Enabling Collaborative Work in Higher Education: An Exploration of Enhancing Research Collaborations Within an Institution

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Abstract: *Higher education institutions are facing an increasing demand to collaborate with each other in the knowledge economy. Yet, research on how higher education management enhances collaborative work is rare. This paper takes research collaboration as an example and presents a provisional exploration initiated by a higher education institution in Singapore to enhance collaborations among researchers within the institution. The paper first explores three key challenges (i.e., harnessing differences, avoiding counterproductive coercing of collaborations, and optimizing team size) and introduces a social network perspective as a means to understand research collaboration. It uses analytic tools from Social Network Analysis to provide insight into the patterns and dynamics of collaborations among researchers within the institution. The insights are used to inform the institution's formulation of strategies to enhance research collaboration, including strategies for research development, research community engagement and talent retention. Critical considerations are given to the ways in which management might adopt and adapt a social network perspective to facilitate collaborative work in higher education. Exploring the utility of social theories and tools for enhancing collaborative work in higher education contributes to 'importing' theories to higher education research, particularly the institutional management and the knowledge and research themes of higher education research.*

Keywords: *Higher Education Management, Research Collaboration, Social Network Perspective, Social Network Analysis, Theory-Practice Translation*

Introduction

With the rise of the knowledge economy in the 21st century, higher education is facing demands for enhancing collaborations in order to strengthen its ability to create and disseminate knowledge and to maximize impact on practice (Bleiklie & Byrkjeflot, 2002; Katz & Martin, 1997). These demands call on higher education institutions (HEIs) to be networked not only with their stakeholders, but also with other HEIs as well as within their own institutions (Jongbloed, Enders, & Salerno, 2008). Building collaborations and networks in higher education contribute to both the institutional management theme (for building collaborations in general) and the

knowledge and research theme (for building research collaborations specifically) of higher education research (Tight, 2014).

While the benefits of collaboration are well documented in higher education literature (Katz & Martin, 1997; Lewis, Ross, & Holden, 2012; Tuire & Erno, 2001), research on how higher education management enables and enhances collaboration is still rare. Kezar (2005) calls on managers in higher education to shift from supporting individual work to facilitating collaborative work. Critically, she observes that there is "virtually no research on how to enable higher education institutions to conduct collaborative work" (p. 831). More recently, in their consensus study on research collaboration, Cooke and Hilton (2015) observed scant literature addressing how to enhance research collaborations in higher education. They had to rely heavily on inferences drawn from the literature of group dynamics in other settings.

As a response to what appears to be a significant gap in the higher education literature, this paper explores how higher education management may enhance collaborative work, particularly research collaborations. More specifically, the focus is on research collaboration within an institution. Collaborations among researchers within an institution enhance an institution's research capacity at an interpersonal level (Huang, 2014). Such a capacity, for example in the context of innovation and collaboration among enterprises, is found to strengthen an enterprise's ability to succeed in external collaborations (Bougrain & Haudeville, 2002).

Importing theories from various disciplines for application to higher education research is recognized by Tight (2014) as one important approach to advance higher education as an emerging field of research. In this study, the utility of a social network perspective, specifically Social Network Analysis (Burt, Kilduff, & Tasselli, 2013) embedded within social exchange theory (Cook & Rice, 2006), in research collaboration is explored. Collaborations as a form of social exchange relationships is examined to understand the challenges in building research collaborations. A case study is reviewed on how a HEI in Singapore uses a social network perspective and related tools to explore the enhancement of research collaborations within the institution. The exploration is then discussed in relation to 'importing' social theories to higher education research and practice.

Challenges in Building Research Collaboration

Researchers are knowledge workers (Olssen & Peters, 2005). In research collaboration, researchers with diverse perspectives, and commonly from different disciplines, have to work together on highly interdependent research tasks in order to achieve deep knowledge integration (Cooke & Hilton, 2015).

