MANAGING SCIENTISTS FOR ENTREPRENEURSHIP: SOCIOLOGICAL AMBIVALENCE, DIVERSITY, AND SCIENTIFIC ETHOS IN THE PUBLIC SECTOR

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ABSTRACT

Recent work examining entrepreneurial scientists demonstrate that different conceptualizations and types exist (Lam, 2010, Louis et al., 1989). The diversity of scientific types suggests that there are a range of adaptive and engagement strategies that scientists employ within these knowledge regimes (Bercovitz and Feldman, 2008, Lam, 2010). This study systematically examines how individual orientations of scientists are mediated by its institutional and organizational contexts and the management strategies of these organizations in response to the rhetoric of new public management for entrepreneurship and commercial outcomes (Cartner and Bollinger, 1997, Luke et al., 2008).

INTRODUCTION

The purpose of this paper is to explore the management of entrepreneurship and innovation in public sector science organizations. Specifically we aim to understand how science managers negotiate their institutional and managerial context in order to facilitate scientists in an increasingly commercialized environment. We explore the notion of scientists' sociological ambivalence within this landscape and manager's conceptualizations of managing their scientists. We integrate these views into typologies of scientists to bring a coherent theory of public sector management and entrepreneurship theory.

The growing intensity of public sector science and industry ties has seen a transformation towards understanding and locating 'entrepreneurial scientists' within this entrepreneurial paradigm (Etzkowitz and Leydesdorff, 2000, Clark, 1998), stressing organizational needs for knowledge capitalization and attention towards commercialization outcomes. The move towards a more entrepreneurial orientation for many public sector organizations is thought to facilitate significant positive outcomes for these organizations, including innovation (Zucker and Darby, 1996), productivity and . For over 30 years, the Western world has embarked on economic rationalisation initiatives that have resulted in the reduction and in some instances withdrawal of government involvement in traditional public social and economic activities. This change in public policies has sparked the interest of management scholars and a proliferation of research to study the impact of the policies on affected actors (Cartner and Bollinger, 1997, Jain et al., 2009, Lehrer and Asakawa, 2004a, Lehrer and Asakawa, 2004b, McMillan et al., 2000, Whitley, 2008). The impact of these changes in government policies are thought to have significant impacts on the management of scientists, particularly in their new roles to encourage entrepreneurship and goals of commercialization (Nowotny, Scott and Gibbons, 2002; Shinn, 2002; Cohen, Duberley and McAuley, 1999; Turpin, Garrett-Jones and Rankin, 1996; Pollitt, 1993). The extant literature abounds with the implications that these changes have on the management of science organisations (Gold et al., 2001; Bouty, 2000; Gupta et al., 2000; Turpin and Deville, 1995) including the evolution of organisational structures to fit with the new working environment and goals (Simpson, 2004; Turpin and Garrett-Jones, 2000); as well as the response of the scientists to the policy shifts (Mallon, Duberley and Cohen, 2005; Sapienza, 2005).

These changes have sparked debates around the blurred boundaries of business and science for the norms and practice of scientific work (Owen-Smith and Powell, 2001, Lam, 2010, Slaughter and Leslie, 1997). On the one hand, proponents see this boundary changes as productive and positive, highlighting the new modes of knowledge production and innovations that emerge (Gibbons et al., 1994, Etzkowitz and Leydesdorff, 2000). Critics, however, presage the normative and institutional

risks around the erosion of academic freedom and autonomy and conflicts of value and identity (Beck and Young, 2005, Hackett, 2001, Slaughter and Rhoades, 2004). However, despite this ongoing debate, studies have largely examined how existing institutional and intellectual property regimes have shaped the work situations of scientists (Siegel et al., 2003, Markman et al., 2008) with limited attention to the micro-level perspectives of organizational change (Lam, 2010, Bercovitz and Feldman, 2008, Louis et al., 1989). It is generally accepted that these changes in the context of public sector science have profound implications for the behaviors and management of scientists for entrepreneurship and innovation (Jain et al., 2009, Martin, 2003). While the shift in the strategic goals of public sector research organisations has generally been well defined, the accompanying organisational architectural components, particularly in relation to staff, rewards and control and the deep rooted administrative heritage or culture of the organisations appear not to have kept pace with the demands of the new roles of public sector research organisations. The growing body of literature on scientific leadership, for example, suggests that there are effective ways in which to manage scientists for enhanced productivity (Sapienza 2005; Pirola-Merlo, Hartel, Mann and Hirst, 2002, Hirsch, Milwitt and Oakes, 1958). These studies point to an increased focus on the management of scientists however these views have less often incorporated the changes in the working environment of scientific activity—traditionally where there was autonomy and freedom in research, an apparent absence of accountability, a focus on basic, strategic long term research usually fully funded by the government—to an environment in which the scientists are constantly challenged by commercial imperatives. However, while the changing environment has spurred many theoretical development and perspectives, these approaches have often been criticized for its lack of attention to micro-level perspectives. Lam (2010) notes that the literature on the shifting landscape of public sector science has neglected the "deeper cultural cognitive aspects of the change process" and that the focus on the macro changes "all too easily obscures the internal diversity in academic scientific work…and the complex dynamics of organizational change…" (pp. 308-309). As such a focus on the context and dynamics of scientists being "entrepreneurial" (Hindle and Yencken, 2004b) is warranted with a focus on the strategies and responses of scientists to this changing landscape. We next review the literature on entrepreneurship among scientists and etch the research space for this paper.

