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

Alice Lam^{*} and Andre Campos

Abstract

The rise of academic entrepreneurialism with its emphasis on industrial engagement is re-shaping the ‘master-apprentice’ relationship between professors and young scientists. This study uses the lens of social exchange to examine this relationship, and how it affects young scientists’ psychological contracts and how they adapt their careers in consequence. The study distinguishes two categories of industrial engagement, collaborative research and commercial ventures, with the former governed by ‘relational’ and the latter, ‘transactional’ exchange. A novel finding is the divergent responses of young scientists to unmet career expectations. Those engaged in collaborative research responded by extended investment in their current jobs. They are ‘trapped postdocs’ in perennial temporary employment: ‘*content to be sad*’. By contrast, those involved in commercialization responded by career crafting. They are ‘*runaway apprentices*’ who seek autonomy by developing their own entrepreneurial careers. The entrepreneurial university hinders the upward mobility of young scientists but it also offers them scope to redefine their work and careers. The study contributes to the psychological contract literature by highlighting the agency role of young scientists in shaping their own careers. The evidence is based on individual interviews with 24 doctoral students/post-docs and 16 professors from three leading UK research universities.

Keywords

Academic scientists, careers, entrepreneurial university, psychological contract, social exchange

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Introduction

The arrival of the entrepreneurial university has dramatically reshaped academic scientific work over the past two decades (Clark, 1998; Slaughter and Leslie, 1997). 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 (Etzkowitz, 2003; Lam, 2010), 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). These young scientists, with their short-tenure and complementary research skills, provide a flexible workforce for the academic laboratories and help to enhance their professors’ capacity to respond to opportunities for external funding and commercialization. This study uses the lens of social exchange (Blau, 1964; Emerson, 1976) and psychological contract theory (Robinson et al., 1994; Rousseau, 1995) to examine the relationship between professors and young scientists engaged in industrial links, and its effects on the training and career experience of the latter. It focuses on academics in the natural sciences where entrepreneurialism is most fully developed.

Scientific training and career formation are embedded in a ‘master-apprentice’ 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 (Reskin, 1979; Long and McGinnis, 1985). Industrial engagement may alter the relationship 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 at the expense of their training and career prospects in an increasingly precarious academic labour market (Slaughter et al., 2002; Harney et al., 2011). This pessimistic view is aligned with the fact that increasing numbers of post-doctoral researchers have become trapped in a sequence of temporary contracts (Laudel and Gläser, 2008). Industrial engagement may restrict intellectual development which could further diminish their chances of obtaining permanent academic positions (Robin and Cahuzac, 2003). Other studies suggest more optimistically that university-industry collaboration can bring new and varied forms of training

to young scientists, and enhance their employability beyond academia (Enders and Weert, 2004; 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. This study distinguishes two broad categories of industrial engagement: collaborative research and commercialization. They entail different exchange relationships between professors as focal links and young scientists as bench researchers. They also provide different learning opportunities to 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 and relational 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. In contrast, commercial research is governed by the norm of proprietary science with the aim of generating specific outputs which can be appropriated for financial returns. It adds a transactional element to the master-apprentice relationship and can undermine trust between them. It exposes young researchers to greater scientific career risks, while also providing opportunities for entrepreneurial learning (Azoulay et al., 2009).

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 collaborative relationship between professors and young scientists in academic research and training (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. Young scientists who progress from doctoral to postdoctoral research usually see the position as a bridge towards a permanent academic post. The academic career promise looms large in their psychological contracts. 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), many have been caught between the squeeze of increased supply and declining job opportunities (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 deepen the crisis in career expectations. These trends are likely to have profound effects on the psychological contracts of young scientists with many experiencing the frustration of unfulfilled expectations.

