HAS KNOWLEDGE MANAGEMENT MISSED THE BUSINESS CONTINUITY BOAT?

A STUDY OF VULNERABLE UNIVERSITY KNOWLEDGE ASSETS

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ABSTRACT

Universities are knowledge banks for society and incubators for innovation. When disaster strikes a university, knowledge assets may not be fully protected. The proposed Knowledge Vulnerability Assessment framework identifies unprotected knowledge most at-risk during a disaster. This includes individual and group tacit knowledge, adaptations to routines and instrumentation, and collaborative relationships. To date, knowledge management may have missed the boat in university continuity planning, however, intensified participation in the future may protect and foster research and discovery (R&D) knowledge assets.

1. INTRODUCTION

Higher education institutions (HEI) are knowledge banks for society and engines for innovation. University innovations contribute to a supply chain of knowledge-related products (Teece, 1998; Lockett et al., 2008). Over the past 30 years, United States (US) universities have spun-off 4,000 new enterprises and worked with partners to generate 658 new technology-related products involving over 18,000 patent applications (AUTM, 2009). In 2007, research at US universities grew to a record $48.8 billion with government, industry, and international support (AUTM, 2007). More over, some research productivity is not reported in the AUTM university statistics, including collaborative alliances and sweat-equity arrangements where research resources may cross organizational boundaries but funding does not.

In the last decade, continuity planning has emerged as a management practice to prepare organizations for natural, human and technological threats, and related unexpected events. By preparing for disaster and protecting highly valued people, facilities, information and technologies, universities theoretically reach an adequate level of risk reduction to ensure post-disaster operations (Ruettgers, 2003).

US HEI are required by federal law to establish continuity of operations plans (McCluskey, 2007). Universities face a number of challenges when preparing continuity of operations plans including an open fluid environment, diverse beliefs and subcultures, and the balance between preparedness and rigid security controls (McCluskey, 2007). HEI have been responsive to policy mandates by establishing clear priorities— human lives, protected facilities, fortified information technologies, and plans for business recovery. The relationship between university continuity planning and preservation of knowledge resources has not yet been fully explored.

2. PURPOSE

Imagine a wooden boat waiting in the Humber Estuary. In a devastating event, this boat is entrusted with Hull University's jewels of knowledge and will carry this knowledge to safer shores. After the crisis subsides and the boat returns, will the essential ingredients of innovation be among the treasures on the boat?

The question addressed by this paper is: If an unmitigated crisis occurred at this university today, what *research* and *discovery* (R&D) knowledge would endure and what would not perish? How would the loss of tacit knowledge impact the university's capacity for innovation? Finally, what is the role for knowledge managers in addressing the identified knowledge vulnerabilities?

This paper examines knowledge vulnerabilities at each step in the business continuity planning cycle. The Knowledge Vulnerability Assessment (KVA) [1]is presented as a framework to highlight realms of unprotected knowledge assets which may be at-risk in many research-intensive institutions. This paper focuses on the knowledge lost or "invisible" to the university in the first step of continuity planning where assets are identified. These are the innovation-generating knowledge assets which fall outside the traditional university continuity plans. Traditional realms of coverage include: physical, human and information resources.

The following definitions have been adopted.

'Knowledge management' (KM) fosters the creation, accumulation, organization, reuse, retrieval, sharing, and transfer of knowledge in organizations (Alavi and Leidner, 2001; Liebowitz, 1999).

'Discovery' is the process of developing proprietary, closely-held, embodied knowledge on the research and discovery (R&D) unit level. These locally embedded knowledge assets have not undergone the evaluation and valuation process.

"Disclosure" is a value-creating process for intangible innovations and discoveries. University inventors enter a process with patent and copyright attorneys to formalize their discovery. The disclosure process qualifies a discovery as unique (or redundant) and possibly market-worthy. Disclosure and the processes that follow assign a future potential monetary value on an innovation.

[1]Housel and Bell (2001) propose a methodology to measure the returns knowledge brings to the firm. This method, termed knowledge-valued-added (KVA), shares the same abbreviation, "KVA". The use of this abbreviation does not to imply a relationship between the two.

3. BACKGROUND

3.1. What is Innovation?

Innovation is an improvement on existing processes and/or products. Innovation cannot stand alone (Berkun, 2010), rather it builds from existing sources of data, products, processes, knowledge and experiences (duPlessis, 2007). Nonaka and Takeuchi (1995) in their pre-eminent work describe the dialogue between tacit and explicit knowledge necessary to generate innovation in organizations. Van de Ven (1986) describes innovation as “the development and implementation of new ideas by people who over time engage in transactions with others within an institutional context (p. 591)”. Universities’ capacity to generate innovation lies in their banks of knowledge, well-resourced facilities, and a robust core of knowledgeable human resources (Secundo et al., 2010).

Creation, codification and dissemination are the three central functions of innovation in organizations (Argote, 2005, Cardinal et al., 2001). These functions are punctuated by three processes in the university context: discovery, disclosure and transfer. Table 1 indicates the level at which each university process takes place. Discovery occurs at the R& D unit level. Codification involves both R&D units and university administrators in the disclosure process. Transfer of innovation occurs in a variety of structured and unstructured social interactions between R&D units and external knowledge alliance partners (Inkpen and Tsang, 2005).

