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Biotechnology integration as a sociology of innovation

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Abstract

Understanding the sociological process by which innovations are developed and adopted provides an interesting challenge for managers and marketers. In practical terms, recognizing the various intangible social influences that modulate innovation development and uptake requires a flexible framework which enables the variable stakeholder contributions to be taken into account. Research into the Australian biotechnology industry has provided valuable insight into the social processes in the development and integration of these innovations. Evidence from the industry reveals integration was a dynamic social process directed by the multiple agendas of participating stakeholders. The social foundation of integration activities was strongly reliant on established research and professional associations. Additional networking activities were also in evident through recognised and historic patterns of research and professional associations. The adoption of a sociological framework enables these interpersonal interactions and negotiations to be strategically interpreted for maximum uptake and market leverage. We present a model which recognizes the socio-cognitive framework of stakeholders in innovation adoption as enacted in the acceptance and integration of emerging technologies in the Australian biotechnology industry. By recognizing the key processes in such a framework activities can be developed that are conducive to innovation integration, technology adoption and biotechnology uptake.

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THE SOCIOLOGY OF INNOVATION AND THE EMERGENCE OF NEW BIOTECHNOLOGIES

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Biotechnology Integration as a Sociology of Innovation

ABSTRACT

Understanding the sociological process by which innovations are developed and adopted provides an interesting challenge for managers and marketers. In practical terms, recognizing the various intangible social influences that modulate innovation development and uptake requires a flexible framework which enables the variable stakeholder contributions to be taken into account. Research into the Australian biotechnology industry has provided valuable insight into the social processes in the development and integration of these innovations. Evidence from the industry reveals integration was a dynamic social process directed by the multiple agendas of participating stakeholders. The social foundation of integration activities was strongly reliant on established research and professional associations. Additional networking activities were also in evident through recognised and historic patterns of research and professional associations. The adoption of a sociological framework enables these interpersonal interactions and negotiations to be strategically interpreted for maximum uptake and market leverage. We present a model which recognizes the socio-cognitive framework of stakeholders in innovation adoption as enacted in the acceptance and integration of emerging technologies in the Australian biotechnology industry. By recognizing the key processes in such a framework activities can be developed that are conducive to innovation integration, technology adoption and biotechnology uptake.

INTRODUCTION

Sociology of Innovation is an approach to establishing a focused consideration of the social dimension in business innovation processes. This paper aims to provide insights into the *contemporary issue* of innovation within the *traditional domains* of marketing and management from the post-modern perspective of *social dynamics*. This is a significant and emerging research area in critical management theory that is central to current business practice, as the roles of customers, participants and clients, in product and service delivery as well as organisational management gain increasing emphasis.

The social contribution to innovation outcomes is well established and acknowledged through recognition that innovation is a profoundly social exercise from initiation and acceptance to commercialisation, integration and widespread adoption (Bessant & Tidd, 2007). This human dimension of innovation is well documented within the literature on the sociology of technology (MacKenzie & Wajcman, 1999). Interestingly, since the 1990s this literature has revealed the increasing importance of the social dimension in innovation activities, most specifically, technological innovation (Fleck, Webster, & Williams, 1990; McLoughlin, 1999). This previous interest in understanding innovation in relation to human experience has largely been examined through change, brought about through technological advances and their associated social disruptions and ramifications (see McLoughlin & Harris, 1997).

A half a century ago Trist and Bamforth (1951) presented their Socio-Technical Systems (STS) theory which demonstrated the importance of balancing the social and technical aspects of innovation in order to achieve maximum integration and efficiency. From this early perspective, the technological or developmental side and social aspects of the innovation process were seen as relational dimensions, requiring negotiation and evaluation. More recently, Orlikowski (1992) discussed the co-evolution of technology and the human experience. She views the development of technology and the concomitant human experience as two sides of the same coin undergoing an evolutionary process. This builds on the social shaping perspective of MacKenzie and others (MacKenzie et al., 1999; Williams, 1997) who view the human experience as providing the directional momentum in the innovation process. In each of these cases the social experience is seen as being closely connected to the process of innovation.

Grint and Woolgar (1997) take a slightly different tack by arguing that in the social construction of technology there is no boundary between the social and the technical dimensions, with the exception of those that are socially defined. Their suggestion implies a fluid process of technological evolution with the human experience except in the case where limitations, boundaries or interpretations are socially imposed. The Social Construction of Technology (SCOT) perspective illustrates the fact that '*interpretative flexibility*' is inevitable and fundamental in the sociology of innovation. In these examples there is clearly a strong inter-relationship between the social and technological to the point that a successful technological outcome is fundamentally socially constructed and popularly determined.

Although the social contribution to technological innovations is acknowledged within these various contributions, greater attention needs to be given to processes of innovation as a fundamentally social exercise from idea generation and its acceptance, to the integration of the final deliverable. From this position we suggest it is timely to develop theoretical investigations from the sociology of technology to the sociology of innovation, in order to further explore the intrinsic inter-relationship of social intent and innovation outcomes. We contend that social involvement in the development process of commercially driven innovations or more socially driven innovations will inevitably shape their development and be the basis of their perceived usefulness to society. Consequently, any attempt to explore the critical perspective of the 'sociology of innovation' in management and marketing should consider the implicit systems of social positioning, negotiation and interaction undertaken to achieve innovations for commercial gain and/or beneficial social outcomes (product, service or professional).

