rousseau and Tijoriwala 1998). ‘Transitional’ and ‘transactional’ psychological contracts, on the other hand, are less stable and more prone to tension. The analysis applies this four-fold typology to examine the psychological contracts experienced by young scientists and the shifts in their expectations as they make the transition from student/learner in training to postdoctoral researcher in employment.

Young scientists may be involved in industrial projects as part of their formal scientific training or employed as researchers to work on their professors’ research programmes which may or may not be directly related to their training. The nature of the relationships and psychological contracts governing training and employment are not the same. In a training context, the mutual obligations between professors and young researchers are
loosely specified in an open, mentoring exchange relationship. Professors, in their role as
teachers/mentors, are expected to help the intellectual development of student/learners.
Doctoral students and junior researchers are at the beginning of their research career and
may not have clear career projects in mind. For these young scientists, the experience of a
fulfilling learning process and acquisition of knowledge and skills that are useful to
future careers are central to their psychological contracts (Bordia et al. 2010). They are
critically dependent on their professors for academic guidance, financial support and
collaborative opportunities. While there is considerable scope for professors to exercise
judgement and influence on the training of students/learners, the scope for young
scientists to influence the terms of the exchange relationship is relatively limited.
Moreover, given the imbalance of knowledge and power between the two parties, the
expectations for exchange symmetry may also be low. The psychological contract is a
nascent one, developing but not fully formed. It is likely to be at the ‘relational’ or
‘balanced’ end of the spectrum.

In an employment relationship, the interface between the two parties is governed by
contractual arrangements with greater clarity of mutual obligations centred around
specific research tasks. It builds on a more developed psychological contract with greater
scope for individual negotiation. Professors, as principal investigators and laboratory
managers, are the primary contract makers responsible for overseeing the performance
and career development of postdocs. Postdocs, as contract researchers/employees, are
agents engaged to perform research tasks and other laboratory work in support of their
professors’ research projects. However, the employment relationship between professors
and postdocs differs from the standard employer-employee relationship because postdocs
are apprentice-employees and have greater expectations than other contracts of
employment. The postdoc period is a crucial transitional phase during which young
scientists are expected to gain independence to become fully-fledged academic
researchers. Those who progress from doctoral to postdoctoral phase usually aspire to an
academic career. They are intensely dependent on their professors for research
collaboration, joint publications and career support in return for their cooperative efforts.

The employment relationship between professors and postdocs is inherently complex and
riddled with conflicting responsibilities and obligations. Industrial engagement increases
the degree of mutual obligations between them, and may further strengthen the postdocs’
psychological contract and expectations of career support. Professors with intense
industrial engagement often suffer from a ‘time squeeze’ problem and are heavily
dependent on postdocs to conduct research and provide various support in the
laboratories. They have strong incentives to retain the experienced researchers and may
be tempted maintain the apprentice-employee relationship long after the initial training
period (Freeman et al. 2001). As principal investigators and employers, professors are
accountable to external funders and they may coerce young scientists to work on projects
not directly related to their research interest. Young scientists may also be under pressure
to adapt to the research preferences of professors with the expectation of reciprocation in
career terms. Psychological contract theory suggests that an employee’s behaviour is
influenced not only by actual fulfilment of promises made by the employer but also the
anticipation of fulfilled promises and future benefits (Coyle-Shapiro 2002). Industrial
engagement may result in an increasingly interdependent and mutual high obligation relationship between professors and postdocs. However, it can also make the fulfilment of the perceived career promise more difficult. This is not only because of the shortages of tenured posts in general but also, prolonged engagement in industrial projects may inhibit young scientists’ ability to build up a track record of research needed for pursuing an academic career.

Many of these young scientists are likely to find their career expectations unfulfilled and may experience violation of the psychological contract implicit in their cooperative relationships with the professors. How might this change the dynamics of the relationships and how might young scientists respond?

Changing psychological contract and response to unmet career expectations: reactive/compromise vs. proactive/control response

Psychological contracts develop and evolve over the course of exchange relationships as positive and negative outcomes are realised. Unmet career expectations can change the dynamics of the relationships and affect employees’ attitudes and behaviours. According to Robinson et al (1994), employees’ can potentially alter their expectations in either the relational or transactional direction and may react differently to unmet expectations. A relational pattern of change may lead to an escalation of commitment between parties to the exchange. In relational exchange, the norm of reciprocity is likely to increase the number and diversity of obligations in the exchange relationships. As relationships mature and trust develops, individuals strive to create a positive balance in their relationships to avoid becoming indebted to the other party (Blau 1964). This may lead to increased mutual dependency over time, making it difficult, if not impossible, to break the relationship. Unmet expectations, in this context, can cause tension and disappointment but may not lead to a breakdown of the relationship. Employees may also experience an instrumental shift in their psychological contracts which is likely to occur when they believe that their contributions outweigh those of their employers’ and perceive unfairness in the exchange. Unmet expectations are more likely to be perceived as psychological violation in an instrumental relationship, and may cause conflict and generate more intense reactions than in the case of unfulfilled expectations. More powerful employees may also feel a greater sense of entitlement and may be more likely to perceive psychological contract violation (Morrison and Robinson 1997). Employees are primed to action when they experience psychological contract violation due to feelings of anger and outrage. They may seek remedial action to compensate for losses while remaining within the relationship or exit the relationship as the final resort.

Psychological contract theory has provided rich insights into the effects of unfulfilled expectations and psychological contract breach on the attitudes and behaviours of employees. Much of the existing literature, however, has emphasised their negative responses in terms of reduced organizational commitment, poor job performance and turnover (Coyle-Shapiro and Kessler 2000; Robinson 1996; Turnley and Feldman 1999). The role of employees as active parties to the psychological contracts and how they might influence the exchange relationships and shape their own careers have largely been
overlooked. Seeck and Parzefall (2008) argue that employees are capable of exercising agency in defining their obligations and roles rather than simply reciprocating by reacting to their employers’ exchanged behaviours. The literature on career self-management also stresses the proactivity of employees in managing their careers and the concrete actions which they undertake to realise their career goals (De Vos and Soens 2008; Hall 2002; King 2004). These actions can focus on either improving one’s current position within the organization or furthering career opportunities elsewhere.

In this study, we argue that young scientists are active parties to the psychological contract and may adopt different strategies for coping with unmet expectations. Two contrasting responses can be identified in the literature: a reactive/compromise response through extended investment in current jobs and relationships (van Dam 2005), and a proactive/control response through job and career crafting (King 2004; Wrzesniewski and Dutton 2001). The former is internally-oriented aiming at attaining career goals within the organization; whereas the latter is externally-oriented for furthering careers elsewhere. Existing research suggests that the characteristics of an exchange relationship, employees’ degree of attachment to current jobs and perceived alternative career options are factors that may influence their adaptive responses (Johnson and O’Leary-Kelly 2003; Sturges et al. 2005). Individuals who have developed strong commitment to current jobs, and experienced relational psychological contracts are likely to adopt a compromise response (Meyer et al. 2002). A proactive/control response, by contrast, is more likely to occur among those who experience a transactional psychological contract and perceive unmet expectations as contract breach. Previous research suggests that psychological breach reduces individuals’ commitment to the organization (Conway et al. 2011) and is strongly associated with intention to quit and actual turnover (Robinson 1996; Robinson and Rousseau 1994). As a result, individuals are more inclined to engage in externally-oriented career self-management activities with the aim of furthering their careers elsewhere.

We expect young scientists engaged in collaborative research and commercial ventures to respond differently to unfulfilled expectations due to the divergent norms and structures governing the exchange relationships with their professors and, the different learning opportunities and scientific career risks associated with the two types of activities. We postulate that young scientists involved in collaborative research may experience a relational shift in their psychological contracts and adopt a compromise approach in the face of unmet expectations. By contrast, those who have extensive involvement in commercial projects may experience an instrumental turn in their psychological contracts and respond to unfulfilled career promises in a more proactive manner. The empirical investigation will look at the psychological contracts of young scientists engaged in the two types of activities and their career adaptive strategies.
RESEARCH METHODS AND DATA

The empirical evidence is based on individual interviews with 40 academic scientists from three major UK research universities. The disciplines covered include biological sciences, computer science and engineering, and physical sciences where academic entrepreneurialism has been most actively pursued. Data on the career histories of young scientists were also obtained from individual CVs and web searches. The interview sample consists of 24 doctoral students/postdocs and 16 professors of whom 13 were supervisors of these young scientists. Given that the study focuses on exchange relationships, a dyadic perspective analysing the views of both parties is essential (Thompson and Walker 1982). We therefore conducted individual interviews, where possible, with matching pairs of professors-students/researchers. In some cases, we interviewed more than one researcher linked to the same professor. Out of the 24 students/postdocs, it was possible to interview the corresponding professors in 20 cases and in the other 4 cases, the professors were not available for the interview. The professors were identified mainly through searches on the universities’ websites and the researchers were identified either from the interviews with the professors or through searches on the relevant websites. A snowball method was also used to obtain additional names.