Table I. Innovative Function, University Process and Level of Activity

INNOVATIVE FUNCTION	UNIVERSITY PROCESS	LEVEL OF ACTIVITY
Creation	Discovery	Research and Discovery (R&D) Unit
Codification	Disclosure	R&D Unit to University
Dissemination	Transfer	R&D Unit to External

3.2. Creation—Discovery

The knowledge creation process in universities occurs on the R&D unit level where a dialogue takes place between and amongst trusted scientists and their fellows, colleagues, lab teams and collaborators. Innovations emerge when an environment facilitates discovery through individual interaction with technology, instrumentation, and with other individuals in the unit and collaborators with the unit. Creation also involves manipulation of biological and intellectual research resources by members of the unit. An example of this is staff interacting with a genetic database or incubating certain cells for experimentation. In this manner discovery is locally embedded in the people and in the technology and routines of the universities as the source of knowledge (Argote, 2005; Argote and Ingram, 2000). Tacit knowledge is generated through experiences on the discovery team and embodied by team members (Saint-Onge, 1996). Working from a shared base of scientific knowledge, teams may integrate new discoveries into a new threshold of shared meaning on a tacit level.

Innovation processes are highly social and difficult to identify, quantify and protect (Borghoff and Pareschi, 1997). Knowledge can be held in the mind, embedded in group processes, operationalized in procedures, and exemplified in the interaction between data/information and human thought processes (Alavi and Leidner, 2001; Johannessen et al., 2001; Saint-Onge, 1996).

Universities and governments deploy technology-intensive initiatives to foster innovation including: large-scale laboratories, seed funding and rsearch resource endowments (Markman et al., 2005). Knowledge repositories and libraries are also technologies which promote the interface between innovators and stores of knowledge (Bezhani, 2010; Kirkland, 2005). BioParks and incubators (Link and Scott, 2003) provide not only high-technology environments, but also geographically desirable conditions for knowledge-intensive interaction with collaborator. Facilities and instrumentation are but one piece in university capacity to generate innovation.

3.3.Codification—Disclosure

Codification of innovation is complex. Because “learning is embedded in [group] the systems, structures, strategy, routines” (Crossan et al., p.529), disclosure involves capturing and formalizing the information that emerges in the discovery process. In HEI, codification is the process of disclosure, when R&D investigators and university officials begin a conversation to formalize discoveries by translating the innovation into terms understood outside the R&D unit.

Explicit knowledge can be digitized, reduced to writing and shared with others (Cardinal et al., 2001). In parallel, the tacit knowledge accompanying an innovation is likely to be practical and closely-held. The contextual understanding of a group of inventors is tied to the processes around the codified discovery (Cavusgil et al., 2003; Inkpen and Tsang, 2005). The disclosure process involves highly experienced lawyers who coach faculty in the codification of all processes surrounding an intellectual property claim. This process of formalizing the discovery intends to identify the source of the innovation and the processes which are embedded in the socio-cultural scientific context at the discovery unit level. Translation is a key factor in the university disclosure process.

3.4.Dissemination—Transfer

Research and development is an expensive process requiring investments in facilities, technologies, human resources and partnerships. To gain a return on investment, the resulting discover must successfully reach the marketplace as a new product (Teece, 1992). The knowledge and facility-intensive nature of R&D universities presents HEI as valuable partners early in innovation and discovery (Cavusgil et al., 2003; Johnston et al., 2010). University-industry partnerships can help discoveries move from laboratory into a product pipeline where the monetary value is determined. In fact, university innovations, in practice, are monetized when commercial viability is confirmed.

Universities are key contributors to innovation through knowledge alliances and other forms of open innovation (Lichtenthaler, 2011). Strategic knowledge alliances can help generate and harvest knowledge (Grant and Baden-Fuller, 2004) but partnerships also add complexity to the exchange and transfer processes. Cultural conflicts arise around trust and differences in organizational decision making. Tacit knowledge transfers require stronger ties whereas codified knowledge and trust are more independent (Nonanka, 1991). Which innovation has value, when, how and why to develop and transfer innovation are all culturally-guided decisions (Choo, 1996).

Knowledge transfer is a key component in university knowledge alliances. Transfer is the active intent to communicate innovation from the source to the recipient context (Argote and Ingram, 2000). The embedded nature of innovation requires tacit knowledge be available for transfer along with codified knowledge. People, routines, and technology hold university knowledge (Szulanski, 2000) and advocate transfer of these "reservoirs" to facilitate transfer of innovation to a new context (Argote and Ingram, 2000). Innovations are standardized for the knowledge transfer process (Argote, 2005), and then must be assimilated into the recipient organization (Nonaka, 1991; Zahra and George, 2002). Because tacit knowledge must accompany codified knowledge, the failure to fully integrate interpersonal and technical aspects of innovation will results in an incomplete transfer of the innovation from the university source to the recipient (Johannessen et al., 2001; Szulanski, 2000).