THEORETICAL ISSUES

A framework facilitating innovation integration is a challenging concept for entrepreneurs and academics alike. An open systems approach has been acknowledged by Dismukes (2004) as being important to such a process in enabling the diversity of changing stakeholders to be accommodated. Merrifield, (2004) refers to the use of a 'disciplined' stage gate model early in the process of technological development, whilst simultaneously acknowledging a general

lack of ‘intrapreneurial’ ability to connect organizational research with business operations. Rogers, (2002) stages of innovation diffusion (knowledge, persuasion, decision, implementation and confirmation) extends the traditional decision making models with its specific application to innovation. These models all provide a simplification of the integration process and while in some cases attempting to express the complexity of interactions and stakeholders, they generally fail to fully express the reciprocal, recursive and reflexive social processes that underlie the acceptance and integration of innovations.

Simon, McKeough, Ayers, Rinehart, & Alexia (2003), in exploring how to best organize for radical innovation, notes the ability to engage senior staff as a significant challenge in supporting successful innovation. Frameworks of social organization, community process, interpersonal associations and professional politics (Jagtenberg, 1983; Nicholson, 1998; Seely Brown & Duguid, 1991; Smith Ring & Van de Ven, 1992) provide an established basis in the literature for developing a framework for innovation acceptance that acknowledges the dynamic socio-cognitive process of integration activities. Deeds, Mang, & Frandsen (2004), writes extensively on the importance of socio-political and cognitive legitimacy in ensuring the flow of capital and resources in high technology organizations however he limits his focus on organizational and industry legitimacy and although he mentions technological legitimacy, he overlooks the importance of the fundamental legitimacy of the entrepreneur and primary stakeholders in the technology integration process.

The underlying social thesis in the integration framework presented here acknowledges that both explicit engagement protocols as well as tacit cognitive structures provide the strategies of association, interaction and relationship building that guide or facilitate stakeholders’ interactions in the integration of innovation and new ideas. To further develop this social platform underlying innovation acceptance a cross-paradigm analysis was conducted across a number of bodies of literature relevant to innovation activities and a process of meta-triangulation of key themes in these literatures was undertaken (Lewis & Grimes, 1999).

Multiple bodies of literature contribute here to a corpus of knowledge supporting the concept of integration frameworks supporting innovation adoption. Collectively examining these literatures creates ‘simulated ecology of interacting theoretical paradigms’ (Sterman & Wittenberg, 1999). This meta-paradigmatic approach to the literature review produces an intellectual nexus for understanding the socio-cognitive complexity of interactions by stakeholders and organizational entrepreneurs engaged in innovation activities. Convergent disciplinary perspectives distilled from these multiple theoretical contributions are condensed through meta-triangulation (Lewis and Grimes 1999). This approach is in keeping with recognition that the complexity of organizations creates inevitable theoretical paradoxes and so comparative analysis and juxtaposition of disciplinary perspectives provides a constructive approach to building theoretical rigor and generating insights (Poole & Van de Ven, 1989). The result is a comprehensive understanding of the dynamic influences, activities and processes that stakeholders engage in during the integration of innovation and new ideas. This type of meta-paradigmatic inquiry has considerable potential for extending understanding of complex and paradoxical organizational phenomena such as interactions and relationships. It enables parallel but disparate theories to be integrated and examines

complementary themes by recognizing theoretical similarities, parallels and inter-relationships as conceptual conjunctions (Lewis and Grimes 1999).

In considering the stakeholders involved in the integration of biotechnology we consider here stakeholders to be any individual, organisation or agent that can place a claim on the attention, resources, or output that arises from biotechnology. Numerous and diverse stakeholders interact as biotechnologies develop in the research environment and emerges as potentially viable applications for commercial advancement and industrial application (Arora & Gambardella, 1990; Buratti, Gambardella, & Orsenigo, 1993; Karet & Studt, 2001; Powell, 1998; Prevezer & Toker, 1996). In such situations, stakeholder's contexts and actions are interwoven to facilitate associations between stakeholders. The system level analysis offered by Giddens (1984) provides a useful guide for empirical research as it acknowledges that practices of stakeholders converge to allow integration of structure and action through 'milestones of interactions'. These 'interaction milestones' emerge through the routinized intersections of stakeholder practice that become the transformational points in relationships and institutional practice and duly become a conduit for further biotechnology development and integration activities.

Multiple stakeholder interactions can be recognised as the activities of a system of agents who draw from the rules and resources of their organisations to produce and reproduce the tacit rules of interaction (Giddens 1984:25). The integration of biotechnology across such diverse groups faces deep barriers (Liebeskind, Oliver, Zucker, & Brewer, 1996), such as, knowledge asymmetry, skill specialisation, language and cultural differences that exist between professionals, research organisations and end-users. Context is an important moderator of process (Ketchen, Thomas, & McDaniel, 1996) and diverse stakeholder contexts contribute to the asymmetries in the industry which provide incentives for complex interactions between stakeholders (Hamilton & Singh, 1991). Literatures were examined in areas such as technology commercialization and transfer, research collaboration and commercialization, knowledge management, relational marketing (new product development) and the uptake and diffusion of innovations to provide a robust academic foundation to support the concept of innovation integration and acceptance as a framework of entrepreneurial leverage. What is revealed from this theoretical cross examination is that intangible frameworks of social interaction and understanding are vital to validate, legitimize and facilitate the interactive process of stakeholders' in developing their entrepreneurial relationships and in the establishment of frameworks that support and guide entrepreneurial interactions in the process of innovation leverage. Logically this level of interaction hardly requires deduction however the strategic significance in understanding the process of innovation integration and technology acceptance provides a fundamental and powerful tool for entrepreneurs and organizations seeking to advance the establishment of their technological and innovative capabilities.