The study compares the career experience of young scientists engaged in collaborative research and commercial ventures and the shifts in their psychological contracts as they make the transition from student-learner to postdoctoral researcher. It examines how they adapt to career uncertainty and unmet expectations. The empirical evidence is based on individual interviews with 40 academic scientists, comprising matched pairs of doctoral students/post-docs (24) and their professors (16) from three leading U.K. research universities. A novel finding is the divergent responses of young scientists to unmet career expectations. In contrast to mainstream psychological contract theory which stresses the 'scaling down' of individual contribution and withdrawal behaviour among those who experience unfulfilled expectations or psychological contract breach, we find that young scientists engaged in collaborative research responded by 'scaling up' their contributions through 'extended investment' in current jobs and relationships (van Dam, 2005), whereas those involved in commercialization craft their jobs and careers (Wrzesniewski and Dutton, 2001; King, 2004) by drawing resources from existing relationships. The former are the 'trapped' postdocs who cannot escape from perennial temporary employment but are '*content to be sad*', to use a quote from the interviews; whereas the latter are the '*runaway apprentices*'² who seek independence from their 'masters' by developing their own entrepreneurial careers. The study contributes to the psychological contract literature by highlighting the agency role of young scientists in shaping their own careers. 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 entrepreneurial university hinders the upward mobility of young scientists, but also offers them scope to redefine their work and careers at the blurred boundary between academia and industry.

The paper is structured as follows. The next section develops the conceptual framework guiding the study. Section three describes the research methods and interview sample. Section four analyses the dynamics of the relationships between professors and young scientists engaged in collaborative research and commercial ventures. It looks at how young scientists' psychological contracts evolve over time and their divergent responses to unmet career

expectations. Section five examines 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.

The conceptual framework: Social exchange and the psychological contract

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 or norms which influence the nature of interaction, flow of resources and how actors use power and respond to risk (Emerson 1976). 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 cooperation (Gouldner, 1960). 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 (1990) distinguishes between diffuse 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, diffuse exchange engenders a higher degree of solidarity because actors place trust in the collective to exert control over individual exchange. Thus, 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 partners are more inclined to maintain equity in exchange rates between them 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.

In this study, 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, diffuse exchange relationship which builds on the 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 publication. 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. 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, the interface between them in commercial ventures occurs at the boundary of science and business, moving away from the safeguards of peer sanction. 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 perceives 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 (Morrison and Robinson, 1997). 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 forms. A common approach is to distinguish between psychological contracts that are largely relational in nature and those that are largely transactional (Rousseau, 1995; Rousseau, 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). 'Transitional' and 'transactional' psychological contracts, on the other hand, are less stable and more prone to tension.

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 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. 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 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.

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 in support of their professors' research programmes. However, the employment relationship between professors and postdocs differs from the standard one 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. 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 riddled with conflicting 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. They have strong incentives to retain the experienced researchers and may be tempted to 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 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 their 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 a mutual high obligation relationship between professors and postdocs. However, it can also make the fulfilment of the perceived career promise more difficult because prolonged industrial engagement may inhibit young scientists' ability to build up a track record of research.

Many of these young scientists are likely to find their career expectations unfulfilled. How might this change the dynamics of the relationships and how might young scientists respond?

Unmet career expectations and adaptive responses: Reactive/compromise vs. proactive/control response

Reciprocal contributions for mutual benefits are the core of functional exchange relationships and constructive psychological contracts (Rousseau 1995). Unmet career expectations can be seen as psychological contract breach and change the dynamics of the exchange relationships (Morrison and Robinson, 1997). 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 intense reactions.

Psychological contract theory has provided rich insights into the effects of unfulfilled expectations and psychological contract breach on the attitudes and behaviours of employees. 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; 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 (Wrzesniewski and Dutton, 2001; King, 2004). 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.

Research methods and data

Individual interviews were conducted 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 conducted individual interviews, where possible, with matched 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 web searches. A snowball method was also used to obtain additional names.

The interviews with the students/postdocs focused on their work roles and research activities, work relationships in the laboratories, involvement in their professors' industrial links, 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 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. Each interview lasted for about 75-90 minutes and all were recorded and transcribed.

The young scientists studied include doctoral students, 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' 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 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 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'* (8 cases) are the doctoral students/ junior postdocs involved in collaborative research as part of their scientific training. The *'extended apprentices'* (7 cases) are the senior postdocs engaged in collaborative projects who had been working as contract researchers for the duration ranging from 10 to 23 years. The *'exploited apprentices'* (5 cases) are the doctoral students/junior postdocs conducting research in their professors' commercial laboratories which may, or may not, be directly related to their research training. The term 'exploited apprentice' is used to denote their vulnerability to intellectual and labour exploitation. The *'runaway apprentices'* (4 cases) refer to the senior postdocs who had extensive involvement in their professors' commercial activities but subsequently sought to break away from the relationship.