4. CONTINUITY PLANNING CYCLE AND VULUNERABILTIY ASSESSMENT

Business continuity planning has its roots in information systems architecture; and these roots have had a lasting influence on the lens through which universities approach continuity. Continuity planning is a stepwise process which involves identification, valuation, decision making, and protection of assets. Asset-based protection is the commonly accepted continuity planning approach (Ruettgers, 2003).

Asset identification and valuation is the first step in continuity planning. Recoverable assets and other intangibles are identified in this step which may ensure the growth or continuity of the organization (DeVargas, 1999). Information security is the systematic process of identifying assets, valuing assets, assessing likelihood, evaluating the impact and taking action to reduce information loss. A variety of mechanisms can be used to capture relevant assets. Classification and identification of assets are requisite in an asset-driven business continuity system.

In the second step an asset must be valued before threats are assessed for highly-valued assets. The difficulty arises when valuable knowledge assets are locally held. Their value is undetermined. Thus when using the DeVargas asset-based framework, uncodified and undisclosed knowledge-assets on the discovery unit level may be eliminated from the business continuity planning in step one—These discoveries will not even reach the second step of planning. Some work-in-progress are "invisible" to the institution's primary protectors of assets: information technology, facilities and maintenance, and human resource offices.

Vulnerability assessments contribute essential information, and they aid decision makers in assessing shortcomings and establishing priorities for action (Ruettgers, 2003). Current perspectives vary in how to approach organizational vulnerability assessment, but all assessments converge in the decision-making and priority setting process. In fact, Vidalis' (2004) work has helped risk assessment mature from an IT-centric to an informationcentric point of view. This paper adopts the knowledge-centric viewpoint in business continuity planning.

5. CONCEPTUAL FRAMEWORK

Continuity plans intend to protect university resources. BCP is a process undertaken by the institution to guide university assets in the event of disaster to ensure their protection in university business and knowledge management systems. Knowledge assets must “fall” within the business continuity cycle to ensure protection (Botha and VonSolms, 2004; DeVargas, 1999) . Currently university continuity plans set human, technical, information and physical resources as the highest priorities which is consistent with federal, state, and local government regulatory requirements (McCluskey, 2007).

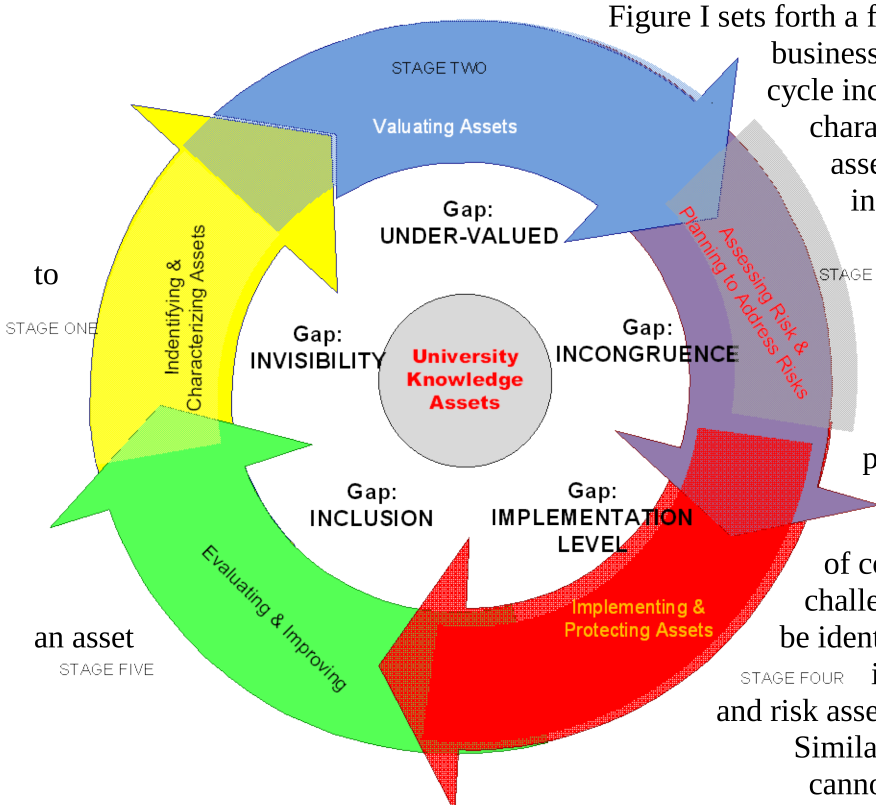


Figure I. Gaps in Protecting University Knowledge Assets By Continuity Stage (Composite by Zaghab, 2010)

Figure I sets forth a five-step asset-based business continuity planning cycle including: 1) identify and characterize assets; 2) evaluate assets for value to the institution; 3) assess asset-specific risks and plan to address risks; 4) implement the protection strategies; and 5) evaluate and improve the continuity plan.

The sequential process of continuity planning is challenging as it requires that an asset be identified before it is included in valuation (step two) and risk assessment plan (step three). Similarly, an organization cannot knowingly protect (step four) an asset that is not in the plan. Thus inclusion of research and discovery knowledge assets in HEI must be involved in step one in order to be protected in step five. In our example, knowledge must purposefully be placed on the boat in the Humber Estuary in order to be protected from whatever terror or natural disaster is to be avoided at Hull University.