The literature presented here provides the foundation for the research questions: What are the socio-cognitive processes of innovation integration? How can that process be developed to facilitate entrepreneurial leverage and advance innovation integration activities? Using inductive theory building, insights from the literature suggest that the frameworks that guide

stakeholders' interactions in the process of innovation integration are both consciously and subconsciously deduced through reference to existing implicit and apparent norms, standards, practices, protocols and regulations.

The proposition, 'that the established routines, practices, norms and standards of various organizational stakeholders can facilitate or impede the integration of innovation' is raised. Indeed, a recurrent theme in the literature of inter-organizational relationships is the significant role of relational capital (Grönroos, 1999; Johnston, Lewin, & Spekman, 1999; Kale, Singh, & Perlmutter, 2000; Stuart & Sorenson, 2003; Witkowski & Thibodeau, 1999) as an informal and implicit control mechanism through which actions such as trust, reciprocity and commitment (Dodgson, 1996; Gulati, 1995; Larson, 1992; Smith Ring et al., 1992) establish the bounds of relational practice. Such cognitive structures are derived from scientific, historical, organizational, professional, political and industry contexts and experiences (Jagtenberg, 1983; Tushman & Rosenkorpff, 1992), as well as the ever-present and dynamic social environment, are continually being formed, reinforced and modified through repeated interactions (Grabher, 1993). This process of recursive and reflexive adaptation of the interaction framework is emphasized in our model of innovation integration.

Mesthene (1969) observed that the creation of new opportunities in technology and science appears to require 'the emergence of new values, new forms of economic activity, and new political organizations', but also that this new system of values and organization 'poses problems of social and psychological displacement' (Mesthene, 1969). Clearly, accepting new ideas and innovations requires stakeholders to be open to new approaches. Amesse & Cohendet (2001) goes further with this view of the process of technology transfer as a specific 'knowledge transfer' process, reliant on the efficiency sought through creating a 'common code' between groups to facilitate the flow of information and knowledge. Large, Belinko, & Kalligatsi (2000) refers to 'linchpins' as those individuals responsible for ensuring appropriate and timely information transfer and team management in the technology commercialization process. These tacit processes confirm the foundation for a socio-cognitive framework of innovation acceptance and integration. As such, the literature reveals an intangible tool for the acceptance and entrepreneurial leverage of innovation through the recognition of the validity and importance of these inter-personal structures in the transfer and integration of new knowledge and new technologies.

The theoretical paradigm developed here supports the concept of unique frameworks of innovation acceptance and integration as it recognizes that both explicit and implicit socio-cognitive structures underlie stakeholders' interactions. Further these structures and interactions provide a necessary and fundamental framework for the various management and organizational tasks which support the leverage and uptake of entrepreneurial activity. Massini, Lewin, Numagami, & Pettigrew (2002) suggest these structures exist, not only as overt codes or predefined parameters for action, as in administrative and governance controls, but also as subtle and implicit parameters such as, tacit expectations, routines, norms and standards of behaviour. These parameters have previously been acknowledged as arising as a result of socio-psychological bonds of interpersonal interactions and political processes (Jagtenberg, 1983; Smith Ring, 1992).

Clearly these intangible frameworks supporting innovation acceptance and integration can be seen to be not only deeply embedded in the socio-cultural environment of the stakeholders, but also potentially codified in institutional policy and governance structures. This is significant as it acknowledges a recursive process of reflection rather than a strict practice of reference to a particular framework of innovation acceptance and integration for successful entrepreneurial integration. The role of the entrepreneur in introducing innovations and negotiating with stakeholders remains reflexive and unique as each situation and opportunity requires strategic revision of the framework of activities to maximize successful interactions. This is particularly significant for those in practice who seek to create entrepreneurial leverage in dynamic and complex high technology industries. Indeed, Sydow & Windeler, (1998) note the recursiveness of social *praxis*¹ which is intricately involved in developing frameworks of biotechnology integration

Complexity and uncertainty in high technology environments require stakeholders to seek recognizable frameworks for interaction in the less volatile structures of organizational and stakeholders norms, standards and expectations. Those shared rules, beliefs and patterns of action create a framework of 'typifications' that provide the blueprints for organizing (Barley & Tolbert, 1997), and bear out the concept of an innovation integration framework. This is also confirmed by the work of Pisano (1990), who noted that historical patterns of R&D procurement reflect deeply ingrained repertoires, rules, operating procedures and routines. Additional support of the concept of integration frameworks is provided by Van de Ven, Emmett, & Koenig, (1974) who noted that established frameworks of relating are likely to inform the emergent normative structures and expectations between new stakeholders in inter-organizational activities.

In the bioindustry, practitioners relate across a range of professions and contexts to facilitate technology integration. This ability to interact proficiently and effectively between groups can be considered as a 'community of practice'; a framework of common understanding that provides the basis for ongoing relations (Grabher, 1993). Capello (1999) notes a 'community of practice' can be seen to occur where learning is derived from the relations and practices of members who share rules and procedures, in a socially embedded process. Such common understandings and expectations then provide a shared foundation for work, learning and innovation activities (Seely Brown et al., 1991).