The analysis shows that those engaged in collaborative research held a 'relational' psychological contract while they were 'learner apprentices' but this evolved over time into a 'transitional' one experienced by the 'extended apprentices' who faced growing career uncertainty. The 'exploited apprentices' displayed a 'balanced' psychological contract but perceived unequal exchange eventually caused a 'transactional' turn in the psychological contract among the 'runaway apprentices'. Figure one shows the positions of the four categories.

The 'learner apprentice' in collaborative research

Reciprocal dependence The relationship between the professors and 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 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. 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).

Relational psychological contract 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 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. 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.

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.

Reciprocal interdependence The seven extended apprentices interviewed had long-standing collaborative relationships with their professors, and one had acquired a ‘semi-autonomous’ status following the retirement of his professor. They had 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. 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 ambiguous; others operated like highly-skilled laboratory technicians.

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. 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 self-perpetuating cycles of mutual dependency:

'... 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, 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 illustrative:

‘...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...’ (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...’ (case 20).

Transitional psychological contract and extended investment The postdocs who have become trapped in short-term contracts experienced a ‘transitional’ psychological contract marked by a growing sense of uncertainty and erosion of expectations. However, they remained committed to academic research. With the exception of case 20 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 options, both socio-emotional and material, to be too high.

In the face of perceived poor career prospect, some of the extended apprentices responded by lowering their expectations. 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... 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 for a few years really... 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 they were unlikely to realise their intended career goals. 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 frustration and disillusionment (Naus et al., 2007). Extended investment is a 'compromise' form of adjustment for ameliorating losses and cynicism reflects 'acquiescence' whereby employees simply give up (Crites, 1969). In both cases, actors adopt a reactive strategy for coping with career uncertainty which further reinforces their dependency. Career blockage and the absence of perceived alternatives mean that the extended apprentices have limited resources to influence the exchange 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

Negotiated dependence 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. Among the five cases studied, two were doctoral students 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. One 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 generate conflict of interests and conflict of obligations of various kinds for the professors. Some professors 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...’ (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.

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 (e.g. patent search, building and testing prototypes and IT support) related to their professors’ commercial projects in addition to scientific bench work. For example, one doctoral student (case 9) reckoned that he was working at least 60 hours per week for the spin-off company in the final year of his study which delayed the completion of his thesis. Another junior postdoc (case 13) found himself having to provide technical support for all the IT equipments in the company: ‘*I worked incredibly long hours and I used to run all the computers for them... I wasn’t paid to do that at all*’. These support tasks substantially reduced their research time.

The second 'exploitative' aspect 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 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 (case 11), 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. The doctoral student, who co-founded a company with his doctoral supervisor and another professor, told one of the authors discreetly during the interview that the distribution of the company shares did not fairly reflect his contribution:

'... 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 (case 9), for example, negotiated for the position of 'technical director' in the spin-off company in return for overseeing the technical side of the business. 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. The 'exploited

apprentices' may display occasional discontent but were mindful of not causing any overt tension or conflict.

Balanced psychological contract 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 'exploitation', they reported positive 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. 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 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. Although they did not have fixed career preferences at the time they started their doctoral studies, 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 career bridging science and business. This change in career preference reflects what some authors refer to as 'social influence effect' (Azoulay et al 2009). 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).

If these junior scientists were considering commercial careers as a possible option, 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 quit 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 alternative career options.

Negotiated interdependence The four cases interviewed had worked with their professors for over 10 years, including two who co-founded spin-off companies with their professors (Case 21 and 23). Three were still working with their professors at the time of the interview but had little intention of staying. One had gained independence by obtaining a five-year personal fellowship (case 24). They all reported strong influence of the professors on their research 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 declared, 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 ... But I wasn’t interested in that, I felt that I had been cornered... And I was going to become unemployed...’ (case 23).

Other postdocs told similar stories 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. The interviews suggest 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. 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. In addition to managing 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, there was an instrumental shift in the relationship as the interface between the two parties became more dominated by commercial activities. Open exchange relationships gradually developed into more restricted and negotiated arrangements. The interviews reveal three factors underlying this shift. 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. 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... 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...to have my own networks and grant writing, and 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 diverts their time and resources away from publication. It is evident from the interviews that intense commercial engagement hinders scientific outputs due to the time constraints and secrecy problems:

‘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...’

(case 21).