The interviews with the students/postdocs focused on their work roles and research activities, extent of involvement in their professors’ research programmes, work relationships in the academic laboratories, interface with industrial partners, learning experience, career expectations/preferences and perceived future prospects. For the professors, we obtained information about their industrial activities and asked detailed questions about funding sponsorships for students/postdocs, the role of these young scientists in their laboratories and industrial links, and evaluation of the influence of industrial engagement on their role as mentors/supervisors. All the professors interviewed had extensive industrial links ranging from traditional modes of collaboration (collaborative research and student sponsorships) to direct involvement in commercialization (patenting and spin-off company formation). Among the 16 professors interviewed, 5 were involved in collaborative links only and 11 were engaged in both collaborative and commercial activities and were company founders. Each interview lasted for about 75-90 minutes and all were recorded and transcribed.

The sample of young scientists consists of those at different stages of their training/research careers and are classified into two broad categories: the doctoral students and junior postdocs in their first or second employment contracts, and senior postdocs who have had more than 10 years of employment as temporary researchers. The sample composition enables us to analyse the experience of the young scientists at different stages of their careers. It introduces a temporal dimension to the data which is needed for understanding the evolving relationships with their professors and how accumulated experience affects their psychological contracts. A longitudinal component of the study is also facilitated by using the retrospective accounts of the individuals’

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2 The sample of professors was drawn from a larger study on the work orientations and careers of university scientists engaged in industrial activities (see, Lam 2011).
career histories based on the interviews and CVs, and subsequent tracking of the young scientists’ career moves based on web searches. The CV provides a rich source of longitudinal data on an academic researcher’s graduate education, timing, sequence and duration of jobs and positions as well as publication productivity and collaborative patterns (Dietz et al. 2000). The interviews were conducted during 2006-07 and we tracked the careers of the young scientists up until early 2012. We were able to track the career moves/destinations of all the young scientists interviewed.

Table 1 shows the number of interviewees by position and modes of industrial engagement. Table 2 outlines the profiles of the 24 students/postdocs and also shows the industrial activities of the corresponding professors.

Tables 1 and 2 about here

YOUNG SCIENTISTS IN COLLABORATIVE RESEARCH AND COMMERCIAL ENGAGEMENT: RELATIONSHIPS WITH PROFESSORS AND THE PSYCHOLOGICAL CONTRACT

The analysis classifies the young scientists into four categories based on the modes of industrial engagement (collaborative vs. commercial) and nature of involvement (training vs. employment).3 The ‘learner apprentices’ are the doctoral students/junior postdocs involved in collaborative research as part of their scientific training. There are eight cases of which six were sponsored by their professors who had funding support from industry and two were funded by industry through a collaborative research centre. The ‘extended apprentices’ are the senior postdocs engaged in collaborative projects well beyond their training period. There are seven cases in this category who had been working as contract researchers for the duration ranging from 10 to 23 years. The ‘exploited apprentices’ are the doctoral students/junior postdocs conducting research in their professors’ commercial laboratories which may or may not be directly related to their scientific training. The term ‘exploited apprentice’ is used to denote the vulnerability of these young researchers to intellectual and labour exploitation. The ‘runaway apprentices’ refers to the senior postdocs who had intense involvement in their professors’ commercial activities and experienced growing tension in the relationship, and who subsequently sought to breakaway from the relationship. There are four cases and at the time of the interview, three were still working with their professors but had no intention of staying, and one had gained independence as a principal investigator.

The analysis shows that those engaged in collaborative research held a ‘relational’ psychological contract while they were ‘learner apprentices’ but this evolved over time

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3 The distinction between training and employment is not always crisp as doctoral students are increasingly paid to work as student-employees and junior postdocs are in transition from training to work. However, these two concepts are used also to denote the career stages of young scientists and the duration of their involvement in their professors’ industrial projects. For analytical purposes, the doctoral students and junior postdocs in their first or second employment contracts are placed in the ‘training’ category whereas the senior postdocs with more than 10 years of work experience as contract researchers are put under the ‘employment’ category.
into a ‘transitional’ one experienced by the ‘extended apprentices’ who faced growing career uncertainty. The ‘exploited apprentices’ involved in commercial ventures displayed a ‘balanced’ psychological contract but the realisation of career blockage eventually caused a ‘transactional’ turn in the psychological contract as they became ‘runaway apprentices’. Figure one shows the positions of the four categories.

The ‘learner apprentice’ in collaborative research

Diffuse exchange and reciprocal dependence

The relationship between the professors and the learner apprentices is close to the traditional ‘master-apprentice’ model of reciprocal exchange where the flow of knowledge and provision of socio-emotional support creates a social bond between them. However, unlike the traditional academic model, the interface between the two parties took place within a more open academic environment with the presence of industrial partners as funders and sources of additional knowledge inputs. The research was conducted in the academic laboratories where the learner apprentices worked alongside other academic peers.

The professors usually acted as buffers between the students/researchers and the firms. They played a key role as ‘strategic brokers’ in liaising the research goals with firms, and dealing with the formal contractual aspects of the collaboration. Most of the professors were experienced in collaborating with industry and sought to balance scientific goals with industrial relevance. One professor, who headed a collaborative research centre, for example, stated that the agreement with the industrial funder rested on ‘what is called two colours. One is freedom of academic research and the other is alignment of our research with Company Y...’ (Professor G). Others pointed out that they would avoid any conflict of interest by maintaining a clear boundary between ‘private’ and ‘public’ work, and ensured that the educational goals were not compromised especially when doctoral students were involved.

The analysis suggests that professors with extensive industrial links and external funding were often regarded as ‘strong mentors’ by their students/researchers. Their laboratories are usually well-funded and they are in a position to provide funding support and collaborative opportunities to the students/researchers. All the learner apprentices reported positive work relationships with their professors and saw their professors’ scientific reputation and wide network of contacts as important assets for their learning and future careers:

‘I am very lucky to be working with Professor L... he is very experienced and he is internationally renowned in this area. And he has a lot of funding which means our labs are quite well-equipped, so we have a lot of learning opportunity’ (case 8).

‘I think Prof X is a very effective academic... He has been extremely good at producing opportunities for me, first of all he has been very good at getting me
the money to do this PhD. And he has got me involved with this project work… who knows he might create more opportunities for me in the future in terms of helping me to secure a permanent position on my PhD’ (case 3; emphasis added).

The majority interviewed reported being given a good degree of freedom in developing their research. They interfaced with industrial partners only when it was necessary and relevant for their research and primarily for expert inputs. Those who were directly sponsored by industry and had industrial supervisors reported the benefits of additional intellectual stimulation. One junior postdoc, for example, believed that his exposure to industrial experts had helped to accelerate the completion of his doctoral thesis because he ‘was exposed to people who were basically all experts in the field’ (case 5).

While the ‘learner apprentices’ are the dependent partners in the exchange relationship, they are not merely passive recipients of their professors’ mentoring support. In return for sponsorships, they provide research assistance in the laboratories and help to cement network ties with firms. One of the professors described the links between his doctoral students and industrial networks as a kind of ‘food chain’ because many of his industrial contacts were his former students. Thus, in the truest sense of an exchange relationship, both the professors and learner apprentices are dependent on each other for valued resources and engaged in enactment of mutually beneficial support behaviour.