Further to this Wikström & Normann (1994) also confirms how knowledge-sharing interactions and relationships enable stakeholders to recognize, exchange and negotiate mutual opportunities and shared values so that a consensus can be developed through a 'community of understanding' (Håkansson & Henders, 1995). Indeed, the accumulation of knowledge has been cited as a critical factor in the evolution of new technologies (Dosi, 1982) and can be recognized as not only an initiating factor for invention, but as now apparent, also a fundamental part of stakeholders learning process in the framework of innovation acceptance and integration. These reticulated refinements of knowledge,

¹ *Praxis* refers to the day-to-day activities undertaken in normal circumstances i.e. the customary practice, the actual way something is done, routine procedures Tullock, S. (Ed.). 1993. ***The Reader's Digest Oxford Complete Word Finder***. London: The Reader's Digest Association Limited.

information and expertise through a community of learning, sharing and understanding are in fact the essence of Rothwell's (1994) fifth generation innovation process. Thus these preceding works confirm the views of Howells (1996) and Amesse (2001) that a framework that enables the transfer of knowledge and understanding between stakeholders can facilitate acceptance and aid the motivation to integrate new technologies and innovations.

The social structure of business relationships is noted as a significant influence on the perceptions of new business ventures (Stuart, Hoang, & Hybels, 1999). Where new ideas and innovations are a result of complex interactions, the conflicting and pluralist views of its effectiveness are not surprising, and tensions or contradictions are inherent between multiple constituents in such dynamic and uncertain environments (Eldred & McGrath, 1997; Sydow et al., 1998). What is clear from this is that frameworks supporting the development and integration of innovation activities and including biotechnology, exist embedded in norms of relationships and associations, and also constantly require attention, adjustment and refinement to maintain and support them. To establish an effective framework of integration between various groups, Amesse (2001) suggests building a common agenda on the basis of organizational objectives, mutual expectations and acceptable practice by creating a 'common code' or a specific knowledge transfer process to facilitate the flow of information and knowledge.

The concept of integration frameworks recognizes stakeholders as gatekeepers in the innovation process albeit embedded within their organizational, technological and professional contexts. It combines the reality of stakeholders, as complex rational beings, negotiating a shared institutional understanding in the innovation integration process (Giddens, 1979; Jagtenberg, 1983; Stein, 1997). The framework deduced from the literature acknowledges stakeholder's individual idiosyncratic perceptions within the path-dependency of organizational operations and the community's interactive practice. As noted by Powell (1998), stakeholders clearly don't exist as isolated entities, suspended in time and space within their environments, but rather are embedded in an evolving organizational and technological community.

The socio-cognitive framework associated with the acceptance and integration of innovation and entrepreneurial activities can be seen to be a process of legitimation, as stakeholders sanction and entrepreneurs enact the activities, behaviours and practices they view as being appropriate for the inter-organizational context (Sydow *et al*, 1998:272). Even though these methods of interacting are common and consensual, they remain personal and unique to each relationship, and are undertaken in a multitude of ways that are uniquely contextually bound, path dependent and socially embedded for different stakeholders in various organizations.

Complexity and uncertainty in high technology environments require stakeholders to seek recognizable frameworks for integration to guide interactions through the potentially volatile structures of organizational and stakeholder's norms, standards and expectations. Those shared rules, beliefs, and patterns of actions create an integration framework as a socio-cognitive means for negotiating innovation acceptance and integration and as a key tool to enable entrepreneurial leverage.

As the acceptance and integration of innovation and the strategic importance of activities that facilitate entrepreneurial leverage continue to be a challenge to organizations, many established organizations with clear systems of production, manufacturing and processing proceed with an uncertain view of the integration process, as it currently exists without guidelines for best practice. This disposition increases the uncertainty of stakeholders and raises the risk associated with the introduction and investment of innovation. Fortunately, increased uncertainty and complexity generally results in an increase in stakeholders promoted by the desire to establish stable frameworks of integration (Burkhardt & Brass, 1990). The Australian biotechnology industry is such an environment, having multiple diverse stakeholders seeking to support emerging innovations both at the organizational and industry levels. As such, it provided an environment ripe to test our proposed framework of integration and in the next section, the details of that research is presented.

METHODOLOGY

An interpretive sociological perspective was adopted for this research through the qualitative analysis of semi-structured interviews that sought to reveal the existence of frameworks supporting the acceptance and integration of biotechnologies as strategic tools for entrepreneurial leverage. The move towards interpretive philosophies as a method for grounding research in a sociological perspective is well established in management studies (Alvesson & Deetz, 2000; Zammuto, 1984) and has been used to understand the relational interactions and the hermeneutics of humanistic factors in the analysis of organizational issues (Prasad, 2002; Robson & Rawnsley, 2001). Interpretive methodologies provide a critical extension to qualitative methodologies by ensuring context and dynamics are recognized as significant contingent factors in the empirical field (Denzin, 2001; Matthyssens & Vandenbempt, 2003).

In grounding this research within an interpretive philosophy, this paper offers a new approach to understanding stakeholder's interactions in the acceptance and integration of innovation by acknowledging multiple contexts, motivational agendas and contingent influences that inform the various entrepreneurs and stakeholders relationships. By acknowledging multiple contexts, motivational agendas and contingent influences inform the various entrepreneurs and stakeholders relationships, the complexity of social acceptance is recognised. This is in keeping with the triadic reciprocal framework presented by Wood and Bandura (1989) which acknowledges the recursive development of the decision-making that we present as fundamental to the acceptance and ultimate integration of biotechnological innovations (see Figure 1).