‘...as soon as there is patenting issue, then immediately there are time constraints... the publication was delayed and the quality of the paper suffered because we compromised what we wanted to say...’ (case 22).

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 declared that he no longer wanted an academic career 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 actively

pursued consultancy to build 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...' (case 21).

Some used influence tactics to initiate role transition at a critical juncture. One postdoc recounted how he went about crafting his own job by setting up a translational research unit:

'...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...' (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 latitude 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 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 become 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... 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...’ (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...’ (case 21).

The runaway apprentices are ‘entrepreneurial bricoleurs’ (Baker and Nelson, 2005) and ‘career crafters’ (Wrzesniewski and Dutton, 2001). They seek to take charge of their own careers by making use of available resources in a constrained environment to open up options. While seeking to break away from the academic bond with their professors, they actively exploit their existing relational resources for developing their parallel entrepreneurial careers. All but one

subsequently left their postdoctoral positions to pursue careers in start-ups but maintained their academic ties in one way or another.

Career transitions and trajectories: ‘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 is reflected in their subsequent career trajectories (Figure 2). 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 initial 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 contract researchers. 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 interviews suggest that collaborative research can benefit young scientists when the projects undertaken are aligned with their research and training needs. These learner apprentices generally reported positive learning experiences, and four out of eight of them obtained permanent positions following the standard academic track. However, collaborative research has limited training value when young scientists are deployed in an instrumental manner, and prolonged engagement hampers their scientific development. This is borne out by the experience of the extended apprentices who found it difficult to make the transition from dependent to independent researchers. The adverse effects of industrial engagement on the academic careers of young scientists are 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 contrasted 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 adopt a compromise approach through extended investment whereas the latter pursue a proactive strategy through career crafting. The divergent exchange relationships with their professors affect their psychological contracts and subsequent adaptive behaviours.

Our analysis shows that collaborative research reinforces the reciprocal mentoring exchange between professors and young scientists. However, the extended apprentices became trapped in a self-perpetuating cycle of increased mutual dependency with their professors. Their 'entrapment' is further reinforced by the 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 career socialisation.

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 progress to postdocs, their academic career aspiration is strengthened and they may consider the cost of pursuing alternative career options too high. Brockener (1992) argues that loss aversion and uncertainty surrounding goal attainment 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.

Commercial engagement, in contrast, adds a transactional element to the relationship between professors and young scientists, and generates conflict. 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 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 pursued

entrepreneurial learning so as to enhance their employability outside academia. Involvement in commercial ventures also shifts their career preferences away from academia towards start-ups or private industry which enables them to see the possibilities of alternative options. This further stimulates their motivation for career crafting. 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 mentality: ‘...I don’t have any worries about jobs now because *I will be able to do something*’ (case 21).

Conclusions

This study contributes to our understanding of the relationship between the psychological contract and individuals’ career behaviour. Whereas the mainstream 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. 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, 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.

The study also sheds new light on the contemporary debate about the changing nature of academic careers. A significant development in the last decade is the increased use of young scientists as contract researchers in a two-tiered structure which has hindered their upward mobility 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 growth of what Marsden (2010) refers to as ‘extended entry tournaments’ in academia, where some become trapped in the low status positions 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 have become much more diverse and fluid than recognised in the literature. 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 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. Survey evidence in the UK and also elsewhere (Lee, 2011; Stephan et al., 2004) shows a growing trend of science and engineering doctorates employed in private industry. A common assumption is that they seek employment in large established firms. Our analysis suggests that beyond the choice between *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.

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 does not merely reflect the limited possibilities offered by traditional academic careers. It is also due partly to the efforts of young scientists 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 role perceptions and career choices as in the case of the extended apprentices, but they 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’ (Dany et al., 2011; Baruch and Hall, 2004; 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. 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).

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 developments 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 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 to act, the capacity of individuals to 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 cross-sector opportunities for career mobility. The same kind of opportunity may not exist in the fields where the relationship between the two sectors is more distant. Finally, the analysis is based on the experience of academic scientists in major research universities and the findings may not be typical of those working in a more constraining environment.