Relational psychological contract and career options

Most of the learner apprentices reported positive learning experience and the benefits of acquiring a broader range of competences beyond scientific bench research as a result of the collaborative experience. Doctoral and early postdoctoral education constitutes the primary period during which young scientists are socialized into the norms and identities of being members of the academic community. Industrial engagement exposes them to more diverse and heterogeneous influence beyond the one-to-one role modelling effect of individual professors and the acculturation steered by academic peers. Their career preferences are likely to be less uniform than those who have been deeply immersed in the disciplinary scientific communities. The interviews show that the majority of the learner apprentices displayed flexible attitudes towards future career options and were generally optimistic about employment prospects. Some believed that the collaborative experience could enhance their careers, in either academia or industry. However, it also made them more aware of the pros and cons of the alternative paths and reinforced their preferences.

The ‘extended apprentice’ in collaborative research

For those who aspire to an academic career and continue as postdocs for an extended period, the relationship with the professors evolves from reciprocal dependence to reciprocal interdependence as trust develops and as they take on more duties in the laboratories. However, the optimism about career prospects dissipates among those who become trapped in temporary employment.
Diffuse exchange and reciprocal interdependence

The seven extended apprentices interviewed had long-standing collaborative relationships with their professors for at least 10 years, and one had acquired a ‘semi-autonomous’ status following the retirement of his professor. They had a varied degree of involvement in their professors’ industrial projects at different stages of their careers. They all share one common feature and that is pro-longed dependency on their professors’ for funding support and employment which inhibits their full transition to independent researchers.

The extended apprentices generally reported having positive and trusting work relationships with their professors although recognizing that they were the ‘junior’ partners. Over the years, the scope of their responsibility expanded from scientific bench research to cover a wide range of technical (e.g. grant application and writing) and non-technical (e.g. teaching and laboratory administration) support tasks in the laboratories. However, the interviews suggest that many can be described as ‘helpers’ (Laudel and Gläser 2008) in that they were mostly conducting dependent research and their main role being to support the work of their professors or other senior scientists. Some appear to be researchers-cum-administrators whose work role was rather diffuse and ambiguous; others operated like highly-skilled laboratory technicians. All the extended apprentices strived to maintain the scientific aspect of their work although their research was largely of an empirical or applied nature, and was driven primarily by the interests of their professors and/or the research funders.

They were compliant and willing to go an extra-mile to help their professors and work flexibly across different projects in return for collaborative opportunities and career support. For example, two of the postdocs who were publicly funded quite happily provided ‘free labour’ to work on their professors’ industrial projects. One stressed the ‘symbiotic relationship’ with his professor:

‘I realised that, you know, he would be instrumental in allowing me that chance to develop so I’ve never felt restricted in any of my research whilst I’ve been doing it… I have a commitment to make sure I deliver on what we need to do, you know. And to be absolutely honest you’re often, hopefully, deliver far more than you’re asked to do’ (case 15).

Another described himself as the ‘pseudo principal investigator’ on the industrial projects in that he wrote the proposals, supervised the doctoral students and wrote the report while the professor remained as the formal principal investigator. He reckoned that this was ‘quite good training because hopefully in the not too distant future I’ll be in a position of my own...’ (case 14).

The professors also recognised the value of these experienced postdocs for sustaining their research capacity and had strong incentives to retain them: ‘... the continuity for us is good because we’ve had 10 years of this fellow, who is competent and had good skills’ (Professor I). Although they expressed concerns about the lack of long-term career
prospects for the postdocs, many also felt obliged to get more grants to maintain the staff in their labs which appears to result in a self-perpetuating cycles of mutual dependency:

‘I mean most contracts are three year contracts but I have some post docs who have been with me for over six years...There is a tension – one side of the tension is to retain good quality scientists working for you. They know the work and they know the system. They are experts. And the temptation is to try and retain them. The other side of the tension is that perhaps for their own career aspirations, it would be almost better to – push some out’ (Professor H).

‘… you know, writing grant proposals and feeding the mouths that I had employed… there are a lot of people to keep… and that’s a feature of, you know you build up a research group and so on and it’s a feature of, you know it’s like having money, you know what you do with the money is you buy a big house and then you’ve got to get more money to pay the mortgage … (Professor C).

The extended apprentices were pessimistic about career prospects. Many pointed out that the applied and fragmented nature of their research coupled with the short-duration of employment contracts, have made it difficult for them to build up their own research profiles. Some felt that the long years of postdoctoral employment had significantly reduced their chance of obtaining tenured positions and closed alternative options. The following quotes are illustrate:

‘...people doing maybe one, two or three postdocs and if they don’t have that tenured position by that stage, they may find themselves unemployable on the grounds that they cost too much… Well, there’s nothing else that I could probably apply my skills directly to…’ (case 15).

‘…the expertise I have got isn’t sellable. I can’t go round – if you are a plumber or brickie or anything you have got – but if you are a scientist you can only work in science…But they want youngsters because they are full of enthusiasm… So you know everybody is over the hill at 35...’ (case 20).

**Transitional psychological contract, extended investment and resignation**

The postdocs who have become trapped in a series of short-term contracts experienced a ‘transitional’ psychological contract marked by a growing sense of uncertainty and erosion of expectations. Despite the frustration, they remained committed to academic research. With the exception of case 19 who was a former industrial scientist, all the others aspired to an academic career at the time of their doctoral training and this remained unchanged at the time of the interview. Although they had been involved in industrial projects and some reported having acquired additional project management skills, none saw employment in industry as an alternative option. What is clear from the interviews is that their intrinsic interest in scientific research had not diminished over time. Many reported a high level of job satisfaction:
‘I love my job. I enjoy being here and I think it is a good lab. I feel that – you know the sort of research that we do – you know trying to cure a devastating disease, it gives you a lot of drive’ (case 14).

‘I’d be happy to commit my sort of medium term to University X you know, and yeah, I mean because I’m excited by the work that I do, you know professor H is a great colleague, a great collaborator…’ (case 15).

These postdocs have clearly developed strong affective and continuance commitment to their jobs. According to van Dam’s (2005) extended investment model, the likelihood of an employee sticking to a job is determined by both the present work situation and the anticipated future situation (alternative job, and loss of investments). Postdocs who have academic career aspirations and invested heavily in scientific training may perceive the cost of pursuing alternative career options, both socio-emotional and material, to be too high. Moreover, investment in a particular relationship or job may close the option for alternatives, leaving one with little choice but to continue to commit oneself to the previous course of action in the hope of attaining some goals (Brockner 1992). From the perspective of social exchange, the norm of reciprocity suggests that the level of obligations between parties to the exchange increases as relationships mature (Blau 1964). Our analysis suggests that both the professors and postdocs experience escalation of commitment to the collaborative relationships.

In the face of perceived poor career prospect, some of the extended apprentices responded by lowering their expectations. This is indicative of a transitional psychological contract which represents a breakdown in the previous established arrangements (Rousseau 2000). One, for example, was considering the option of a quasi-academic post as an administrator in a research laboratory:

‘I am building my portfolio so I am trying to write as many papers as I can, you know with the people that work around me. And you know making sure that I get grants so that I have proof of external funding and things like that. So these will you know stand me in good stead for when I move on. Now the question is where to. Well because I am not entirely sure at the present stage and this is something that has dogged me, or dogged me for a few years really… And so the alternative would be building on my strength of sort of grant writing and sort of administrative roles which I have had forced upon me as it were over the last five years or so, so it would be perhaps like some sort of senior administrator role …’ (case 14).

Those in their late careers concluded that the chances of realising their intended career goals were unlikely to be forthcoming. They responded to the situation with ‘cynicism’ which reflects an apathy-based attitude, one that depicts resignation and weariness (Andersson 1996). For example, one of the extended apprentices who had been a contract researcher for over 20 years, responded to the question about the possibility of a permanent contract in a poignant manner:
‘You could kick up a fuss and claim all sorts of legislation [concerning permanent employment] like that but then they would offer you the safety officers post’ (case 17).

Others responded to the question about their career prospects with a sense of disillusionment and resignation:

‘I don’t want any grief. I just want to come in do the work, enjoy the work...So you know but it is not the way I planned it, it is just how it has come out’ (case 20).

‘…you know, I wouldn’t recommend it to anybody but I’m content to be sad’ (case 15; emphasis added).