How to effectively harness these differences in pursuing deep knowledge integration is often a key challenge faced by higher education management (Bammer, 2008). Firstly, it is challenging to foster collaboration between heterogeneous researchers who have diverse expertise and social norms (Bammer, 2008). Collaboration between homogenous researchers is easier, given their cognitive and social proximity (i.e. the extent to which people share the same knowledge base

and social relationships). As McPherson, Smith-Lovin, and Cook (2001) observe, "birds of a feather flock together" (p. 417). However, Kimble, Grenier, and Goglio-Primard (2010) caution that such a homogenous collaborative group tends to reflect its own norms, resulting in cognitive lock-in (Boschma, 2005), and hence is unlikely to generate novel ideas on its own. To break away from the lock-in effect, deep knowledge integration among heterogeneous researchers is necessary (Cooke & Hilton, 2015). Yet, collaboration among heterogeneous researchers is challenging due to the very fact that they lack cognitive and social proximities (Challenge 1).

Secondly, coercing researchers to collaborate can be counterproductive. When coercing researchers to collaborate, management can ensure the complementarity of knowledge and expertise in the team necessary for knowledge integration. Despite these efforts, Kraut, Galegher, and Egido (1987) highlight that forming a collaboration involves not only a task aspect (e.g., completing research work) but also a relational aspect (e.g., forming and maintaining relationships). A systematic examination of 53 collaboration cases in physics by Shrum, Genuth, and Chompalov (2007) shows that collaboration is more likely to be productive when researchers have autonomy in choosing collaborators they trust. Arne Brekke, Nyborg, and Rege (2007) also find that when the formation of a research team is endogenous (i.e., through self-selection), individual researchers make more effort to collaborate. Therefore, coercing researchers to collaborate may impede successful collaborations (Challenge 2).

Thirdly, optimizing collaboration is challenging. Empirical data (Heinze, Shapira, Rogers, & Senker, 2009; Kenna & Berche, 2012) suggests that collaboration contributes effectively to research performance when the team size is within certain upper and lower thresholds. For example, according to Kenna and Berche, upper thresholds are estimated to range from four to forty-eight depending on specific academic disciplines. Hence, achieving the optimal team size for greatest efficacy in collaboration is challenging as well (Challenge 3). One way to address this challenge is to make progressive enhancements and continuous calibration towards the optimal team size.

To attend to these challenges, one may conceive research as the social production of new knowledge and regard collaborations as a network of social activities and relationships among researchers. Shrum et al. (2007) find that research collaborations are more likely to take place among researchers with pre-existing relationships. Existing collaboration networks are also found to be more influential than synthetic new networks created (e.g., through the coerced assembly of research teams) as part of the change process (Cole & Weinbaum, 2010). These findings support social networks as a significant complementary lens in understanding and influencing research collaborations.

Social network perspective as a complementary lens to understand research collaboration is considered in the next section.

A Social Network Perspective on Research Collaboration

The network is a fundamental analytic construct in social science. Network analysis examines

how social relationships among individuals in a social system form network structures and influence joint activities (Burt, 2000). Social theories embedded in the network perspective provide explanations on why and how people interact and with what kind of outcomes.

Kapferer (1972) proposes that social exchange theory provides the most suitable theoretical basis for analyzing social interactions. Social exchange assumes that rewards and costs drive relationship decisions. Each party pursues options to maximize rewards and minimize costs. Fulfilling self-interest is the guiding force for each party, and the outcome is interdependent —based on both parties' efforts and mutual and complementary arrangements. For example, for a customer to procure a loaf of bread from a store, a good way to balance costs and benefits for both parties is to offer the store owner the amount of money printed on the price tag. From the perspective of social exchange theory, research collaboration may be conceived as two or more researchers exchanging research ideas and contributing their research expertise and time together to obtain desired outcomes, such as attainment of a research grant.

The social exchange theory provides explanations to the consequential effects of network structures. For example, Granovetter (1973) refers to strong ties as relationships among friends and weak ties as relationships among acquaintances. Information within a cluster of strong ties tends to be rather homogeneous and redundant as a result of frequent communication among members within the cluster. To garner new information or insights, members of a cluster will have to look beyond the cluster – to its acquaintances. Hence, an individual with more weak ties has an advantage when seeking information and innovation. This phenomenon is called "the strength of weak ties" (Granovetter, 1973, p. 1360). According to social exchange theory, weak ties contain new information (or research expertise) and have higher rewards for social exchange. Building social relations among weak ties hence have the potential to prepare researchers for future grant collaboration (i.e., strong ties).

When two separate clusters have control over and access to non-redundant information (e.g., novel research ideas or new expertise), there is said to be a structural hole (Burt, 2000) between them since they are not connected to each other. An optimal network structure has a vine and cluster structure (Granovetter, 1973), providing access to many different clusters and structural holes. The individuals, whose ties are usually weak, bridge structural holes and play the role of brokers and bridges. They have a network advantage in social exchange because it is only through them that non-redundant information flows between the two otherwise separate clusters.