-- INSERT FIGURE 1 HERE --

In exploring the concept of integration frameworks four case studies were undertaken. The versatility and relevance of case study analysis for theory building in contemporary and pre-paradigmatic research fields was a fundamental rationale for using this methodology (Perry, 1998). Each case presented a different context of biotechnology research in Australia. These were a) the wider bioindustry, b) an agricultural research organization, c) a human

therapeutics research laboratory and d) medical diagnostics company. Further to this, these cases also represented a) industry, b) government, c) tertiary, and d) commercial perspectives respectively. Purposeful case selection was undertaken to enable dissimilar examples to contribute to theoretical development as well as to the transferability, generalisability and empirical soundness of the empirical research beyond what is possible with a homogenous sample (Eisenhardt, 1989). Following individual case analysis, a cross-case analysis enabled the examination of the collective evidence to reveal empirical parallels across the cases and congruence across the bioindustry sectors.

Empirically, a multiple participant approach was adopted to provide a research methodology that makes sense of more than the observed reality of the entrepreneurial environment. Alvesson and Deetz (2000) note a multiple participant approach is not new in organizational studies and is achieved by extending interpretation through multiple ‘dialogues’ (Denzin & Lincoln, 2000) which grounds the research outcomes in the experienced realities of stakeholders. These multiple dialogues provide a robust depiction of stakeholder interactions through the identification and subsequent exploration of dominant ideas and significant themes (Numagami, 1998). In doing so, this approach enables holistic theory development across diverse perspectives and positions while avoiding preconceived pattern seeking which may suppress understanding of complex social systems (Moss, 2001; Stacey, 1995).

The multiple participant perspective in organizational studies provides management research with a methodology that addresses the epistemological ground rules necessary for acknowledging the social construction of organizational knowledge (Crotty, 1998; Jagtenberg, 1983). Alternative approaches frequently imply an analytical isolation of the diverse contextual elements of entrepreneur’s activities and so ignore the dynamic way in which those factors frame interactions and influence the construction of knowledge and inevitably the frameworks of acceptance and integration of innovations through their recursive expression (Butel & Watkins, 2000; Dooley & Van de Ven, 1999). Conversely, the multiple participant approach is able to embrace the broader interplay of stakeholders’ diverse and dynamic contexts as they continually re-inform and recreate the interactive paradigm of knowledge and understanding of biotechnology innovation.

The empirical evidence for this research involved interviews with representatives from diverse positions in the bioindustry; all involved in biotechnology innovation. This was a multi-level analysis of stakeholders from diverse roles and hierarchical positions within each of the case studies to ensure representation of the perspectives of diverse participants in these innovation activities. Interviews were conducted across multiple bioindustry stakeholder groups including industry (MNC’s, publicly listed Co’s, spin-outs etc), research (public, private, corporate, government), government (local, state and federal) and business (financial/accounting, venture capital, entrepreneurs, marketers etc) professionals. Table 1 reveals the positions and roles of the stakeholders interviewed from the Australian biotechnology industry and research organizations.

(INSERT *Table 1* HERE)

In-depth semi-structured interviews provided over 400 hours of qualitative data which revealed significant insights into the relational experiences of stakeholders in the process of innovation acceptance and integration. The multi-level research approach which was undertaken here provides a critical view of these interactions and experiences by recognizing that biotechnology stakeholders interact in a heuristic process of innovation acceptance and integration. This critical approach is gaining greater acceptance as management research seeks to understand the co-evolutionary influences of complex environments and multiple stakeholders (Lewin & Koza, 2001). Moreover it is useful here as it enables heterogeneous knowledge inputs of stakeholders to be recognized as contributions and contingencies to their interactions and the development of integration frameworks.

Inductive theory building from the case data through thematic analysis and cross-case examination enabled the complexity and dynamism of stakeholder interactions in the bioindustry to be acknowledged by revealing common themes emergent across the diversity of interviewed groups. In this way, the deduced themes extend the existing knowledge paradigm of stakeholders interacting in the bioindustry through theory development by comparison of observable facts with the theoretically known (Webb, 1995). In keeping with the format of semi-structured interviews, interviewees were asked questions following a series of key issues under investigation however both the interviewer and the interviewee are given the flexibility to develop the discussion and disclose information that they feel is relevant or important to those issues.

In this research the key theme under investigation, the process of acceptance and integration of new biotechnologies, was apparent at the outset. Further questions introduced issues such as 1) the role and importance of relationships in research development and innovation acceptance; 2) the influence of policy, protocol, rules, resources and strategy on innovation acceptance and the integration process; 3) factors affecting the directions and motivations of research and innovation development and 4) the affect of industry and organizational expectations on competitive development, risk and innovation legitimization. Interviews were conducted on a one-to-one, face-to-face basis.

This style of idiographic research of the multiple stakeholders engaged in entrepreneurial and innovation activities facilitates discussion and reflection of the ambient conditions that influence their interactive environment and encourages these to be revealed. In this way the research investigates both the stakeholder's perspectives and their interactions to disclose the motivational objectives in the interactive agenda. This reflective duality acknowledges the existence of stakeholders' original agendas and primary motivations as well as their subsequent shared agenda and negotiated objectives in the process of innovation acceptance and integration.

RESULTS AND DISCUSSION

The evidence from the four case studies revealed stakeholders and their network participants were active in complex associations that raised support and acceptance of biotechnologies relevant to their research agenda and organisational outcomes. This is in keeping with the

established positions in the literature that innovation is a fundamentally social exercise (Bessant et al., 2007; Fleck et al., 1990; MacKenzie et al., 1999). One interviewee commented that:

The company interacts with the investment community, lawyers, patent attorneys, auditors, tax advisors, basic accounting firms....certainly the industry association, maybe other research institutions, and other research groups, and government.

Reputation, professional associations, research connections and history contributed to activities in the wider relational architecture. In the case studies, stakeholders mentioned R&D objectives, regulatory guidelines, consumer/end user attitudes, public policy directives and an uncertain wider international context as factors that needed to be considered in negotiations in order to progress their integration objectives.