While extended investment (van Dam 2005) is an attempt to exert a degree of control over the exchange relationship under conditions of uncertainty, cynicism serves as a form of self-defence to cope with the frustration and disillusionment following repeatedly failed attempts to influence the outcomes (Johnson and O’Leary-Kelly 2003; Naus et al. 2007). Extended investment is a ‘compromise’ form of adjustment for ameliorating losses and cynicism reflects ‘acquiescence’ whereby employees simply give up and endure their plight (Crites 1969). In both cases, actors adopt a reactive strategy for coping with career uncertainty which further reinforces their dependency. This can result in what Shore and Barksdate (1998) describe as an ‘employee over-obligation’ exchange relationship. Career blockage and the absence of alternative career options mean that the extended apprentices have limited resources to influence the exchange relationship in a perpetually unequal partnership in which they, the disadvantaged actors, must continue to give more in order to maintain the reciprocity of the more powerful partners, the professors.

The ‘exploited apprentice’ in commercial engagement

Restricted exchange and negotiated dependence

All the five cases interviewed were closely involved in their professors’ commercial activities, including one whose PhD research formed the basis of a spin-off company. Four of them had mixed public and private funding and one was fully publicly funded but was also conducting research connected to her professor’s company.

These junior scientists had multiple roles both within and outside the research laboratories. They were student researchers and also employees or quasi-employees (without formal employment contracts) of their professors’ spin-off companies. The two doctoral students were part-funded by their professors’ spin-off companies (cases 9 and 10). In both cases, the thesis topics were closely defined by their professors at the outset which formed part of the research agenda of the spin-off companies. Others were paid wages as contract researchers (cases 12, 13) to conduct relevant research for their professors’ commercial projects. The publicly funded junior postdoc (case 11) worked
alongside other privately funded researchers but without any additional compensation, apart from the promise of possible joint publications. In all but one of the cases, the industrial sponsors were the professors themselves who had dual roles as mentors and managers/business entrepreneurs.

The ambiguous boundary between ‘academic’ and ‘commercial’ research, and the multifaceted relationships between professors and student researchers generates conflict of interests and conflict of obligations of various kinds for the professors. Some of the professors interviewed expressed their concerns:

‘I have two people working for [Company X] in my group and two people who are funded by a grant working on something else, but may be they kind of share resources or they share equipment. You know the complex is very hard to narrow down ... I have dreams about going to jail because of conflict of interests between BBSRC research and the company...’ (Professor F).

‘Well ... there was a time in which he [the student] was both my Co-Director and an employee and a student, so I had a relationship with him at all of those levels and had to be very careful about making quite sure that that was dealt with appropriately...’ (Professor C).

Others saw the overlap between academic and commercial research rather convenient for flexible utilisation of student researchers. For example, one professor who had employed a doctoral student to provide part-time technical support in his company, joked about the fact that the amount of time the student could be expected to spent on company activities could be ‘anything between 0-100%’ because of the co-location of the two activities in the same lab.

The interviews reveal ample evidence of what might be considered as ‘labour’ and ‘intellectual’ exploitation of junior researchers much discussed in the ‘academic capitalism’ literature (Slaughter et al. 2002). Two aspects are particularly notable. The first relates to the multiple role demands and the heavy workload that ensued. All the exploited apprentices interviewed reported excessively long working hours and having to perform a wide range of support tasks related to their professors’ commercial projects in addition to scientific bench work. These tasks could range from patent search, building and testing prototypes and IT support services to business operation including marketing, sales and dealing with client queries. They substantially reduced the amount of time that the young researchers could devote to their own research. For example, one doctoral student (case 9) delayed the completion of his thesis and reckoned that he was working at least 60 hours per week for the spin-off company in the final year of his study.

The second ‘exploitative’ aspect of the relationship relates to research outputs, ownership of intellectual property and distribution of financial gains. The classic problem of publication restriction was reported by all the interviewees who could not freely disseminate or publish their research results until the patents were issued. None of them had the share of patent ownership generated from the research to which they had
contributed. The two doctoral students had signed off any intellectual property that might generate from their research to the universities and spin-off companies which sponsored them. Although patent ownership did not appear to be a major issue for these junior scientists, they were aware of the potential financial returns based on the collective research outputs. One junior postdoc, for example, talked about the ‘dollars’ that the professors were getting and was adamant that she was not offered any company shares despite the ‘extra work’ that she had to do for the company:

‘…And from the very beginning, they always kind of promised us “Oh, you get the shares in the company” and this and that... so far, I haven’t got anything. They always promised us that, but it never happened…’ (case 11).

The doctoral student, who co-founded a company with his doctoral supervisor and another professor in the department, told one of the authors discreetly during the interview that the distribution of the company shares did not fairly reflect his contribution:

‘Off the record I would say that the equity stakes wasn’t entirely well set up. I mean, that information is confidential… Now, as it turns out for years this equity style does not reflect equal involvement with the company. Me, I am doing almost all of the work. Professor C contributed a little bit but Professor Y was so busy with his other interests that he had time to contribute with nothing. So I wouldn’t say that the structure is very equitable anymore... You know, so I would personally not enter a deal like this again’ (case 9).

Perceived unequal exchange may prompt the development of a more vigilant and transactional attitude (Morrison and Robinson 1997). There is evidence of a quid pro quo mentality developing among some of the ‘exploited apprentices’. The aforementioned doctoral student, for example, negotiated for the position of ‘technical director’ in the spin-off company in return for overseeing the technical side of the business: ‘… they [the professors] were equal partners, so during the PhD they were supervisors, one of the first things I said is “I will do the technical director job, but if I do technical director job then I am the technical director’ and they were fine with it” ’ (case 9). The junior postdoc (case 11), also quoted above, subtly voiced her discontent by pointing out to the professors that it was not within her contractual terms to work for the spin-off company. These incidents suggest that conflict and tension may be lurking behind the cooperative relationship.

However, in an unequal dependent relationship, the weaker actors cannot afford to adopt too tough a stance with their stronger partners because they are more likely to lose out if they do so. Power disadvantage compels actors to consider carefully options that do not jeopardize cooperation in an exchange relationship (Molm et al. 1999). The critical dependence of the ‘exploited apprentices’ on their professors for training and career support constrains any attempt to negotiate for a more equitable exchange. They may display occasional discontent but were mindful of not causing any overt tension or conflict.
The ‘balanced’ psychological contract, a hybrid type consisting of both relational and transactional elements, best describes the exploited apprentices’ expectations and perceptions of obligations. Despite the apparent ‘exploitative’ relationship, they reported positive and rewarding work relationships with their professors. It appears that any perceived unfair exchange in the commercial relationship was offset by the learning opportunities and mentoring support provided by the ‘entrepreneurial’ professors whose well-funded laboratories and business networks could help their career development. The exploited apprentices emphasised their positive learning experience and believed that the commercial expertise acquired would be beneficial for their future careers. The following quote is illustrative:

‘Yeah, I learned, I learned, I mean everything I did was useful and I learned something from it. Consulting-wise you learn a lot of people skills, corporate politics, all that stuff. On the business side, you learn a lot about structuring contracts and deals and licensing and intellectual property. Everything around that…Well, the equity side is not necessarily the most important side to me anyway, because I think I wouldn’t have learned about companies without this. I would like to do it again, the experience and contacts are worth more in the long term’ (case 9).

It is also notable from the interviews that these young scientists have picked up their professors’ ‘entrepreneurial career imprints’ as a result of the close working relationships and exposure to commercial ventures. They saw their professors as ‘role models’ for emulation and believed that commercial science would be a viable and potentially promising career option. Although these young scientists did not have fixed career preferences at the time they started their doctoral studies, they indicated in the interviews that an academic career was what they had initially expected. However, they pointed out that having worked on the commercial projects, they would now consider an industrial or a hybrid academic career bridging science and business. This change in career preference reflects what some authors refer to as ‘social influence effect’ (Azoulay et al 2009). The reply of one of the doctoral students to the question about his career expectations well illustrates this:

‘I would say the work that I did in the company might have changed my career expectations more than the PhD itself… The [spin-off] company has opened up more options than there were before. I didn’t have an idea that something like that was possible when I started my PhD…’ (case 9).