Entrepreneurial Scientists

Recent work examining entrepreneurial scientists demonstrate that different conceptualizations and types exist (Lam, 2010, Louis et al., 1989). Louis et al (1989) present data that show different entrepreneurial patterns and forms with those engaging in large-scale research, earning supplemental income, gaining industry support for their research, obtaining patents or generating trade secrets, and commercialization in the form of forming or holding equity in private enterprises. In contrast, Lam (2010) identifies different 'entrepreneurial scientist' types from 'traditional' at one polar end to 'entrepreneurial' at the other, with 'hybrid' types in between, uncovering the strategic adaptations and change strategies used to navigate their changing institutional boundaries. The diversity of scientific types suggests that there are a range of adaptive and engagement strategies that scientists employ within these knowledge regimes (Bercovitz and Feldman, 2008, Lam, 2010). From this perspective, it is clear that scientists do not respond uniformly to the changing institutional environment, and actively shape and alter the meaning of their work including maintaining or transforming existing institutional structures (DiMaggio, 1997, Colyvas and Powell, 2006). Congruently, while recent research has shed light on the agency of these entrepreneurial scientists, the influence of the scientific fields or institutions to which they are affiliated can have significant effects on their work behaviors (Kenney and Goe, 2004, Hagstrom, 1965). The individual responses to these changes plus the radical transformation of public sector science combine to create a complex and dynamic landscape for understanding how scientists are coming to meet the needs of specific sectors of the economy including their own organizations. Negotiating the sometimes inconsistent currents of new public management (Bercovitz and Feldman, 2008) must incorporate an ideology of competition, efficiency and productivity, measurable outcomes, and guaranteed accountability (Morris and Jones, 1999, O'Flynn, 2007, Simpson, 2004). The demands of academic versus commercial areas for research and development have different implications for the organisation and management of scientists (Hirsch et al., 1958, Goldberg and Kirschenbaum, 1988, Tingey and Inskeep, 1974, Jacobs, 1981). While the individual characteristics of scientists (Louis et al., 1989) have been posited to be a weak predictor of different types of entrepreneurship, it is perhaps the process and responses that appear to be the mediating variables in the engagement of entrepreneurship in scientific circles (Lam, 2010, Hindle and Yencken, 2004b). Hindle and Yencken (2004a) developed theoretical framework for understanding how the accumulated knowledge and expertise of the entrepreneur is transferred into the business

models of research commercialization. Their model incorporates the entrepreneurial inputs (such as tacit knowledge), the external environment or 'border scanning' (such as competition and the economy), and the resource inputs from investors and other interests. Their model takes into account the academic entrepreneur as requiring both prior knowledge and lateral thinking ability (entrepreneurial skills) with the capacity to access differing inputs of entrepreneurial capacity through developing their own competencies and experience, or by alternatively bringing in an experience surrogate entrepreneur as a partner. Alternatively, Lam (2010) suggests that the strategic action and change at the forefront of changing institutional spheres may represent far more accurately the changes in science-business dichotomy. When taken together, the above findings suggest the need to direct attention on the management of these individuals and resources to address the adaptive strategies of "boundary work" inherent in responding to often contradictory demands of their professional roles and institutional contexts (Lam, 2010, Gieryn, 1983, Waterton, 2005). This approach suggests that further investigation into the management of scientists utilizing a framework that assesses these adaptive responses is crucial for understanding the how and why of entrepreneurial scientists in the public sector.