Universities are limited in the resources available to protect their people, facilities, technology and information. Items of value to the university are given protection under the business continuity plan. Organizations determine value based on financial and marketplace considerations and cultural factors. Thus, even if assets are identified in step one they may not be a priority in step two due to lack of present value.

As illustrated in table II below, each step of the continuity planning process is met with challenges for tacit knowledge.

Disclosure marks a change for the R&D team. While the research may continue to develop, the disclosed activity signals a point of full disclosure. The codification process on the university level (as opposed to the codified practices on the unit level) is undertaken in earnest.

The value of the disclosed work is largely dependent upon the history of previous discoveries by the R&D Unit. University priority setting around research in progress is also complicated by the distance between innovators and university official. Top-down university decision-making to protect priority knowledge assets is *incongruent* with the nature of locally-held tacit knowledge. The evaluation and process improvement step of continuity planning precludes *inclusion of* local knowledge generating units.

Table II. Asset-based Approach to Continuity Planning: Gaps and Challenges

Step	Gaps	Challenges
One-Identifying Assets	Invisibility	Embodied, closely-held and difficult to capture knowledge is invisible to university knowledge management systems.
Two-Valuating	Under-valued	Once disclosed, intangible knowledge assets are novel and lack evidence from the market about actual or potential value. Value is embedded locally with locally held-knowledge.
Three-Assessing Risks and Planning to Address Risks	Incongruent	Centralized decision-making regarding locally-held assets is incompatible with the understanding of the need to protect this knowledge.
Four-Protecting	Implementation Level	University strategies involve primarily organization-wide policies, routines, and data capture systems. Embedded knowledge is vulnerable on the discovery unit level.
Five-Evaluating and Improving	Inclusion	University decision making and leadership evaluation teams may lack the involvement of innovators and knowledge managers to ensure relevance of plan.

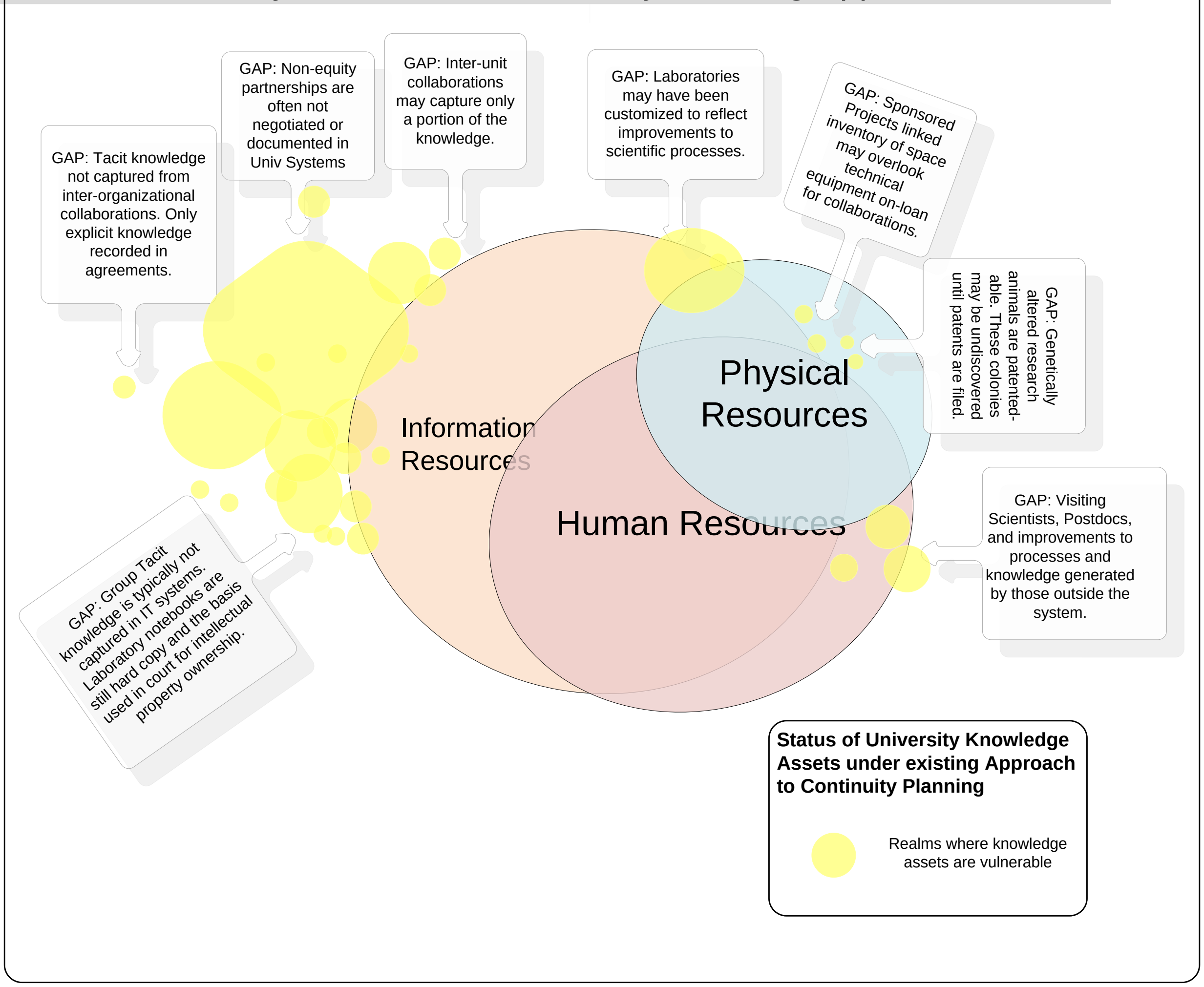
5.1. Framework for Knowledge Vulnerability Assessment