Conducting applied and commercially-oriented research during the formative years of young scientists’ careers can significantly influence their motivation and academic identity (Hakala 2009). The narratives in the interviews show the formation of an ‘entrepreneurial’ orientation among the exploited apprentices. They shared a common view that research should be ‘useful’ and ‘practical’ in order to be worthwhile, and that
‘commercialization is good and sensible’, to put it in the words of one junior postdoc (case 11). Although most stated that they kept an open mind about future careers, it was evident from their accounts in the interviews that the appeal of an academic career was dwindling. Low pay, poor career prospects and publication pressures were all cited as the downsides of an academic career.

If the intention of these junior scientists to follow the academic career path was diminishing and they were considering commercial careers, then the benefits of undertaking training in a commercial environment would seem to outweigh the scientific risks entailed. Moreover, performing additional duties in their professors’ spin-off companies and taking on various external business liaison roles could be instrumental for their career development. As pointed out by an astute doctoral student: ‘You know as soon as you’re introduced to contacts, and they are your contacts, you can then use them to your own career, right’ (case 9). Thus, what may seem like ‘exploitation’ to an outsider could be seen as an ‘investment’ for advancing one’s own career future.

The ‘runaway apprentice’ in commercial engagement

The intention of these young scientists to exit academia became more apparent as they continued to involve in their professors’ commercial activities. Over time, the relationships shifted from negotiated dependence to negotiated interdependence as the postdocs accumulated experience and became more powerful employees. Conflicts over fairness of exchange frequently occurred and the postdocs gradually experienced a transactional turn in their psychological contracts. Growing realisation that the academic career might be closed to them eventually prompts them to look for escape routes and breakaway from the academic bond with their professors. They are similar to the ‘runaway apprentices’ in late 18th century North America described in the work of Hamilton (1995), who faced the frustration of being denied independence and disserted their masters by migrating elsewhere. The postdocs looked at in this study sought independence from their professors by pursuing career options outside academia.

Restricted exchange and negotiated interdependence

The four cases of ‘runaways’ interviewed had worked with their professors for over 10 years, and two of whom were doctoral students with the same professors prior to their postdoctoral appointments. All had been closely engaged in their professors’ commercial activities, including two who co-founded spin-off companies with their professors (Case 21 and 23). They reported strong influence of the professors on their research orientations and career progress over the years. For example, one indicated that his doctoral research topic was ‘written up as a paragraph’ by his supervisor which subsequently became part of the research leading to a spin-off company. The same postdoc said in the interview, with a sense of resentment, how his ‘life was changed unalterably by interacting with this person [the professor]’ (Case 23). He then went on to explain how his professor ‘prevented’ him from entering the pharmaceutical industry after his PhD which was his ‘big goal’ at the time, and how he was persuaded to take on three successive postdoc contracts with the promise of an academic career:
‘...I found myself in the position where I was doing a postdoctoral appointment with my ex-PhD supervisor... A three year postdoc, so I was coming to the end of this and I think it was his hope that I would, because again, once again, it was a very successful three years and I think he was hoping that I would take on another three years with him, perhaps with a view during these three years to write a Fellowship application and become a Research Fellow in his lab and then maybe to go on from there and establish my own laboratory... But I wasn’t interested in that, I felt that I had been cornered... And I was going to become unemployed...’ (case 23).

Similar stories were told by the other postdocs about how their careers had become intertwined with their professors’ commercial ventures. For example, cases 21 and 22 followed their professors’ job moves to the present institutions for project and employment continuity. What the interviews suggest is that professors who are heavily engaged in commercialization need experienced postdocs not only for resolving the ‘time squeeze’ problem, but also for risk sharing. Company formation is a high risk activity and often leads to conflict of interests in various ways. Some of the professors sought to reduce personal risks by delegating the key commercial responsibilities to the senior postdocs. One of the professors, for instance, stated in the interview that he was ‘fighting not to be a director’ at the time when the company was set up because he felt that he was ‘wearing two hats at all stages’ (Professor F). In the end, the main coordinating role was taken up by the postdoc (case 23) who saw the spin-off company as an opportunity for acquiring new experience. The same applies to another postdoc (case 21) who was initially Chief Scientific Officer and later took over as CEO of the company which he co-founded with his professor. In addition to managing the commercial projects, the postdocs also played a central role in coordinating the research in the academic laboratories. Thus, the professors become heavily dependent on the postdocs as research collaborators as well as business partners.

Over the years, as the interface between the two parties became more dominated by commercial activities, the relationship started to shift. What initially started as an open exchange relationship gradually developed into one that is more restricted and subject to negotiated arrangements. The interviews reveal three factors underlying the instrumental shift in the relationship. The first is that the postdocs had become more ‘powerful’ employees and sought greater recognition for their contributions as they acquired technical expertise and entrepreneurial acumen. The three postdocs who remained in the relationships at the time of interview believed that their contributions to the work of their professors far outweighed the benefits that they had received. A sense of injustice and unfairness permeated the conversations in the interviews. All three expressed dissatisfaction and intention to dissent. One of the postdocs expressed his anger and frustration over the unequal exchange:

‘You know he has benefited more from me than I have from him, Definitely... Well he has got two strands to his research group bio responsive polymers and everything else and the bio responsive polymers count for over half
of his research but done by me. And one of the reasons that I was looking to get out of university… I mean this is true I would say of every post doc that they have been undervalued, under appreciated, certainly underpaid… And they don’t get the credit for it. Unless you actually know that and you actually stand – I know it because I have worked for him for so long … if you are not very careful about it then you end up losing out’ (case 21).

Another talked about the competitive tension in the relationship with his professor as he sought a more equal partnership:

‘I think he had a vision of me as being somebody whose role was to provide him with support. And to begin with that was fine, because that was what I did… But I got to the point where I wanted to stand on my own two feet. And he found, that’s where the tension came, where I would say, where I demand to be able to approach, to have my own network of [contacts] and grant writing yes, and that he found that very, very difficult… He wanted to keep me as a support and I wanted to build myself up and build my own pyramid’ (case 22).

A second factor which triggers an instrumental turn in the relationship is the frequency of disputes over the share of financial rewards. For example, one of the postdocs whose relationship with his professors was clearly under great strain, talked about how he was ‘ripped off’ by his professors over the consultancy work and the dramatic deterioration of their relationship:

‘He is a user basically … Well yes, and he thinks he is doing you favours… But on the other side on the consultancy work that we do with Company X for example, you know the amount of money that he actually pays me compared to what we are actually getting for the contract it just – you know it is totally opposite to that… It was a good relationship up until the Company X situation and then he basically ripped me off big time and that really probably destroyed eight years of a good relationship’ (Case 21).

Finally, the realisation that the academic career path might be closed to them further fuels the tension. Commercial engagement can seriously jeopardise the academic career of young scientists by diverting their time and resources away from producing publications. It is evident from the interviews that intense commercial engagement hinders scientific outputs due to the time constraints and secrecy problems. The following remarks are illustrative:

‘When would I do my work, for example, if I had a grant that had nothing to do with the company and I had the company? I would have to work sometimes two different working days. What I’d probably end up doing is doing the company stuff during business hours and my academic stuff would get pushed out into peripheral hours…’ (case 23).
‘I would rather have three or four times as many papers as I have got – those I have – but because of the confidentiality issues then that is just not possible. But I can certainly say that when I had applied for some of the academic positions, my publication list wasn’t long enough which is a result of waiting, say, three years for a patent to come out’ (case 21).

Having worked hard on their professors’ commercial projects and compromised their own research, the realisation that their contributions might not be rewarded in career terms arouses feelings of injustice and betrayal: ‘...there has been very little interest in this department in terms of, you know, advancing my career. In fact there is none. They have actively blocked it...’ (case 21). This quote is indicative of the emotion of anger and outrage associated with psychological contract violation (Robinson and Rousseau 2004).

Transactional psychological contract and career crafting

Psychological contract theory suggests that violation of psychological contract involves not only attitudinal reactions, but also a readiness for action (Morrison and Robinson 1997). Postdocs who believed that their professors had failed to meet their obligations and found the option of an academic career closed sought remedial action to compensate for their losses. The transactional turn in their psychological contracts ultimately triggers their desire to exit the relationship.