Organizational change: Responses at the individual and organizational levels

In order for us to understand the strategic responses of scientists in an ever increasing entrepreneurial environment, we refer to the work of Robert Merton (Merton, 1996, Merton and Barber, 1963, Merton and Barber, 1976), who understood the institutions of science to be "patterned in terms of potentially conflicting pairs of norms" (Merton, 1976, p. 33). At the forefront of the norms of professions and its changing contexts is the idea of sociological ambivalence (Merton and Barber, 1976, Jansen and Von Glinow, 1985). This "sociological ambivalence" refers to incompatible normative expectations of attitudes, beliefs, and behavior assignment to a status (such as a social position) or to a set of statuses in a society (Merton, 1996). Sociological ambivalence in psychology refers to the experienced tendency of individuals to be pulled in psychologically opposed direction. While this perspective highlights a psychological individual analysis directed at the individual, sociological ambivalence most often refers to the incompatible normative expectations incorporated in a single role of a single social status (for example, in our sample, the scientists professionalized roles as public sector scientists or science managers). The social ambivalences is most often located in the social definition of roles and status and thus analyses of how the social structure generates the circumstances in which ambivalence is embedded into particular statuses and status-sets together with their associated roles become important. For example, the multiple types of functions (both expressive and instrumental) assigned to a status for can be found to have significant effects on outcomes. These increasingly blurred boundaries and growing pressures to exploit commercial opportunities have pushed to the forefront neo-institutional perspectives of 'sociological ambivalence' (Merton and Barber, 1963) and 'boundary work' (Gieryn, 1983, Gieryn, 1999), whereby scientists negotiate and defend the boundaries of their work while at the same time pursuing critical resources for their career goals (Lam, 2010). Within this context, the management of 'entrepreneurial scientists' becomes critical to identify, recognize and encourage their creativity and innovation.

The small pool of scientific talent around the world (Coates and Wolff, 1996), evokes the need to carefully manage the careers and motivations of these elite knowledge workforce. For example a study by Bercovitz and Feldman (2008) found that when scientists face dissonance in the workplace (i.e., engagement in a new initiatives for increased technology transfer when their individual training norms were not congruent with the localized social norms in their work environment), they conformed to the local norms rather than adhere to norms from their prior experiences. Important factors such as the leadership of the localized social environment (e.g., the chair of the department in their sample) and social peers (such as those academics who were perceived to be similar to them) tended to mediate the behaviors to engage in these new initiatives. Their research suggests that social learning and local context influences an individual's decision to follow strategic initiatives and participate in new activities such as commercialization or entrepreneurial endeavors in an organization. These results also suggest the roles that selection (in the decision to engage in these new initiatives) and socialization may play in the effort to commercialize. Indeed, other recent work in the social ambivalence of scientists have found that information withholding by other life scientist are influenced by the behaviors of their peers as well as the attitudes of superiors in the profession (Haas and Park, 2010). Norm violations in information sharing can occur when professional norms are valued but it is difficult to ascertain the appropriate course of professional conduct. However, significant attention needs to be placed into how organizational change initiatives are diffused through individuals across individuals.

How the different types of entrepreneurial scientists are managed become important from a leadership point of view. Other research affirms the attention to specific structural and organizational perspectives of science managers in enabling scientists to further engage in commercial outcomes by taking into account their individual characteristics, motivations and organizational contexts (Bartunek, 2007, Mayers, 1966, Roberts and Biddle, 1994, Mallon et al., 2005).

In sum, the attributes of the change process highlight that responses to strategic initiatives are mediated by individual, local and organizational contexts. However, these alone are inadequately deterministic, as individuals respond to their leaders and their local contexts (Bercovitz and Feldman, 2008). This study attempts to provide a lens into this multi-level phenomenon by focusing the lens on the science managers' attempts to negotiate the role of dissonance and symbolic compliance within this change process. By providing a theoretical framework which integrates the "demand" side (so to speak) of strategic change and implementation, an insight (and prescriptions) into the change process can be obtained. The need to consider individual heterogeneity, professional dynamics and factors that influence compliance suggests that scientific leaders and managers must react to a bottom-up approach in implementing change and rethinking how resources which are allocated may fit into energizing this "entrepreneurial spark".