The author proposes a conceptual map of traditionally protected university knowledge assets (human, physical, and information resources) and the realms inside and outside traditional business continuity protections. See figure II.

Human resources, information resources and physical resources are priorities for protection under asset-based university continuity plans. University priorities are responsive to stakeholder requirements including a complexity of federal, state, and university system policies, regulations, and related procedures. To protect human resources, universities establish required organizational policies and undertake implementation to “watch over” the health and well-being of their employees in the case of emergency. During disaster, the universities provide shelters, evacuation plans, and public health facilities. Many institutions provide preventive programs such as first-aid training and employee immunization.

With the exception of technology safety breaches, disruptive events are location-based. From sprinkler systems to biohazard containment, universities have facility plans for a range of potential emergencies. Teams of qualified facilities engineers and maintenance staff attend to the physical plant preparation for emergency.

Figure II. Map of Knowledge Asset Vulnerability
University Asset-based Continuity Planning Approach



The university-wide information assurance plans secure information and technology for the business, financial, legal and regulatory systems on the unit, department, school, and university levels. These systems include documentation related to grants, contracts, material transfer agreements, copyrights, trademarks, and patents. Patient and clinical care data are protected in both hard copy and electronic files. Human and animal protection is in place. Facilities have data monitoring systems and tracking systems for environmental hazards and research related space.

5.2. Realms of Vulnerable Knowledge

This work proposes a framework (figure II) with four realms of vulnerable knowledge in research and discovery intensive universities. While the case study details the application of the framework to human health discoveries where the financial stakes are high, the framework suggests applicability to other fields such as the physical sciences, engineering, and agricultural research.

Areas of vulnerable knowledge appear as a yellow overlay in figure II representing the social nature of innovation during the discovery and transfer processes in research-intensive universities. The framework proposes four realms of vulnerability: 1) person-to-person (including group tacit knowledge); 2) person-to-technology (adaptations and innovations); 3) person-to-routine adaptations, and 4) group-to-group (exchange through social interaction).

Person-to-Person. Research and discovery takes place on the local level where group members participate in joint problem solving. They share many tacit understandings and meanings related to the discovery. Team may involve collaborators inside and outside the organization in formal and informal knowledge alliances, and procedural adaptations for both equipment and technology. Innovations that solve relevant problems for the group require tacit understanding of the context (Polyani, 1966).

Person-to-Technology. Research technologies and R&D instrumentation require practical adaptation to be locally useful. In this manner, tacit knowledge becomes embedded in technology use. Technology, tangible products and processes couple with tacit knowledge to operate effectively (Johannessen et al., 2001). The person-to-technology interaction is where translation and customizations occur. These adaptations are innovations where humans are mediators between a number of technologies in a research-intensive setting. Moving from one piece of equipment to the next involves manipulation of input and translation output from one technical device to another.

Person-to-Routines. Empirical research processes involve established protocols and standard operating procedures so results can be replicated and published. Local adaptations exist between the human and the research routine (Gertler, 2003). Early innovators in in-vitro fertilization talk about the magic they would sprinkle in the petri dish to affect fertilization. Some clinics experienced success in fertilization while others did not. Now such processes are standardized across locations.

Group-to-Group. University teams engage in open innovation with a diversity of knowledge partners at every stage of discovery (Inkpen and Tsang, 2005; Johnston et al., 2010). Transfer of knowledge between groups is a process involving people, technology and routines (Abou-Zeid, 2002; Cardinal et al., 2001; duPlessis, 2007). Transactions occur on the individual, team, unit and organizational levels between collaborating groups. The nature of innovating organizations and the process of knowledge transfer are both social processes (Inkpen and Tsang, 2005).

The dynamic exchange of knowledge changes the knowledge base of the innovator and in the recipient organization (Leonard-Barton, 1988). Some transfers must occur in close proximity due to the contextually embedded nature of the innovation (Gertler, 2003). Social interaction through networks facilitate transfer of innovation through actual or technology-enhanced proximity (Inkpen and Tsang, 2005; Liebowitz, 1999).

6. METHODOLOGY

The Knowledge Vulnerability Assessment (KVA) framework identifies potential gaps in the current approach to university continuity planning. These gaps involve unprotected knowledge on the R&D unit level. In the following case study, the author applies the KVA framework to practice settings and provides details through observation and available reporting systems. Findings are shared on the observation of two administrative entities (Units H and P) in a single research-intensive university (University B) over a three year timeframe. Due to the sensitive nature of the vulnerabilities and the possible but unexpected impact on industry and government funding, the name of the institution has not been used.