The three postdocs who remained in the relationships at the time of the study were all planning their ‘escape routes’. One, for example, declared that he no longer wanted a position in the university after several unsuccessful applications for a tenured position. This prompted him to channel his effort into the spin-off company as an avenue for future employment (case 21). Another was determined to build his own contacts with companies and actively pursue consultancy as part of his ‘portfolio’career (case 22). The third postdoc (case 23), who felt that he had been ‘cornered’ by his professor to take on one postdoc after another, said, ‘I can’t be trapped in that way...I would even ruin myself in order to escape’. He subsequently negotiated a ‘special deal’ with his department which enabled him to be on half-time secondment to the spin-off company for a period while retaining his research position in the university.

These examples illustrate the active role of the runaways in shaping their jobs and careers in order to reduce uncertainty and assert autonomy. Unlike the extended apprentices who remain committed to an academic career, the runaways’ intention to pursue a pure academic career has diminished over time and they regard a hybrid or entrepreneurial career as a viable and even more appealing option. Although commercial engagement has constrained their scientific training, it also provides them with the opportunities to redefine the boundary of their jobs and acquire the necessary expertise for pursuing an entrepreneurial career. Changing task boundaries is a form of career crafting which can be used as a means of acquiring new skills (Wrzesniewski and Dutton 2001). One common strategy used by the postdocs was to manage their role transition by gradually reducing the amount of bench work and allocate more time and effort to managerial tasks:
‘Well I decreased the amount of actual lab work that I do. And I am pretty much supervising the lab. I do, yes, a little bit of lab work but I am trying to get away from that… I want to manage a company and run a company and have people working and I am going to move away from that...’ (case 21).

Some used influence tactics to initiate role transition at a critical juncture. For example, one ‘runaway’ postdoc who appears to have successfully created his own hybrid position by setting up a translational research unit recounted how he went about crafting his own job:

‘Well it’s always been my view that if you want, you know, you just write your own job description, just write exactly what you’d like to do and then take it to somebody and convince them that they really want somebody like that, is a much better way to go about getting a job than just looking for one that somebody else has decided what they want, so yeah I basically worked with them and persuaded them they needed to start an activity like this and that I was the right man to head it up and they said “yes”…’ (case 24).

Compared with those engaged in collaborative research, postdocs engaged in commercial ventures perceive more opportunities and are more motivated to engage in career crafting. They operate at the boundaries between science and business, away from the centre of attention of their academic peers, and thus experience greater freedom in their day-to-day work. The same postdoc quoted above, for example, pointed out that his ‘constantly moving mirage of activities’ had generated ‘some mystique’ in his department and ‘so not surprisingly the majority of my colleagues only know snippets of what I do and how I manage it and everything else...’ (case 24). Role ambiguity appears to have given him much scope for crafting his career within and outside the academic laboratories. This postdoc set up several spin-off and consultancy companies in parallel with his academic post.

Further, the belief that the academic career path might be blocked adds to the incentive for career crafting. The runaway apprentices actively pursued self-directed learning (McCauley and Hezlett 2001) so as to accumulate the necessary human and social capital for pursuing an entrepreneurial career. Setting up spin-off companies, which was seen initially as a means of off-setting employment insecurity had subsequently became the focus of sustained learning and career building:

‘Of all of us I think I’m the one who takes Company X the most seriously. I’ve probably gone to more of the meetings with third parties and handled more of the potential business and more of the writing than any of the others… And I also liaise very closely with the CEO so like it’s my goal to learn as much as possible during this very lucky period...I have now got a lot of skills to do with entrepreneurialism per se, so that’s good, you know, I could do something completely unrelated to [science]...’ (case 23).
‘I am basically running that company… So I have done a lot of networking. The Enterprise Fellowship was based up in Scotland so it was a flight to Scotland a couple of times a month to do MBA modules and things like that, build up some networks up there, down in London, going to conferences, talking to people… I mean the MBA and the commercial training that I have got there have been very valuable to me in sort of setting up a company and running a company…’ (case 21).

The runaway apprentices are ‘entrepreneurial bricoleurs’ (Baker and Nelson 2005) and ‘career crafters’ (Wrzesniewski and Dutton 2001). They refuse to enact limitations and take charge of their own careers by making use of available resources in a constrained environment to open up options. While seeking to breakaway from the academic bond with their professors, they actively exploit their existing knowledge and relational resources for developing their parallel entrepreneurial careers. All but one of them subsequently left their postdoctoral positions to pursue careers in start-ups but maintained their academic ties in one way or another.

**CAREER TRAJECTORIES OF YOUNG SCIENTISTS IN THE ENTREPRENEURIAL UNIVERSITY: ‘CONTENT TO BE SAD’ OR ‘RUNAWAY APPRENTICE’**

The contrast between the career experience of young scientists engaged in collaborative research and commercial ventures is striking. This has consequences on their subsequent career trajectories. Figure 2 shows the career transitions and destinations of the two categories. The great majority of those who had been involved in collaborative research remained in academia whereas all but two of those engaged in commercial ventures sought employment outside academia. Among the 15 collaborative cases, four obtained permanent academic positions after their first or second postdoctoral appointments (standard academic track), seven remained as contract researchers (slow/trapped academic track)\(^4\), two progressed from students to junior postdocs and two left for employment elsewhere. Among the 9 cases in the commercial category, seven subsequently pursued careers in private firms including six in start-ups and one in a large established firm, two remained in academia as researchers and continued to be involved in commercial activities. The divergent career paths suggest that the influence of collaborative research on the careers of young scientists is ambiguous, with some progressing to permanent academic positions and others trapped in temporary employment. The effect of commercial engagement, however, is clear and consistent: it closes the academic career for the majority and shifts their employment towards start-ups or private industry.

The analysis suggests that collaborative research can benefit scientific training if the projects undertaken are aligned with the research and training needs of the young scientists involved. Other studies also show a positive picture in some cases (Mendoza 2007; Salminen-Karlsson and Wallgren 2008). The learner apprentices interviewed

\(^4\) Two senior postdocs subsequently obtained tenure posts after nearly 20 years’ in temporary employment as contract researchers.
generally reported positive learning experiences, and four out of eight of them obtained permanent positions following the standard academic track. However, where young scientists are deployed in an instrumental manner, then collaborative research may have limited training value and prolonged engagement can hamper their scientific development. This is borne out by the experience of the extended apprentices who were unable to make the crucial transition from dependent to independent researchers. The adverse effect of industrial engagement on the academic careers of young scientists is most apparent among those involved in commercial ventures. Unlike their professors who adapt their secure careers to the dual roles of scientist-entrepreneurs, young scientists have limited resources and often ended up jeopardising their academic careers when they seek to combine science and business.

The contrasting career trajectories reflect not only the different resource constraints and opportunities associated with the two types of activities but are also outcomes of young scientists’ adaptive strategies. Both the ‘extended’ and ‘runaway’ apprentices experience the frustration of unfulfilled expectations but responded differently. The former adopts a compromise approach through extended investment whereas the latter pursues a proactive strategy through career crafting. The divergent exchange relationships with their professors governing the two types of research affect the psychological contracts of young scientists and, their subsequent career choices and adaptive behaviours.

Our analysis shows that collaborative research reinforces the reciprocal mentoring exchange between professors and young scientists, and creates a cooperative dynamic in the relationship. However, the extended apprentices became trapped in a self-perpetuating cycle of increased mutual dependency relationship with their professors. Their ‘entrapment’ is further reinforced by the affective and continuance commitment to academic research which they have developed over time. While young scientists may differ in their initial career preferences, their academic career aspirations can be strengthened or weakened as a result of early socialisation experience. Collaborative research with industry may lead to more open attitudes towards career options among some of the young scientists but it does not appear to erode the appeal of an academic career for the majority. For those who move on to become postdocs, their commitment to an academic career is strengthened. Postdocs who have strong academic aspirations may perceive the cost of pursuing alternative career options too high. Brockener (1992) argues that uncertainty surrounding goal attainment and loss aversion may prompt actors to persist with failing courses of action in the hope of attaining some of their goals. In the absence of perceived alternatives, the extended apprentices responded to unfulfilled aspirations by lowering their expectations and sought to reduce uncertainty through extended investment. The interview quote, ‘I am content to be sad’ (case 15), depicts acquiescence and resignation of those trapped in temporary employment in their preferred jobs.