METHODOLOGY

This paper takes a qualitative methodology. Based on a non-probabilistic sample, we report on a total of 31 in-depth interviews with scientist managers from four different New Zealand Crown Research Institutes (CRIs). As elsewhere around the world, the past 30 years have also witnessed an enormous change in the management of science and technology in New Zealand. National research laboratories in New Zealand were re-constituted as government-owned entities (or Crown Research Institutes- CRIs) in an effort to extensively reform and modernize publicly funded science research organizations (Cartner and Bollinger, 1997, Simpson and Craig, 1997). The traditional bulk funded and divisionalized public science research organizations were dismantled and reconstituted as ten corporate-styled CRIs which were vertically integrated to meet the needs of specific sectors of the economy. The imperative driven by the rise of new public management were to encourage an ideology of competition, become more efficient, have measurable outcomes, and to guarantee accountability (Simpson, 2004). These policy changes were part of the wider economic reforms implemented in New Zealand in line with international developments occurring in industrialised countries such as the United States and Australia (Scott et al., 1997, Boston, 1991). Initiatives to scale back government's involvement in areas that could be undertaken by the private sector and for the public sector organizations to be more client and customer orientated were introduced progressively through the 1990s and these had ramifications in the way that public sector research organizations came to be managed, requiring both structural changes in the organizations as well as behavioural changes for management and the employees. The changes in the New Zealand public sector scientific organizations, with their complex interconnections and influence of many stakeholders from both public and private actors, have varying effects on the structuring and management of scientific professionals through the sometimes conflicting processes of policy-making, implementation and interpretation.

Changes in the context of public sector science are mandating consideration of appropriate management strategies. Post-reform organizational forms of these CRIs suggest that the new transitional organizational forms for production of knowledge require critical management and leadership in interpreting and giving sense to the ever changing demands of public research (Simpson, 2004). Along with the relative shortage of competent science managers (Aitken, 1997) and the myriad of influences on scientific careers (Duberley et al.) the understanding of management and engagement of public sector scientific professionals is imperative in understanding how the public sector can stimulate entrepreneurship and innovation within its CRIs. This context provides a significant opportunity to examine how sociological ambivalence is managed and entrepreneurship among scientists is encouraged. In addition, data collection incorporated the institutional context in which research was carried out and the response of the institutions to the policy of commercialization through an examination of the discourses articulated in a variety of sources—published works and records; and official documents of the institutions. The identities of the participants and their organizations will not be identified due to confidentiality agreements and responses are analyzed as a whole.

Analysis of the data was conducted using a two prong approach whereby the first researcher utilized traditional methods of data analysis (theoretical propositions, codification, thematic analysis- (Denzin and Lincoln, 1994)) while the second researcher utilized qualitative analysis software inductively (Leximancer- which transforms lexical co-occurrence information from natural language into semantic patterns in an unsupervised manner, and thus eliminates researcher bias) in the analysis of the transcribed interviews (For a detailed description of the Leximancer rationale and methodological analytical approach see, Martin and Rice, 2007, Smith, 2000, Smith and Humphreys, 2006). For the Leximancer analyses, the data was analyzed inductively by the software. Following this initial analysis of the data, specific concepts maps and analyses was focused on concepts of commercialization (commercial) and opportunity (idea). Both data analysis was then compared and validated to build the common themes that emerge from the scientists' interviews between the two researchers. The themes were then triangulated with other sources of data including the use of published works and records and official documents of the institutions. In this study we report on the themes from these two approaches by organizing the results around the Leximancer concept map of the interview data. We highlight the findings of this research with representative quotes from the data collection.

RESULTS AND IMPLICATIONS

We present our overall findings with regard to the impact of public sector reform on the management of scientists for entrepreneurship. This study systematically examines how individual orientations of scientists are mediated by disciplinary and institutional contexts. We highlight specific processes and strategies around managing the contradictory institutional logics (such as professional/organizational orientation tensions, and policies and practices around work and research) that are inherent in the management of public sector scientists in our sample. Within the institutional frameworks of our sample, conflicting expectations have created a tension at the boundaries of scientific profession and the pressures imposed by encroaching occupations and administrative structures that subordinate their work to bureaucratic goals (Haas and Park, 2010). The pervasiveness competing role expectations have been shown to occur in professional roles such as scientists (Mitroff, 1974), physicians (Merton and Barber, 1963), an even accountants (Sorensen and Sorensen, 1974). Table 1 establishes the sociological ambivalence recognized by the science managers from both analytical approaches (The results of the social ambivalence of scientists is reported in detail elsewhere see, Wong and Ho, 2009). Themes around the conflicting nature of strategic orientations, goal conflict, motivation, resource mobilization, and teamwork are well established within these CRIs.