6.1.The Case Study

University B is a nationally ranked research-intensive university with a 60 acre urban campus. This HEI is a science and technology hub in human health research. The university occupies 6.2 million square feet of space including a biopark, two medical centers, a forensic lab, and sixty plus buildings housing nearly 150 research-intensive units. Last year, the university reported over half a billion dollars in external research funding and $45 million in industry partnerships (2009). Awards indicate a model of open collaboration at the discovery and licensing stages of innovation development. Material-data transfer agreements represent thousands of knowledge-rich exchanges annually between university innovators and the outside world. Research income contributed 40% of the university's budget while tuition charted only 10% (2008). The pipeline of innovation is promising with 1,200 patents in the pipeline and more than 450 patented products now ready for licensing (www.invenioip.org, 2010). In 2009 the university engaged 2,321 faculty, 1639 science-intensive graduate students, and staff (2008).

The literature establishes a strong rationale for organizations to empower a leader, a chief knowledge officer (CKO) as the chief advocate to optimize knowledge (Earl, 2001; Liebowitz, 2002; Abdelhakim and Abdeldayem, 2009). University B does not have a CKO role equivalent or a position similar in nature to that described as CKO such as a knowledge strategies director, director of intangible assets, a director of intellectual capital nor a head of knowledge development (Liebowitz).

7. ANALYSIS AND FINDINGS

The proposed Knowledge Vulnerability Assessment examines junctures where research-related knowledge assets are potentially vulnerable in Units P and H. Data were gathered from publicly available sources and through direct observation. The examples provided are representative and illustrative but not exhaustive.

7.1. Threats to Continuity

University B is categorized as a soft target. Threats are largely geographic in their impact: biohazard, fire, floods, electrical outage, theft, shooters, and bombs. Earthquakes are unlikely although instantly devastating. Infectious disease, intensified community needs, and civil unrest are more likely threats. Most disasters are bound by a physical location (Cardona, 2002) and as such they can destroy research-related knowledge assets (human life, equipment and facilities, and information) at the location in which the incident occurs.

Location-specific lesser incidents are not rare in Units H and P. Floods, malfunctioning freezers, and intentional or unintentional theft of clinical or laboratory materials can adversely impact the continuity of work in-progress. One example of an unfortunate event happened when Unit H investigator left the country for a conference and was delayed for weeks due to visa issues. Because this expert was the reservoir of tacit knowledge on how to incubate a specific subset of cells, operations ground to a halt for all interdependent laboratories requiring these valuable cells for testing. Lab specific small fires, biohazard spills, and bursting pipes are unfortunately not an uncommon occurrence.

7.2. Realms of Protected Knowledge

Information assurance plans of University B meet and exceed the required standards protecting enterprise-wide systems. Systems protecting information resources include: documentation systems for funded grants, programs, and partnerships; intellectual property databases and data storage systems to gather and protect patent and copyright-eligible disclosures by inventors; human and animal research protocol tracking and approval systems; biohazard and stem cell registration systems; and standardized information technology protocols to protect all data on shared drives.

University B has continuation of operations plans which meet federal and state policy requirements for a research-intensive university. Many of these policies impact facilities and physical resource protection. This includes Presidential Directive-20 National Continuity Policy; Presidential Directive 5 Management of Domestic Incidents; Federal Civil Defense Act of 1950 (as amended); Disaster Relief Act of 1974; Emergency Planning and Community Right-to-Know Act; Stafford Disaster Relief and Emergency Assistance Act; Public Health and Welfare Disaster Relief Chapter 68; Disaster Mitigation Action of 2000; Public Safety Code of State title 14; a state emergency management act; Occupational Safety and Health Administration Standards on Emergency Action, Fire Prevention, and Hazardous Waste; and state university system policy on campus emergency planning, preparedness and response.

The university also has plans to protect facilities in case of disaster including: emergency plans, unit protocols, trained incident commanders, and buildings/laboratories (audited regularly for safety and compliance). Human resource systems have campus-wide functionality; and like all other systems are highly integrated, secure, and password protected with appropriate trust levels. University B has efforts underway to assess the need for highly secure off-site storage for large research-related pre-disclosure proprietary data.

7.3. Case: Realms of Vulnerable Knowledge

Person-to-Person. Observation of Units H and P indicate a continual influx and outflow of people, their ideas, their talents and skills, and related research resources such as tools and cell samples. Some collaborators suggested improvements in laboratory and clinical processes, new methods, and some even lent technology or equipment toward their shared goal. The cycle of engaging and disengaging post-doctoral fellows and graduate students in the discovery team is very fluid. It appears the relationship which begins in the laboratory or clinical site, extends into a social network when students graduate and post-docs move into faculty positions around the globe. In addition, visiting faculty collaborators from campus and around the world were also evident. A rubric to estimate the porous boundaries of the R&D teams and their impact on the process of discovery is provided in tables III and IV. Patterns of exchange across the porous boundaries of these units are not surprising given the expanding person-to-person and history of collaborative interactions with former students, post-docs and collaborators. Even (or especially) after successful disclosures and transfer of discoveries to market, the science lives on in the relationships between units of discovery in the university and outside.