Commercial engagement, on the other hand, adds a transactional element to the master-apprentice relationship between professors and young scientists, and generates a conflict dynamic at the interface. The intention of the young scientists to ‘run away’ reflects considerable strain, and in some cases, a breakdown in the relationship. The experience
of psychological contract violation further erodes the relationship and spurs an instrumental turn in their attitudes and behaviours. The runaway apprentices sought to compensate for losses by redefining their roles and relationships with the professors. They actively engaged in self-directed learning so as to enhance their employability outside academia. Involvement in commercial ventures also shifts their career preferences away from academia towards entrepreneurial start-ups or private industry which enables them to see the possibilities of alternative options. This further stimulates their motivation for career crafting in order to realise the perceived new possibilities.

Unlike the extended apprentices whose action and cognitive reappraisal are avoidant in nature, the runaway apprentices display personal agency in managing their careers. The following interview quote well captures the take-charge and proactive orientation of the runaway apprentices: ‘...I don’t have any worries about jobs now because I will be able to do something’ (case 21).

CONCLUSIONS

As the entrepreneurial university seeks out opportunities for the accumulation of economic capital, a growing number of academics have moved from a bounded world of academic science to operate at the overlapping spheres of science and business. This study has demonstrated the influence of academic entrepreneurialism on the careers of young scientists. It examines the dynamic of the relationship between professors and young scientists through the lens of social exchange and psychological contract theory. It looks at how young scientists’ psychological contracts evolve over time and how their adaptive responses to unmet career expectations influence their subsequent career trajectories. The study shows that the type of industrial engagement shapes the ‘master-apprentice’ relationships between professors and young scientists, and generates different responses among the latter; resignation among those trapped in collaborative links and career crafting among those in commercial ventures.

This study contributes to our understanding of the relationship between the psychological contract and individuals’ career behaviour. Whereas the mainstream psychological theory argues that unfulfilled career expectations or psychological contract breach leads to scaling down of employee contribution and withdrawal behaviour (Coyle-Shapiro and Kessler 2000; Robinson 1996), our findings present a more diverse picture. The extended apprentices responded to unmet expectations by ‘scaling up’ their contributions through extended investment in current jobs and relationships. The runaway apprentices did not just exit the relationship but sought to craft new jobs and careers by drawing value from existing relationships. Both categories seek to influence the exchange relationships with their professors and their own careers, albeit under different constraints and possibilities. Our analysis suggests that individuals are capable of exercising agency, to a greater or lesser degree, by taking actions to shape their careers. This is so even among those who are apparently lacking in power and resources as illustrated by the young scientists in unequal dependency relationships with their professors. Employees have greater scope for agency than typically depicted in the psychological contract literature.
The study also sheds new light on the contemporary debate about the changing nature of academic careers within an environment in which boundaries between academia and industry are blurred and career lines are redrawn (Vallas and Kleinman 2008). A significant development in academic employment in the last decade is the increased use of young scientists as contract researchers in a two-tiered structure which has hindered the upward mobility of many new entrants and eroded the dominant career expectations institutionalised in the university system. The extension of the ‘apprenticeship’ career ladder by a sequence of temporary posts reflects the decline of institutional regulation of entry routes and the growth of ‘extended entry tournaments’ (Marsden 2010) in academia, with some become trapped in the ‘low status’ positions or ‘slow track’ of their preferred profession. Much of the existing literature has highlighted the plight of the ‘trapped postdocs’ and portrays young scientists as victims of the new knowledge production regime. The experience of the ‘extended apprentices’ clearly illustrates the vulnerability of these pre-tenured researchers.

However, our analysis also indicates that the career trajectories of young scientists under the entrepreneurial regime are much more diverse and fluid than that presented in the literature. Moreover, we argue that young scientists are not just resources for the entrepreneurial efforts of their professors or universities, but are active agents in promoting the new knowledge regime. The transition of the ‘runways’ towards employment in entrepreneurial start-ups is a case in point. They actively exploit boundary-crossing learning opportunities and network resources to develop ‘hybrid’ careers at the intersection of science and business. Recent surveys in the UK and also elsewhere (Lee 2011; Mason and Wagner 1994; Stephan et al. 2004) show that the proportion of science and engineering doctorates employed in private industry has increased significantly since the early 1990s. A common assumption is that they seek employment in large established firms. Our analysis suggests that beyond the dichotomous options of employment in either academia or industry, the confluence of two previously separate organizational fields has led to the emergence of new career opportunities in entrepreneurial start-ups. These organizations provide career options different from those in R&D in large established firms because they have academic roots and offer young scientists more intellectual challenge as well as opportunities to maintain academic network ties (Roach and Sauermann 2010). They are, in part, the product of young scientists’ efforts to realign the boundary of their work and careers with the commercial learning and career aspirations which they have acquired over the course of their ‘apprenticeships’ with the entrepreneurial professors. While empirical evidence on the number of young scientists engaged in founding new firms is hard to come by, some authors (Shane and Khurana 2003) note a growing trend of young scientists pursuing careers in knowledge-intensive start-ups.

The transformation of universities into entrepreneurial organizations has expanded the institutional context in which academic careers develop and unfold. The emergence of new career trajectories in the overlapping institutional spheres does not merely reflect the limited possibilities within the boundary of traditional academic careers. It is also due partly to the efforts of career actors to redefine their professional roles and careers in response to the boundary-crossing opportunities created by the entrepreneurial university.
As Inkson et al note (2012: 313), ‘boundaries are social creations and career actors help create them’. Career boundaries can constrain the role perceptions and choices of career actors as in the case of the extended apprentices, but they can also enable boundary crossing activities as illustrated by the entrepreneurial behaviours of the runaway apprentices. Another important insight gained from this study is that the conventional debate about whether academic careers have become more ‘bounded’ or ‘boundaryless’ (Baruch and Hall 2004; Dany et al. 2011; Kaulisch and Enders 2005) misses an important point in that the processes underlying the two are closely intertwined. The entrepreneurial university has strengthened organizational control over academic careers by aligning the activities of academics more closely with the interests of universities (Harley et al. 2004). At the same time, it has also created a ‘free’ social space spanning academia and industry which facilitates the development of network careers between the two sectors (Lam 2007). A fruitful line for future inquiry would be to examine more closely the effect of these developments on the motivation and career choice of young scientists, and the development of new career paths across organizational fields.

Scholars in career and organization studies have thus far paid little attention to careers in academia despite a growing interest in careers and employment in knowledge intensive activities. University scientists are archetypal professional knowledge workers operating in a sector where the pressures for greater organizational flexibility and growth of contingent work have profound implications for career progression and labour market entry. Similar trends can be observed in other knowledge-intensive sectors (Marsden 2010). This paper has highlighted the value of studying academic careers for understanding the impact of these labour market trends on the psychological contract and career behaviour of individuals. The general theoretical insights gained from this study, therefore, have wider relevance. However, a number of qualifications should be noted. First, university academics enjoy considerable freedom in their work and this is so even among those in low status positions. Thus, the scope for exercising agency and asserting control over the task and relational boundary of their work is likely to be greater than that experienced by knowledge workers in other sectors. In the absence of freedom or options to act, the capacity of individuals to influence the psychological contracts and proactively manage their careers will be minimised. Second, the study was conducted in the scientific fields where the research goals of academia and industry increasingly overlap with increased opportunities for career mobility across the two sectors and options for pursuing hybridised careers. The same kind of boundary-crossing opportunity may not exist in the fields where the relationship between the two sectors is more distant. And third, the conception of the role of academics is placed implicitly within the Anglo-American context characterised by competitive funding structure and tournament style career. It is possible that the findings of this study cannot be generalised to countries with more hierarchical research and career systems such as in France and Germany. International comparative research would enrich our understanding of how academic careers evolve in response to similar organizational pressures in different institutional contexts.
Table 1 The interviewees: distribution by position and industrial engagement

<table>
<thead>
<tr>
<th></th>
<th>Collaborative*</th>
<th>Commercial**</th>
<th>Total no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professor (Supervisor)</td>
<td>5</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Senior post-doc</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Doctoral student/Junior post-doc</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Total no.</td>
<td>20</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