Table 1. Sociological ambivalence themes and sample quotes

Theme	Sample Quotes
Strategic Orientation: Individual vs Organisation	*That is a problem for some individuals, too much consulting work, marginal time is squeezed, they don't get the fly wheel up to speed, the critical mass of quality time you need to write a paper – it's actually hard in this environment to write scientific papers because a consulting client can ring up any time and interrupt the thought train right when you were going to have the Nobel Prize winning idea so there's a problem there.*
Goal Conflict	*It results in these, you know, just very obvious inefficiencies and that, I think that's one of the recurring themes that makes scientists very despondent and, and I guess, yeah if you know just, we've been talking with these scientists from overseas that they were part of this 2 day meeting that I referred to, and having come from overseas, having worked overseas, some of the contrasts are just really stunning. Well the ability to do research is quite impacted by the regulation occurs in New Zealand*
Motivation	*I know how difficult and how intellectually challenging or interesting what they are doing is, ...it's just not making money.*
Resource Mobilisation	*We've had to fragment our research up so that we can reinvent ourselves into, do new sexy research every time we bid, because you can say, but this is a serious problem*
Teamwork	*They basically stand back and say you know good on you sort of thing, you know and if you don't succeed or you fall over, they don't come in and kick and pummel you, they are basically oh well bad luck, better luck next time. Whereas in NZ its totally different, this tall poppy syndrome is absolutely key thing here, and if people see you standing out or trying to take a risk and then it doesn't work they*

	are down on you like a tonne of bricks.

Conflicting expectations which exist in these CRIs generate tensions not only at the boundaries of the profession but also within them imposing sometimes contradictory demands on members of the profession (Lam, 2010). This creates an environment where resolving sociological ambivalence becomes critical for science managers.

Identifying and framing sociological ambivalence

Science managers understand the environment in which they managed but make the distinction between the commercial environment and entrepreneurial behaviors assumed in new public management,

We are not actually driven that much by commercialization of products as such but we do have to operate in a commercial way and I think you have got to make that distinction so we have actually only got a few people on our staff who are involved in specific commercialization projects but we have got all of our staff are operating in a commercial manner and they are all, just about everyone, is involved in commercial consulting work - (Science Manager 22)

Specific analyses around the pursuit of opportunity and commercial outcomes were analyzed in further detail (see appendix 1 for Leximancer analysis settings). Figure 1 shows the concept maps generated around the Leximancer analysis around pursuit of opportunities (idea) and commercialization outcomes (commercial). Overall, the findings in this study suggest that management strategies utilized within these contexts are aimed at reducing tension and promoting productivity through strategies such as recognition, promotion, engagement and leadership to address the range of adaptive strategies by 'entrepreneurial scientists' at the one end and 'traditional types' at the other. We highlight our findings by focusing our analysis on the concepts of the pursuit of opportunity ("idea") and commercialization outcomes ("commercial"). It is acknowledged that while there is an accepted definition of entrepreneurship which encompasses specific behavioral definitions and concepts (Shane, 2003), our purpose is to examine science managers' conceptualization of entrepreneurship in the public sector and their associated management strategies and issues. Thus, a focus on the participants' natural conceptualization and language are retained and form the basis of our analysis.

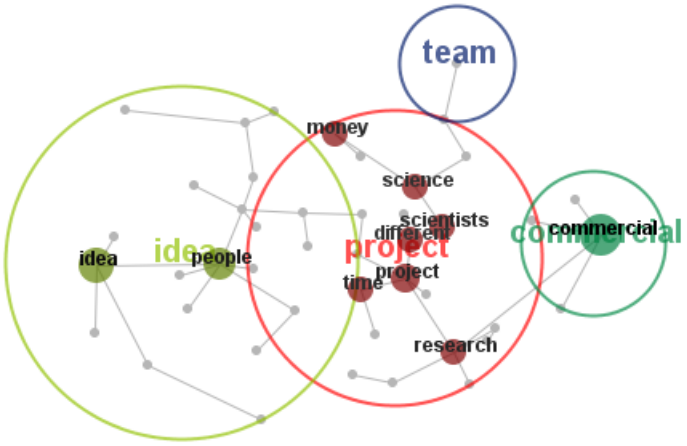

Figure 1. Concept Map of data (visible concepts=25%; % theme size=60)

In particular, our results suggest that science managers are cognizant of the importance of getting the right people, who demonstrate the "entrepreneurial" traits in pursuing opportunities around their research. As a science managers commented,

Of course they come with quite a different world view, they are more used to this investor type idea and they are more used to being accountable, so as a section I haven't had as much difficulty as others because it's a relatively young section, they're used to the idea of setting milestones, delivering, being accountable - (Science Manager 5)