With integrating new ones (biotechnologies), it is the path of least resistance within the context of the regulatory bodies, and the funding bodies and also to a certain extent the peer group as well.

These various factors were seen to influence stakeholders' biotechnology integration activities. The relational complexity of stakeholders, their significant multifarious influences and contexts in stakeholder integration activities can be illustrated by proposing an acceptance paradigm within the conceptual relational architecture (see Figure 2). The acceptance paradigm illustrates the consensual position of interacting stakeholders required to facilitate progress in integration activities.

--- INSERT Figure 2 here ---

In the cooperative environment of the Australian bioindustry, networking activities were supported and encouraged by key stakeholder groups acknowledging the dynamic socio-cognitive process of integration activities consistent with Dismukes (2004) open systems approach that accommodates the diversity of changing stakeholders and multiple frameworks of social organization, community process, interpersonal associations and professional politics:

The personal relationships in Australia are important. I think any endeavour, which has a huge amount of creativity about it, requires personal relationships.

Stakeholders, in the case study organisations, all disclosed that they had participated in these external networking activities and confirmed the usefulness of these activities to create and develop biotechnology integration opportunities and associations. Given the importance of socio-political and cognitive legitimacy in developing relational networks (Deeds 2004), it's clear that the value of relational capital and the social investments necessary to develop these are appreciated in the Australian bioindustry. Wider industry level sanction was considered essential to engage new groups in the integration process. Most stakeholders interviewed in the Australian bioindustry made it known that they actively engaged in open and flexible interactions to support biotechnology integration activities. As one interviewee explained:

We are a very open company, we share information and we believe in working with people inclusively because everyone has something to offer.

An exclusion to this was in the case of a stakeholder, who was a R&D head in a large corporate multi-national organisation, the executive of which had informed the R&D department that biotech' improvements were not considered to be economically viable. The general adoption of activities such as cooperation, communication, and engagement are consistent with philosophies of open innovation confirm Mesthene's (1969) view that new systems will be put in place that will challenge some participants. Professionals from business, commerce and industry, as well as the case study organisation, were all shown to participate in industry networking activities. These activities suggest that social interactions assist them to become recognised as legitimate players in the integration process. New associations and diverse interactions were routine in the emerging bioindustry relational network. Transient relationships and open communication between stakeholders were seen to enable flexible relational parameters for participants who sought information and/or opportunities to participate. These flexible recurrent activities reveal how the knowledge transfer process (Amesse, 2001) seeks efficiency by creating a 'common code' between groups to facilitate the flow of information and knowledge.

I think the more we can encourage people to be more mobile to understand how the other sector (biotechnology) works so that they don't come into a relationship imagining where a person is coming from and having absolutely no idea of what the realities are in that industry and what the imperatives are for that person.

Cooperation was considered as fundamental in all cases and was demonstrated across various operational and professional groups. Stakeholders in each of the cases revealed multiple levels of integration activities, and various gatekeepers were involved, dependent on the degree of disruption caused by the particular integration. For example, at CommTech, integration of a new bio-technique into the R&D process would require formal sanction from the project leader. However, at AcaBio a post-doctoral researcher could instigate the integration of a different biotechnique (usually after informal discussions with the team leader) if a particular technique was considered to be unsatisfactory. The important common element in these interactions was that researchers preferred not to make significant changes in biotech' protocols without consulting anyone. Clearly the organisation's structures of control and authority are maintained, as suggested by Pisano's (1990) acknowledgement of historical patterns of R&D, but apparently there are also implicit expectations of consensus even where minor changes may be affected. As one informant noted:

'we constantly seek input from other intellectual brains; it's always an ongoing thing.'

The confirming opinion of a peer, team worker, project leader or research associate could be recognised as valued and sought when the integration of new biotechnologies was required in the R&D process. The relational architecture in these cases provided the reference contact through the deliberate search activities of stakeholders. The concept of relational architecture proposed in this paper embraces the stakeholder's professional and social networks employed

in the research development process as context for action. That context can be considered as a community of practice, consistent with Grabher (1993) & Capello (1999), derived from the shared understanding and values of the research scientists striving to leverage their science.

You have to utilise people that are going to benefit you, but then you have to manage that relationship because they're not going to work with you unless they see what's in it for them.

Each case demonstrated activities of differing scope within those networks, the frequency and extent of those interactions largely related to the 'newness' of the biotechnology being proposed. Information initiatives and networking activities were undertaken to engage potential stakeholders across broad research and professional groups in the earlier consideration (sanctioning) stage of the integration process. It is interesting that at this early stage, social networking appears to have a significant role in validating various biotechnological ventures. This interpretative process of technological socialisation is strongly reflective of Grint and Woolgar's (1997) Social Construction of Technology (SCOT) perspective. Activities across all case studies confirmed the information agenda as a strong influence in relational activities supporting biotechnology integration in the research development process. This evidence is consistent with Dosi (1982), Rothwell's (1994) and Amesse (2001) in that information, and the subsequently derived knowledge, is critical in the development of new technologies as well as the generation of stakeholder's commitment through understanding and acceptance of the innovation integration.

Interviewees in all case studies also confirmed the role of positive political activities in support of the emerging bioindustry, as paving the way for the development of new relationships and interactions. Funding incentives and political infrastructure set up to support biotechnology commercialisation activities demonstrated government's belief in the potential economic benefits to Australian and state based industry, and was a key influence on stakeholder's activities.

I think we need to be in the face of the federal government with what we're doing... just for them to see what is happening here ... just building the relationship and for if there are federal government programs for us to get a fair share of that.