Table 1 The interviewees: distribution by position and industrial engagement

	Collaborative	Commercial	Total no.
Professor	5	11	16
Senior post-doc	7	4	11
Doctoral student/junior post-doc	8	5	13
Total no.	20	20	40

Table 2 Interviewee profile

Students/ Postdocs Case no.	Academic position	Discipline	Age group	Employment status (duration and no. of contracts)	Mode of industrial engagement	Corresponding professor/industrial engagement (Case code)
1	Doctoral Student	Biosciences	25-30	Student	Collaborative	Collaborative/ commercial (A)
2	Junior postdoc	Biosciences	31-35	Contract researcher 7 yrs (3 contracts)	Collaborative	Collaborative/ commercial (B)
3	Doctoral Student	Computer science	25-30	Student	Collaborative	Collaborative/ commercial (not interviewed)
4	Doctoral Student	Computer science	<25	Student	Collaborative	Collaborative/ commercial (D)
5	Junior postdoc	Computer science	25-30	Contract researcher 3 yrs (1 contract)	Collaborative	Collaborative/ commercial (D)
6	Doctoral student	Chemistry	25-30	Student	Collaborative	Collaborative/ commercial (G)
7	Junior postdoc	Physics	25-30	Contract researcher 2 yrs (1 contract)	Collaborative	Collaborative/ commercial (G)
8	Junior postdoc	Engineering	31-35	Contract researcher 6 yrs (2 contracts)	Collaborative	Collaborative (L)
9	Doctoral student	Computer science	<25	Student /employee	Commercial	Collaborative/ commercial (C)
10	Doctoral student	Physics	25-30	Student/employee	Commercial	Collaborative/ commercial (E)
11	Junior postdoc	Biosciences	31-35	Contract researcher 3 yrs (1 contract)	Commercial	Collaborative/ commercial (F)
12.	Junior postdoc	Chemistry	31-35	Contract researcher 4 yrs (2 contracts)	Commercial	Collaborative + commercial (G)
13	Junior postdoc	Physics	36-40	6 yrs (2 contracts)	Commercial	Collaborative/ commercial

14.	Senior postdoc	Biosciences	36-40	Contract researcher 15+ yrs (numerous contracts)	Collaborative	Collaborative (H)
15.	Senior postdoc	Biosciences	36-40	Contract researcher 10+ yrs (6 contracts)	Collaborative	Collaborative (H)
16	Senior postdoc	Biosciences	40+	Contract researcher 17 yrs (5 contracts)	Collaborative	Collaborative (I)
17	Senior postdoc	Engineering /Physics	40+	Contract researcher 23 yrs (numerous contracts)	Collaborative	Collaborative (not interviewed)
18	Senior postdoc	Chemistry	36-40	Contract researcher 15+ yrs (numerous contracts)	Collaborative	Collaborative/commercial (G)
19	Senior postdoc	Biomedicine	40+	Contract researcher 18 yrs (5 contracts)	Collaborative	Collaborative/commercial (K)
20	Senior postdoc	Biosciences	50+	Contract researcher 10 yrs (20+ yrs as industrial researcher)	Collaborative	Collaborative + commercial (A)
21	Senior postdoc	Chemical engineering	31-35	Contract researcher 10 yrs (5 contracts)	Commercial	Collaborative/commercial (Not interviewed)
22	Senior postdoc	Biosciences	36-40	Contract researcher 14 yrs (5 contracts)	Commercial	Collaborative/commercial (M)
23	Senior postdoc	Biosciences	36-40	Contract researcher 10 yrs (3 contracts)	Commercial	Collaborative/commercial (F)
24.	Senior postdoc	Biomedicine	36-40	Contract researcher 14 yrs (numerous contracts)	Commercial	Collaborative/commercial (Not interviewed)
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

Modes of industrial engagement \ Nature of involvement	Training (Students/junior postdocs)	Work (Senior postdocs)
Collaborative (Diffuse/relational exchange)	<p><i>‘Learner apprentice’</i> (Cases 1-8)</p> <p>Reciprocal dependence</p> <p>Relational PC</p>	<p><i>‘Extended apprentice’</i> (Cases 14-20)</p> <p>Reciprocal interdependence</p> <p>Transitional PC</p>
Commercial (Restricted/negotiated exchange)	<p><i>‘Exploited apprentice’</i> (Cases 9-13)</p> <p>Negotiated dependence;</p> <p>Balanced PC</p>	<p><i>‘Run away apprentice’</i> (Cases 21-24)</p> <p>Negotiated interdependence;</p> <p>Transactional PC</p>