One important finding that can be seen from Figure 1 is the distance between "idea" and

"commercialization" concepts. The concept map from the Leximancer analysis demonstrates that these two concepts appear to be separate distinctions of entrepreneurial behaviors. On the one side, the pursuit of opportunity is conceptualized as distinctly different to commercial outcomes. As the opening quote suggests, science managers have specific conceptualizations of science "entrepreneurship". In this study, their conceptualizations of "entrepreneurial scientists" (Lam, 2010, Lehrer and Asakawa, 2004a) encompass characteristics of an inventor, the ability to network and mobilize people and resources, and to champion the pursuit of research within the public sector framework,

...Other than maybe ambition, which is the same in both cases, and the way it is usually done is that you have that one key person, the flag bearer, the champion of the idea who pushes it all the way, or as far as possible so it becomes all of this and the proof of concept stage that then other people buy into it and begin to see the value of money in it. But to take it through this from the bench to the investor stage you have to have a champion and the champion has to have the motivation to do that, and it can't be a basic scientist who conceive the idea - (Science Manager 13)

We certainly do have people like that in our institution. There are two or three that I can name, that fit into that category – (Science Manager 11)

On the other side of the spectrum, commercial outcomes revolved around the everyday goals for commercial activities in these CRIs,

Part of that is the push for people out in to commercial work. Yeah it's a sink or swim mentality a little bit - (Science Manager 22)
The pursuit of commercial outcomes is predicated on the organization of research within these CRIS. Part of the distinction for public sector scientists is the everyday need to engage in commercial clients and balance the pursuit of basic vs applied research for the organization,

No because we are operating in a commercial environment and that is a problem if you have done ... it is not an issue with research; foundation funded research project. But if you are working on an interesting consulting job, the client doesn't want to pay for you to write a paper so you have got to have priced the job competitively because we are not operating in isolation we have got other CRIs who we do compete with.– (Science Manager 24)

From a commercial point of view, the push towards engaging in new public management revolves around structuring the work of the scientists to maximize commercial goals while motivating and resolving the sociological ambivalence of scientists. An important management strategy is the utilization of work and team structures to bring organization and control around research that leads to commercial outcomes.

Resolving sociological ambivalence

While recognition of the range of entrepreneurial types are an important course of action for science managers, the strategies and actions that influence entrepreneurial behavior can be categorized around project management work structures at these CRIs. Managing the project teams are also influenced by the diversity of team composition and structures (various entrepreneurial types) which are indirectly influenced by funding, incentive structures, and work allocation designed to manage commercial outcomes. As several science managers commented,

What we've discovered now is really is quite a sobering experience for us that withholding information actually did more harm than good. And the reason for that was that a lot of potential collaborators in the same area really took umbrage to us not publishing or making public a lot of our data. Because again, you know, science works best, even if you're ultimately competing for certain, if your end goal is a commercial product, it's often still best to be as collaborative as you can, as close as you can to be to that product.- (Science Manager 14)

Being able to talk and relate to people and talk to them about their work. Provide them with systems to help them with their work, whether it is project management systems or just idea, better ideas on how to do their science. It seems like you have to help people at a whole range of different levels - (Science Manager 16)

We can't, we all can't afford to do it individually. It's better we chip in to get that sequence and then what we might so with a little more commercial sensitivity is the little bits of that gene that we might pull out ... for ourselves. But I think we all realize that the sooner, the quicker we get that sort of fundamental bit of data, the quicker everything else, even our commercial projects will proceed - (Science Manager 11)

1. Resolving issues of research

A fundamental management issue that is critical to the resolution of social ambivalence at the nexus of commercial outcomes is the need to manage the research objectives of the project teams. From the onset, science managers in our sample make the everyday decisions of pursuing specific objectives for their particular teams or divisions. Science managers in our sample utilized a variety of strategies to appease the range of responses from scientists including meeting the needs of the particular careers of scientists including directing time and resources for publications,

No, because we are operating in a commercial environment and that is a problem if you have done ... it is not an issue with research; foundation funded research projects. But if you are working on an interesting consulting job, the client doesn't want to pay for you to write a paper so you have to do what you can to motivate them…got to have priced the job competitively because we are not operating in isolation we have got other CRIs who we do compete with – (Science manager 11)

In addition, allocating the needs for the different types of research to certain groups of scientists also becomes one of the responses of science managers,

At the same time principal scientists were kind of freed up a little bit to lead their respective disciplines in science programs and that kind of thing" – (Science manager 14)

The imperative around matching scientists to the types of research is seen as a way in which to motivate scientists who worked for them and to consider the career developmental paths within these organizations (Biddle and Roberts, 1994, Duberley et al., Fox and Stephan, 2001). Managers in our sample also engaged in reframing the needs of their particular teams or divisions for funding or commercial work.