The case for the wider Aus. Bioindustry clearly revealed the perception of a bioindustry environment open to the growth and integration of biotechnology applications and product and process outcomes. Collective evidence from the four cases is summarized and discussed here in relation to how that evidence supports or refutes the proposition: *The integration of biotechnology occurs through a complex and strategic process of stakeholder interactions.* The discussion is developed with reference to the conceptual model of relational architecture, proposed as a mechanism for understanding the activities of stakeholders, through their relationships and interactions, as they influence the integration of biotechnology.

You have (to have) the right technology and the right people and the right structure in relation to your planning processes.

For each case, multiple, complex and strategic relationships were seen to contribute to a corpus of biotechnology knowledge and expertise being intentionally cultivated by stakeholders. Integration in each case relied on a shared acceptance of the use and application of a particular technology by key stakeholders as well as the recognition of up-stream benefits for the organisation. In all cases both formal and informal discussion between key stakeholders, peers and professional associates was undertaken before a biotechnology was sanctioned.

It's very important to have people (in the bioindustry) that can see most of the connections that are required. So that those connections can be managed... complex issues that need to be resolved and each of them require(s) negotiation... ' it's the complexity and multiplicity of the relationships and conversations that need to be had to go to the next step.

Such interactions could be recognised as legitimisation activities and involved multifarious relationships and complex interactions either actively pursued (particularly with significant strategic stakeholders) or casually involved (particularly in the case of peer opinion) in an apparently recursive process of biotechnological promotion. As stakeholder's and entrepreneurs sanction the activities, behaviours and practices they view as being appropriate for their inter-organizational context they implicitly made them legitimate (Sydow 1998:272).

And I actually think it comes down to people and culture - nothing to do with potential or capabilities.

This has always been the central dilemma; the two cultures (business and science) you're working in are completely different... I just find it incredibly frustrating.'

Both the literature and the empirical evidence of this research confirmed that the collaborative community makes a significant contribution to the process of legitimation in the validation and uptake of biotechnologies. From this it is apparent that the integration of biotechnologies into the established systems can be seen to occur via this process of gradual acceptance and recognition of value-adding potential.

These fundamental interactions fit well with the concept of relational architecture as it is proposed to describe the relationships and interactions of stakeholders motivated to promote biotechnology integration. The issue that is then duly raised through this interpretive approach however is that in exploring the 'sociology of innovation' in management and marketing there is clearly a gap for critical research. An opportunity thereby exists to consider the potential problems of these implicit systems of social positioning, relationship disparities in negotiations and resistance to interactions that undermine innovations for commercial gain and/or beneficial social outcomes (product, service or professional).

CONCLUSION

This paper presents a framework for innovation integration which contributes to the skills set of entrepreneurs, biotechnology research organizations and other high technology companies. Understanding the reciprocal and socio-cognitive basis of negotiation and acceptance is important for entrepreneurs and innovation practitioners wishing to embark on strategic relational activities. Entrepreneurial leverage may subsequently be achieved by pursuing a fully informed framework for integration by undertaking activities such as contextual reconnaissance and deliberate engagement of key stakeholders early in the development process to facilitate the commercialization and adoption of biotechnologies and innovations into existing organizational systems.

Integrating innovation has been shown through this research to be more than just the introduction of an explicit technological asset into an established system. This work advances previous research in the area by revealing the integration process not only influences organizational change to aid negotiation and accommodation of the innovation but also, that innovation acceptance and integration requires social adjustment in other parts of the system in the process. This dynamic system approach addresses some inadequacies of previous research in innovation decision making, technology transfer and innovation diffusion by enabling a holistic negotiation of the social, contextual and technical environment and its stakeholders into which the innovation is being introduced. In this way, innovation integration can be seen to involve the specialist adaptation of activities and expectations to enable its inclusion into an established system. Ultimately, the successful negotiation of a shared agenda and the integration of these innovations means they become part of the

dominant paradigm that goes on to inform the norms and practices of stakeholders and entrepreneurs in further leveraging activities.

While the results of the empirical research in this paper are limited to the Australian biotechnology industry and concomitant biotechnological innovations, there are clear parallels with stakeholder's interactions and entrepreneurial activities in other innovative and high technology industries providing many opportunities for further research. Nonetheless a major conclusion derived from both the literature and results presented here, is that both tacit and explicit organizational and socio-cognitive structures provide the framework for innovation acceptance and integration activities through recognition and negotiation of acceptable norms and practices. These findings are undoubtedly significant for entrepreneurial stakeholders as they seek to leverage their activities in dynamic and complex high technology industries.

This research also provides an opportunity for entrepreneurs and stakeholders in the biotechnology industry to recognize the complex nature of the frameworks that support the integration of biotechnology innovations. Furthermore, the evidence strongly supports the proposition that an essential requirement of constructive collaborative associations and alliances in the biotechnology industry, that are aimed at achieving innovation integration, is to deliberately enlist strategic stakeholders and incite known paths of interaction along common lines of practice that will provide stability and flexibility to all parties to facilitate the further relational advancement and the integration of biotechnological innovations. We conclude that the transfer of knowledge, information, resources and understanding through networks of stakeholders in biotechnology, contributes to entrepreneurs ability to recognize and leverage their opportunities as well as interpret and negotiate a shared framework that supports innovation acceptance and integration. In sum, frameworks of innovation integration proposed and supported in this paper arise through the recognition of malleable norms, practices and routines of stakeholders that define the dynamic socio-cognitive parameters for their innovation integration activities.