Table III. Findings: Human Resources and Knowledge Alliances (Source SciVal, 12/31/2010)

	No of Faculty	No of Grad Students (Est)	No of Pubs (Actual)	No of External KA (Actual)	No of Internal University KA (Actual)	No of KA per Faculty
Unit P	32	22	490	87	21	3.4
Unit H	58	41	2874	420	30	7.76

Person-to-Technology. Laboratories in Units H and P had no fewer than nine pieces of equipment and instrumentation to conduct their research. While some of these technologies provided computer data as output, most required human-technology interaction. (See figure VII.) This includes sample preparations using technology, equipment set-up, calibration, operation, and interpretation of the results. In addition, highly sophisticated shared facilities and technological testing devices introduce additional staff and adaptations into the research process. The local adaptation of technology and equipment occurs by individual and not just by location. This introduces increased complexities in the identification, codification, protection, and transfer of shared knowledge. The data and local adaptations in the people-to-equipment interface are difficult to document.

Figure VI. Technology and laboratory instrumentation requires set-up, calibration, operation, and interpretation of results. Oftentimes the results of one form of technology must be translated and inputted into a second technology.

They are potentially lost in continuity plan protections.

Site-based technologies and instrumentations are locally held and controlled. This includes information and technology, such as personal drives, laptops, hand-held devices, equipments generating data, clinical protocol notebooks, laboratory notebooks, and clinical trial participants. Other information may not be recorded such as special cell-lines in the freezer, or the tacit process between people and the technical equipment they operate. Still other knowledge activities are dependent upon external information systems. (See figure VI.) One national center interfaces continuously with a national mapping and imaging capability. In summary, both P and H adapted and customized national protocols to local platforms.

The tacit knowledge each individual holds is irreplaceable, but group tacit knowledge (such as research units) extends beyond the individual. Social "boundaries" are porous with three to five scientists-in-training in laboratories and clinical research settings. Visiting scholars are a regular occurrence. Research units experience loss of tacit knowledge regularly as staff, graduate students, and post-docs leave University B without transferring or making this knowledge explicit as in operating procedures. This loss has "invisible" implications for protection of proprietary knowledge and other intangible research assets.

Figure V. Clinical and laboratory protocols are often locally adapted for a number of reasons. Even published assays require tweaking. These adaptations are hand written in notebook margins or in local notebooks. Exceptions to this practice include facilities with advanced regulatory and certification requirements, such as GMP facilities and labs using radiation.

Changes and adaptations are recorded in bound hard copy laboratory notebooks along with cell lines, genetic codes, vaccine formulas, and other findings. Notebooks may be secured in locked filing cabinets. Clinical protocols do not contain proprietary data and handwritten changes to items such as telephone scripts are made on the protocol notebook (See figure V.)

Figure IV. Bound lab notebooks continue to be the standard in recording laboratory processes, observations, test results, and preparations for FDA and patent filings. A transition to electronic lab notebooks is technically feasible but faces widespread cultural resistance.

Person-to-Routines. Research processes are a series of inch-by-inch dynamic adjustments involving experience-based intuition to change the research process in search of the desired effect. As Figures IV and V identifies protocols, routines, telephone scripts, bench science assays, and procedures which were adapted locally. The results of one test must be translated into another system another. Incubation of rare disease or population specific cell lines is one example of specimens requiring "coaxing" in preparation for incubation.

Group-to-Group. In an attempt to characterize the nature of knowledge alliances and human resources on the local unit of discovery level, a formula to quantify the social networks has been devised. Based on the actual number of documented formal collaborations for Units H and P, this exercise provides only a glimpse into the potential for vulnerable knowledge in the discovery and transfer stages. A complete social network analysis study would be required to track a complex assessment.

The proposed formula is three to five university B faculty are linked to one discovery-level unit. We are assuming collaborators in Knowledge Alliances interact twice annually. A fraction of a graduate study (seventy percent effort) is the campuswide average and this will be attributed to each faculty member in the discovery unit.

Table III. Findings: Human Resources and Knowledge Alliances (Source SciVal, 12/31/2010)

	No of Faculty	No of Grad Students (Est)	No of Pubs (Actual)	No of External KA (Actual)	No of Internal University KA (Actual)	No of KA per Faculty
Unit P	32	22	490	87	21	3.4
Unit H	58	41	2874	420	30	7.76

Table III displays data gathered from SciVal Experts (http://www.experts.scival.com , 12/31/2010) as a preliminary documentation of the porous nature of the research-intensive environment and the openness of innovation. Data are retrospective; providing reports of collaborations resulting in published work. In-progress research activity is not reported. Using 2008 data, an estimated rate of .7 graduate students per faculty member was established. Data is not reported on the number of visiting scientists and collaborators. It was noted that some units treat visitors more informally, but those with multiple innovations in the disclosure stage have formalized laboratory visits with confidentiality nondisclosure agreements and material data transfer agreements as applicable. Cell lines and research samples in freezers across samples are artifacts of these collaborations.