We've had to fragment our research up so that we can reinvent ourselves into, do new sexy research every time we bid – (Science manager 27)

They all go in to bat for you in certain situations you know if you really think you have got something that is worth pursuing and perhaps is not commercial, they will back you up when you go to the different, particularly within the (CRI), if you try and apply for money, capability development, and it is not obviously commercial they will support you and say this isn't commercial now but it is interesting and it could be in the future – (Science manager 7)

In resolving the social ambivalence of the different types of scientists within their teams, science managers are better able to manage the different motivations and engagement of scientists within their teams or divisions. Haas and Park (2010) postulate that the dyadic exchange between parties in information exchange among scientists may be mediated by status (both professional and organizational). In this study, we have found evidence that mediating the engagement of scientists is largely based on motivating scientists through their research interests and career developmental pathways.

2. Team composition

Even within project teams, having to manage diverse scientist types (Lam, 2010) is critical to commercial outcomes. Science managers in our sample highlighted the need to identify and manage the different adaptive strategies of scientists (Haas and Park, 2010, Lam, 2010),

It's a lot of hype and I think for the most part, they're very focused on commercial outcomes and I think, you know, in some cases they've been successful at that – (Science Manager 15)

So these scientists have to be managed a little bit differently because they're not doing routine work I

think when the pendulum swung to being too commercially focused, science quality went out the window a little bit - (Science Manager 31)

In these cases, the different orientations of scientists require almost careful management around their "entrepreneurial" orientations. Science managers are increasingly required to shift the working orientations of scientist within their organizations by implementing prior "traditional expectations. This attention to team composition and the various ways in which work can be organized becomes a balancing act in building and allocating people in the work design of their teams or divisions,

The main sort of parts of the job where people are going to do it and you assign hours to it and you cost it out and go back and reduce people's hours to fit the budget, or you take bits out, so then everybody has got an assignment of hours on a particular job- (Science manager 12)

In addition, managing non-"entrepreneurial" types are specifically reframed through the everyday activities of the managers. These remain a problem for some science managers who are increasingly unsure about how to manage these tensions

Now what tends to happen is that some way I have observed it is that there is less motivation to really focus on the IP with the commercial contracts because the scientist doesn't get anything out of it. So they work really hard and make mention the other group, the commercial client that owns it, and they will do what they like with it, so its actually quite de-motivating for the scientists- (Science manager 5)

And so as a consequence, I think the CRIs, they pay a lot of lip service - (Science manager 11)

While the focus on individual responses of scientists in shifting environments include a focus on the institutional and scientific fields (Lam, 2010, Kenney and Goe, 2004), this study demonstrates that when social ambivalence accosts entrepreneurial behaviors, science managers attempt to influence scientists' entrepreneurial engagements through cultural norms and allocation of work practices and design.

3. Time, funding and incentives

From the management of scientists based within their teams and divisions, the science managers in our sample report on the critical role of timelines, funding, and incentives as management responsibilities and influences on commercial outcomes. In an ever increasing commercial environment, time becomes an issue not only for the increased attention to goals and directed research but also as a means to which to allocate work and division of specialties,

And so the time lines to actually get a commercial .product are about 10-12 years from when you say this is it to actually getting it in the market, and so like a strong motivation for me is that I want to see that happen - (Science Manager 12)

Well we do sometimes but not that often, and that leads to problems because the business development manager doesn't necessarily understand the time involved or whatever and so they make promises that we have to attempt to keep that aren't necessarily realistic. And of course when it comes to, like end of our financial year is the end of June, and so all the commercial milestones have to be finished in time to be paid out to account for that year, and so May and June are just mad, and every year they're just mad, and every year they say well next year we won't do that, but it always ends up May and June – (Science Manager 12)

These negotiations around time are critical to enabling scientists to measure and direct outcomes. The nature of funding and research in CRIs is inextricably linked. The move from traditional bureaucratic bulk funding to becoming more competitive in seeking funding has brought about change into the objectives and direction of CRIs. The changes are fundamental and entrenched in the workings of these CRIs and form the basis of management imperative.