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Table 1. Case study interviewee details

Case Study	No. of Interviewees	Interviewee positions
Tertiary/University Human Therapeutics Research Centre	12	3 x Post-doc Researchers, 3 x Scientific Research Assistants, 2 x Scientific Research Fellows, 1 x Program Leader/Scientist, 1 x Centre Director/Scientist, 1 x Head of School/Scientist, 1 x Head of Faculty/Scientist
Government Agricultural Research Organization	11	4 x Technical Research Officers, 3 x Biotechnologists, 2 x Research Scientists, 1 x Director/Scientist, 1 x Policy Officer
Commercial Medical Diagnostics R&D Corporation	13	3 x Team Leader/Scientist 3 x Research Scientist 1 x Production Manager 1 x Marketing Manager/ Scientist 1 x New Product Manager/ Scientist 1 x Regulatory Manager 1 x Chief Financial Officer
Wider Australian Bioindustry	13	3 x Industry Executives 6 x Government Agents/Researchers 5 x Directors/Managers/CEO's 4 x Scientists/ Entrepreneurs <i>Some interviewees held more than one position relevant to the research.</i>

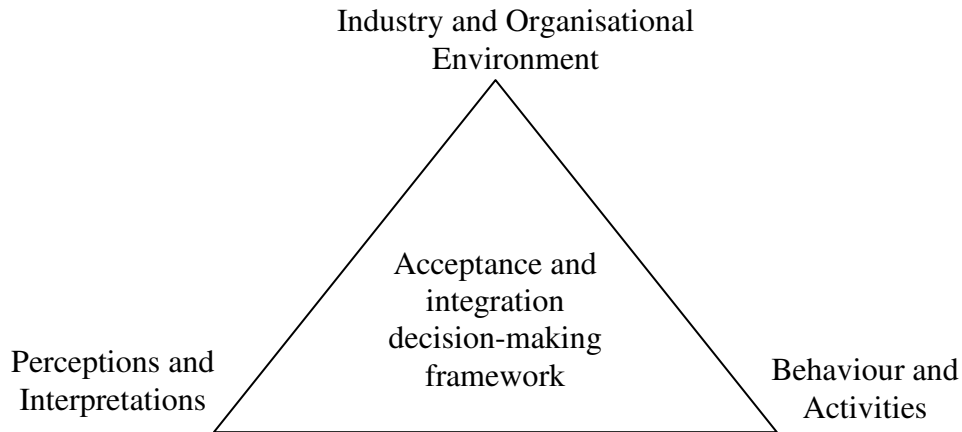


Figure 1. Dynamic recursive process of triadic negotiation by stakeholders in considering 1) behaviour and activities, 2) social and professional perceptions and interpretations and 3) social, industry and organisational environments (adapted from Wood and Bandura (1989)).

Biotechnology Push

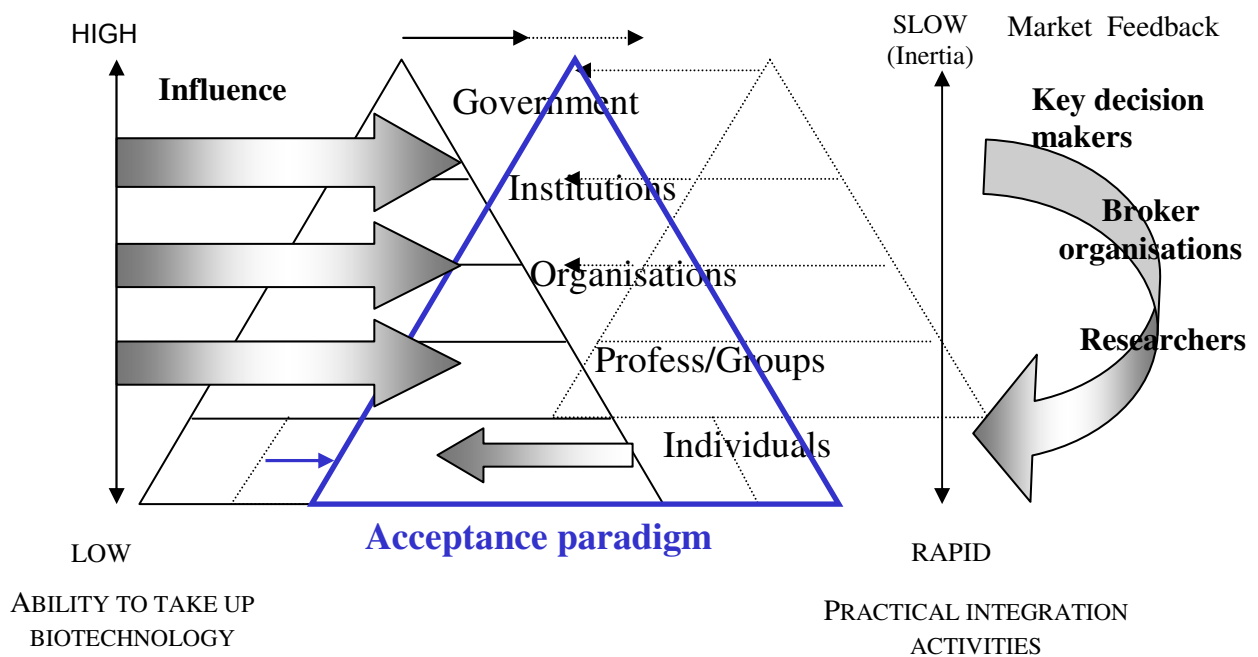


Figure 2. The sociology of acceptance and recognition of biotechnology between stakeholders and organisations.