Table IV. Projected Number of Continuity-related Interactions Annually

	No of Faculty in Discovery Unit	No of KA per Faculty	No of Grad Students per faculty	Estimated No of Continuity-related Interactions Annually
Unit P (low)	3	3.4	0.7	12.2
Unit P (high)	5	3.4	0.7	20.5
Unit H (low)	3	7.8	0.7	25.4
Unit H (high)	5	7.8	0.7	42.3

7.4.Open Innovation, Continuity and Vulnerability

The data in table IV suggest that face-to-face knowledge exchanges occur within formal collaboration relationships in the range of 12.2 and 42.3 times annually for each discovery unit within H and P. An untracked number of informal or pre-disclosure collaborations are likely to occur in parallel. This number, while an estimate based on actual codified knowledge in the literature, provides only a snapshot of the intensely interactive nature of research collaboration for discovery and transfer. This preliminary data also suggests the magnitude of uncodified knowledge and tacit understandings shared between and amongst a complex network of scientists. This unprotected realm of knowledge relates to continuity planning, but it also suggests other vulnerabilities related to protecting university economic interests in these collaborations.

7.5.Study Limitations and Weaknesses

This case study is useful in illustrating the proposed intersect between knowledge management and vulnerability assessment. While this work provides a proof of concept, a more rigorous examination of the KVA framework and variations among universities is needed to test the validity of the model. Specifically, an analysis of the expanding university discovery team networks would be helpful in better understanding points of vulnerability in informal alliances. It would also provide valuable data on knowledge flow and potential vulnerabilities.

8. CONCLUSION: KNOWLEDGE MANAGERS IN UNIVERSITY CONTINUITY PLANNING

The Knowledge Vulnerability Assessment framework offers some answers for the basic questions: What university knowledge is protected under business continuity planning? We have found that knowledge is most vulnerable during university processes of discovery and transfer. Knowledge alliances, open innovation networks, and pre-existing collaborative relationships generate complexities which must be better understood through social network analysis, before it can be fully protected under the business continuity planning process.

Question two asks how the loss of knowledge from a disastrous event would impact the innovative capacity of units of discovery. The two units observed in this case study suggests unprotected knowledge in clinical and laboratory units is pervasive. Destruction of notebooks and valuable specimens would derail efforts to push the discover toward disclosure and intellectual property formalization. The loss of a single life could be devastating to the continuation of research depending on the role of the individual in gathering and generating the pre-articulated knowledge on the subject of research.

Finally, this paper raised the question of the role of knowledge managers in university continuity planning. This top ranked research university serves as an example of perhaps a larger dilemma for knowledge-intensive institutions—who are the knowledge managers? In University B, why not engage a chief knowledge officer? With the economic, political and scientific stakes growing for top research universities the urgency escalates. The importance of re-evaluating, planning, protecting, and measuring knowledge assets grows. A knowledge team could work to empower discovery units with customized plans and resources to protect developing knowledge assets. In doing so, universities stand to add value by capturing pre-discovery data and developing a pipeline of promising research.

This brings us to topic of this paper. Has knowledge management (KM) missed the boat on business continuity planning? Over the last decade KM has defined itself as a profession by delineating a taxonomy, defining roles, and standardizing practice certification. Earl (2001) examined the schools of KM thought to find the technocratic, economic and behavioral approaches to knowledge management. The commercial school suggests a key role for KM in “protecting and exploiting a firm’s knowledge or intellectual assets” (p.222). The organization school of KM also has merit in its focus on “preserving and codifying”, while the strategic school of thought focuses on “raising consciousness about the value creation possibilities available from recognizing knowledge as a resource” (p.228). These frames of reference are helpful to suggest a path for KM’s involvement in business continuity planning.

The path takes us to the examination of literature about the role of the CKO. This role is described as a leader and advocate, a designer, an implementer, and a builder of plans for knowledge in the firm (Liebowitz, 2002). It is at once, a person experienced in technology, knowledge creation, product development, knowledge dissemination, and application (Liebowitz). Noticeably missing from these qualifications generated from the prestigious CKO summit, is preservation and continuity. University of Dubai set out to define the role of a university CKO (Abdelhakim and Abdeldayem, 2009). Unfortunately, Abdelhakim’s paper also lacked discussion of a role for the CKO in business continuity planning.

Finally, the practice of KM is where the “rubber hits the road” and Knowledge Management Certification Board of the Knowledge Management Professional Society (KMPro) (www.kmcertification.org) sets the scope and standards for the practice of KM. Of the 160 core concept areas identified by KMPro in their certification exams, not a single topic or subtopic addressed continuity planning, disaster, preservation, or emergency. Qualities of KM such as agility, perceptiveness, superior use of information, ability to disseminate innovative approaches and new thinking throughout an organization, could conceptually help large decentralized institutions protect knowledge assets in continuity planning. These capabilities could also help facilitate recovery and promote productive outcomes after a devastating event.

Has knowledge management missed the business continuity boat? Perhaps the field of KM has failed to articulate a role in business continuity plan. It is this author’s opinion that KM are the group of professionals to identify and place the “right” knowledge assets on that boat before it leaves Humber Estuary.

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