Yeah there has been pretty massive changes I suppose from the government department type system...mentality and there is certainly things that we did then that we wouldn't probably contemplate now or won't be able to have funding to do because in those times time was cheap so it was already funded but you know travel or resources and things like that cost extra money and were hard to get, so

you make quite different. Decisions now about how we do things and what is an efficient way of doing things because the dollars become the bottom line and our time is fully costed, so you realise an hour mucking around doing something is costing quite a lot of money and a day mucking around doing something is, you would be better to buy something that seems relatively expensive but it actually saves a lot of time - (Science Manager 3)

Decisions now about how we do things and what is an efficient way of doing things because the dollars become the bottom line and our time is fully costed - (Science Manager 22)

The difficulty for scientists is that clearly they cannot have personal assistants or people that can discuss the intricacies of their science and so managing the workload, staff and external expectations can be a real juggle at times. Inevitably things get forgotten - (Science Manager 8)

Funding of these teams and divisions also has implications for the incentives for the scientists engaged in commercial outcomes. On the one hand, the primary attention to funding of research becomes ingrained in the need to project commercial interest to their projects.

So the challenges are getting the funding, and part of that challenge is about convincing people you have a compelling project, you have a good idea within this CRI, and particularly within this section, we also absolutely have to show that we have freedom to operate – (Science Manager 11)

This approach between the CRIs. I think it would be major. I think removing this stupid quazi-commercial motivations and us paying a dividend is just bookkeeping nonsense really – (Science manager 7)

Science managers are cognizant of the need to present monetary incentives for pursuing commercial outcomes, however, these requirements are not always factored into the organizational directives nor filtered in an appropriate manner. This issue becomes an important managerial balance for science managers in that many of the ensuing management of their staff becomes central issues in how to motivate and engage scientists in their organizations (Beltramo et al., 2001, Farris and Cordero, 2002, Harrison, 1974).

IMPLICATIONS FOR THEORY AND PRACTICE

This study has highlighted the ways in which managers manage the social ambivalence of scientists working in new publically managed research organizations. The relative importance of the behaviors and actions of managers on the entrepreneurial behaviors of scientists in resolving sociological ambivalence is critical to the extant literature and for practice. The salient and explicit strategies of management to encourage the pursuit of opportunity and commercialization outcomes demonstrate the agency of top down approaches to organizational change and outcomes. It contributes to the literature on scientific entrepreneurship by exploring how public sector science managers engage, develop and manage the diverse 'entrepreneurial' types within their organizations (Audretsch and Erdem, 2004, Jain et al., 2009, Lam, 2010, Martin, 2003). In addition, the success of innovation and its implementation in the public sector rests on managers' abilities to garner the entrepreneurial behaviors required in this new paradigm (Mack et al., 2008). Because of the numerous and complex tensions around public sector management and science, management must create, to the extent possible, an organizational context that supports and sustains "entrepreneurial" scientists. Through this study, practices aimed at identifying and managing these "entrepreneurial" types and incentivizing less entrepreneurial types become a main consideration for the performance of these firms. By addressing the cognitive conflicts and 'boundary work' of these scientists, managers in these CRIs reduce the tensions and conflicts that arise around the new institutional and social structures (Oliver, 1991). These responses are necessarily based on the normative acceptance of the professional scientific collective and countervailing institutional and historical trajectories of the institutions.

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Appendix 1. Leximancer Settings

Preprocessing Options
Sentences per Block: 3
Prose Test Threshold: 1 (default)
Duplicate Text Sensitivity
Identify Name-Like Concepts: Yes
Break at Paragraph: No
Auto-paragraphing: Yes
Merge Word variants: No
Apply folder tags: No
Apply file tags: Yes
Apply dialog tags: No
Auto Profiling
Mode: Off
Concepts to add: Auto
Similar Text Threshold: Auto
Similar to Add: Auto
Thesaurus Learning
concept thesaurus: Yes
Learning Threshold: 14 (normal)
Sentences per context block: 3
Break at Paragraph
Learn Tag Classes, Yes
Number discovered (concepts): 10
Concept classification
Sentences per context block: 3
Break at Paragraph: Yes
Word Classification Threshold 2.4 (normal)
Name Classificantion Threshold, :4.5 (normal)
Locate Concepts
Required Concepts: Idea, Commercial

Map settings
Generate: Conceptual Map
Map Type: Linear

The seed concepts were subjected to an editorial process where name tags, and common word were removed. In addition, common concepts were merged (e.g., manager/managers, product / products, and technology/technologies, etc).