*Those engaged in collaborative links only: collaborative research, contract research and student sponsorships
**Those engaged in commercial ventures including patenting, affiliation with start-ups and company formation.
### Table 2 The interview sample

<table>
<thead>
<tr>
<th>Students/Postdocs Case no.</th>
<th>Academic position</th>
<th>Discipline</th>
<th>Age group</th>
<th>Employment status (duration and no. of contracts)</th>
<th>Mode of industrial engagement</th>
<th>Corresponding professor/industrial engagement (Case code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Doctoral Student</td>
<td>Biosciences</td>
<td>25-30</td>
<td>Student</td>
<td>Collaborative</td>
<td>Collaborative/commercial (A)</td>
</tr>
<tr>
<td>2</td>
<td>Junior postdoc</td>
<td>Biosciences</td>
<td>31-35</td>
<td>Contract researcher 7 yrs (3 contracts)</td>
<td>Collaborative</td>
<td>Collaborative/commercial (B)</td>
</tr>
<tr>
<td>3</td>
<td>Doctoral Student</td>
<td>Computer science</td>
<td>25-30</td>
<td>Student</td>
<td>Collaborative</td>
<td>Collaborative/commercial (not interviewed)</td>
</tr>
<tr>
<td>4</td>
<td>Doctoral Student</td>
<td>Computer science</td>
<td>&lt;25</td>
<td>Student</td>
<td>Collaborative</td>
<td>Collaborative/commercial (D)</td>
</tr>
<tr>
<td>5</td>
<td>Junior postdoc</td>
<td>Computer science</td>
<td>25-30</td>
<td>Contract researcher 3 yrs (1 contract)</td>
<td>Collaborative</td>
<td>Collaborative/commercial (D)</td>
</tr>
<tr>
<td>6</td>
<td>Doctoral student</td>
<td>Chemistry</td>
<td>25-30</td>
<td>Student</td>
<td>Collaborative</td>
<td>Collaborative/commercial (G)</td>
</tr>
<tr>
<td>7</td>
<td>Junior postdoc</td>
<td>Physics</td>
<td>25-30</td>
<td>Contract researcher 2 yrs (1 contract)</td>
<td>Collaborative</td>
<td>Collaborative/commercial (G)</td>
</tr>
<tr>
<td>8</td>
<td>Junior postdoc</td>
<td>Engineering</td>
<td>31-35</td>
<td>Contract researcher 6 yrs (2 contracts)</td>
<td>Collaborative</td>
<td>Collaborative/commercial (L)</td>
</tr>
<tr>
<td>9</td>
<td>Doctoral student</td>
<td>Computer science</td>
<td>&lt;25</td>
<td>Student/employee</td>
<td>Commercial</td>
<td>Collaborative/commercial (C)</td>
</tr>
<tr>
<td>10</td>
<td>Doctoral student</td>
<td>Physics</td>
<td>25-30</td>
<td>Student/employee</td>
<td>Commercial</td>
<td>Collaborative/commercial (E)</td>
</tr>
<tr>
<td>11</td>
<td>Junior postdoc</td>
<td>Biosciences</td>
<td>31-35</td>
<td>Contract researcher 3 yrs (1 contract)</td>
<td>Commercial</td>
<td>Collaborative/commercial (F)</td>
</tr>
<tr>
<td>12</td>
<td>Junior postdoc</td>
<td>Chemistry</td>
<td>31-35</td>
<td>Contract researcher 4 yrs (2 contracts)</td>
<td>Commercial</td>
<td>Collaborative/commercial + commercial (G)</td>
</tr>
<tr>
<td>13</td>
<td>Junior postdoc</td>
<td>Physics</td>
<td>36-40</td>
<td>6 yrs (2 contracts)</td>
<td>Commercial</td>
<td>Collaborative/commercial</td>
</tr>
<tr>
<td>14</td>
<td>Senior postdoc</td>
<td>Biosciences</td>
<td>36-40</td>
<td>Contract researcher 15+ yrs (numerous contracts)</td>
<td>Collaborative</td>
<td>Collaborative/commercial</td>
</tr>
<tr>
<td>15</td>
<td>Senior postdoc</td>
<td>Biosciences</td>
<td>36-40</td>
<td>Contract researcher 10+ yrs (6 contracts)</td>
<td>Collaborative</td>
<td>Collaborative/commercial</td>
</tr>
<tr>
<td>16</td>
<td>Senior postdoc</td>
<td>Biosciences</td>
<td>40+</td>
<td>Contract researcher 17 yrs (5 contracts)</td>
<td>Collaborative</td>
<td>Mainly collaborative (I)</td>
</tr>
<tr>
<td>17</td>
<td>Senior postdoc</td>
<td>Engineering /Physics</td>
<td>40+</td>
<td>Contract researcher 23 yrs (numerous contracts)</td>
<td>Collaborative</td>
<td>Mainly collaborative (not interviewed)</td>
</tr>
<tr>
<td>18</td>
<td>Senior postdoc</td>
<td>Chemistry</td>
<td>36-40</td>
<td>Contract researcher 15+ yrs (numerous contracts)</td>
<td>Collaborative</td>
<td>Collaborative/commercial (G)</td>
</tr>
<tr>
<td>19</td>
<td>Senior postdoc</td>
<td>Biomedicine</td>
<td>40+</td>
<td>Contract researcher 18 yrs (5 contracts)</td>
<td>Collaborative</td>
<td>Collaborative/commercial (K)</td>
</tr>
<tr>
<td>20</td>
<td>Senior postdoc</td>
<td>Biosciences</td>
<td>50+</td>
<td>Contract researcher 10 yrs (20+ yrs as industrial researcher)</td>
<td>Collaborative</td>
<td>Collaborative + commercial (A)</td>
</tr>
<tr>
<td>21</td>
<td>Senior postdoc</td>
<td>Chemical engineering</td>
<td>31-35</td>
<td>Contract researcher 10 yrs (5 contracts)</td>
<td>Commercial</td>
<td>Collaborative/commercial (Not interviewed)</td>
</tr>
<tr>
<td>22</td>
<td>Senior postdoc</td>
<td>Biosciences</td>
<td>36-40</td>
<td>Contract researcher 14 yrs (5 contracts)</td>
<td>Commercial</td>
<td>Collaborative/commercial (M)</td>
</tr>
<tr>
<td>23</td>
<td>Senior postdoc</td>
<td>Biosciences</td>
<td>36-40</td>
<td>Contract researcher 10 yrs (3 contracts)</td>
<td>Commercial</td>
<td>Collaborative/commercial (F)</td>
</tr>
<tr>
<td>24</td>
<td>Senior postdoc</td>
<td>Biomedicine</td>
<td>36-40</td>
<td>Contract researcher 14 yrs (numerous contracts)</td>
<td>Commercial</td>
<td>Collaborative/commercial (Not interviewed)</td>
</tr>
</tbody>
</table>

**Total no. of students/postdocs interviewed = 24**

**Total no. of professors interviewed = 16***

*13 out of the 16 professors were supervisors of the students/postdocs interviewed; 3 were in similar roles but not directly linked to the students/postdocs.*
Figure 1  Four categories of young scientists: exchange relationships with professors and psychological contracts

<table>
<thead>
<tr>
<th>Modes of industrial engagement</th>
<th>Training (Students/junior postdocs)</th>
<th>Work (Senior postdocs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative (Diffuse/relational exchange)</td>
<td>‘Learner apprentice’ (Cases 1-8)</td>
<td>‘Extended apprentice’ (Cases 14-20)</td>
</tr>
<tr>
<td></td>
<td>Reciprocal dependence</td>
<td>Reciprocal interdependence</td>
</tr>
<tr>
<td></td>
<td>Relational PC</td>
<td>Transitional PC</td>
</tr>
<tr>
<td>Commercial (Restricted/negotiated exchange)</td>
<td>‘Exploited apprentice’ (Cases 9-13)</td>
<td>‘Run away apprentice’ (Cases 21-24)</td>
</tr>
<tr>
<td></td>
<td>Negotiated dependence;</td>
<td>Negotiated interdependence;</td>
</tr>
<tr>
<td></td>
<td>Balanced PC</td>
<td>Transactional PC</td>
</tr>
</tbody>
</table>
Figure two  Career transitions and destinations

Note: figures in brackets show the number of cases
References