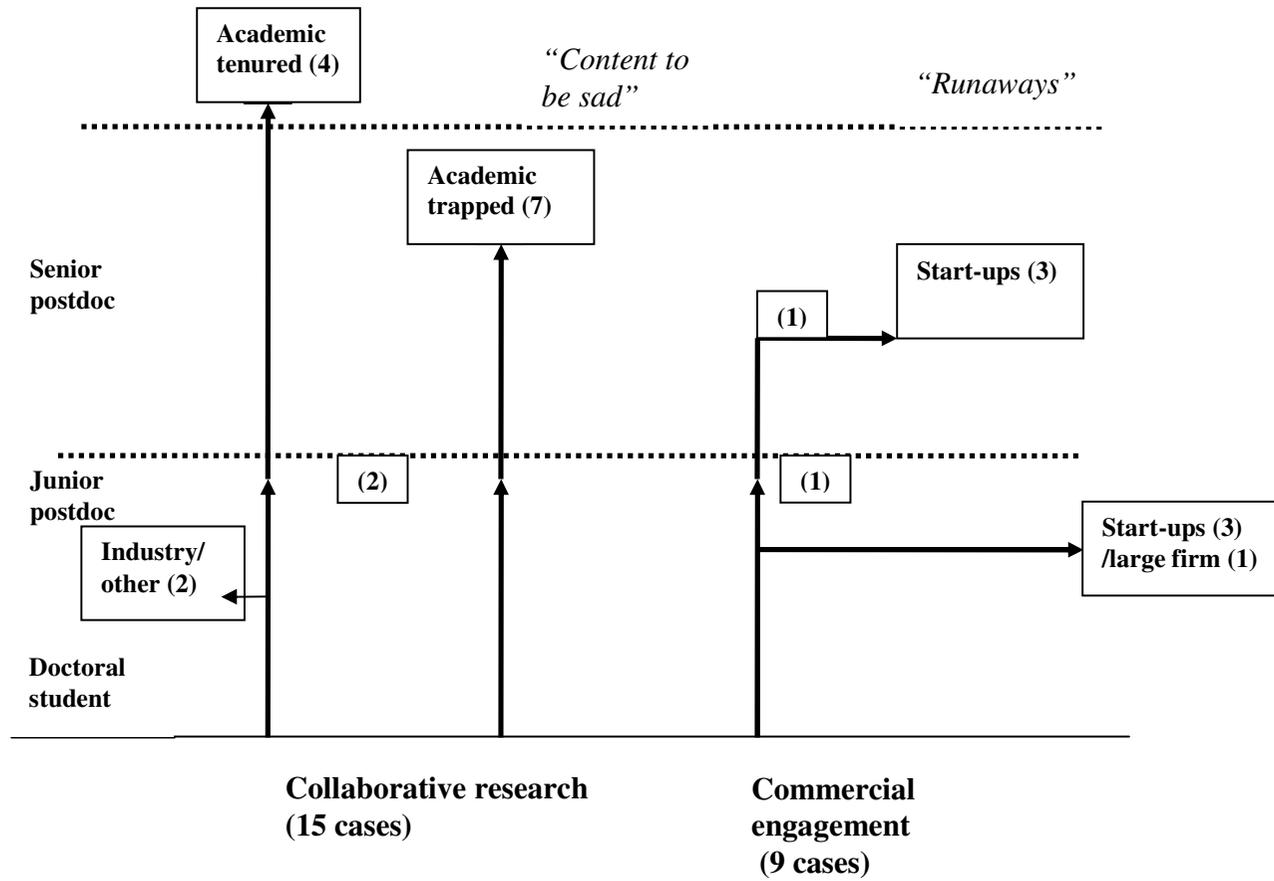


Figure two Career transitions and destinations

Note: figures in brackets show the number of cases

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Notes

¹ According to the Royal Society Report (2010), in the UK, 30 percent of science PhD graduates go on to postdoctoral positions, but only around 4 percent obtained permanent academic posts.

² This term has been used by Hamilton (1995) to refer to trainees who ran away from their masters in late 18th century North America which subsequently led to the breakdown of apprenticeship there.

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. For analytical purposes, the doctoral students and junior postdocs are placed in the 'training' category whereas the senior postdocs are put under the 'employment' category.

⁴ Two senior postdocs subsequently obtained tenure posts after nearly 20 years' in temporary employment as contract researchers.