If a social network perspective is adopted, research collaboration can be considered in terms of social exchange networks that connect researchers. It is possible to discern a 1+1>2 effect when researchers collaborate with each other within an institution. Such an effect cannot be explained merely by the sum of individual researchers' capacities. Network patterns, for example, the existence of weak ties and structural holes could affect how knowledge is shared, cross-fertilized and integrated among researchers, and influence research productivity (Burt, 2000; Granovetter, 1973).

In the following case study, a Singapore institution's provisional exploration is presented on how a social network perspective was adopted to enhance research collaboration within the institution,

making use of social network analysis tools (Burt et al., 2013). Exploring the utility of social theories in higher education management practice complements the existing literature in higher education, in which social network analysis is used to characterize and evaluate collaboration networks (Aboelela, Merrill, Carley, & Larson, 2007; Fagan et al., 2018).

A Provisional Exploration Initiated by a Higher Education Institution in Singapore

Informed by a social network perspective, a Singaporean HEI (hereafter referred to as SHEI) used Social Network Analysis to analyze collaboration patterns among researchers within the institution. The analysis was used to inform SHEI's formation of administrative strategies to progressively enhance collaborations within the institution.

After the strategies presented in this paper were enacted, SHEI underwent a change of management, leading to formal structural changes, which included restructuring the existing research centers and forming formal research clusters. These changes make it difficult to attribute the enhancement of expanded collaboration within the institution solely to the administrative strategies presented in this paper or the subsequent structural changes. Therefore, semi-structured interviews were conducted to understand the implementation of the strategies presented in this paper, their benefits in enhancing research collaborations, and issues to deal with when enacting these strategies.

The Context

SHEI is an institution based in a comprehensive university in Singapore. It focuses primarily on teaching and research in the social science domain, with a strong professional commitment and a close working relationship with a government agency. At the point of data collection, SHEI has 14 academic departments with about 400 academic staff. About half of the departments are defined by a distinct disciplinary subject (i.e., subject-specific), and the other half are defined by themes that range across disciplines or subjects (i.e., subject-general). With dedicated research funding, SHEI transformed from a predominately teaching-oriented institution to a research-intensive institution over a period of 15 years. It has consistently ranked among the top 20 in the QS subject ranking in recent years.

SHEI identified a need to enhance internal research collaboration in order to benefit from cross-fertilization of ideas and to deepen research integration across departments. Often segregated by departmental structure, especially between subject-specific and subject-general departments, researchers are heterogeneous in expertise and social norms (Challenge 1). Coercing them to collaborate can be counterproductive (Challenge 2). Identifying strategic opportunities to optimize collaboration is also challenging (Challenge 3). To gain the insight required to address these challenges effectively, SHEI adopted a social network perspective to analyze the collaboration patterns among researchers within SHEI, drawing specifically on Social Network Analysis.

Social Network Analysis

Social Network Analysis (SNA) (Burt et al., 2013) studies the patterns of social relations by examining how the structure of social relations influences information flow, constrains behaviour, and channels social change. It evaluates the location of actors in the network by providing both a visual and a mathematical analysis of human relationships (Burt et al., 2013). In the visualization, the nodes in the network are the people while the links represent relationships or information flow between the nodes. In the mathematical analysis, the centrality of a node (i.e., how well a node is connected to the rest) is analyzed by measuring the network location of the node. These measures give insights into the various roles and groupings in a network, for example, who are the leaders, hubs, bridges, brokers, and isolates, where and who the organic clusters comprise, core network composition, and who is on the periphery. Examining organic clusters (i.e., informal self-organizing research clusters as compared to research clusters established formally by institutions) complements understanding of human interactions based on organizational hierarchy (e.g., departmental charts).

The particular SNA tool used in this example is ORA NetScenes (Carley, 2014). The tool contains a large number of built-in social network metrics and procedures for grouping nodes, thus allowing identification of local patterns and comparing and contrasting network clusters, groups and individuals. The figures presented in this paper are reproduced for better visibility in black and white. They retain all the nodes and links of the original ORA analysis figures.

Social Network Data, Coding and Representations

SHEI used 'grantsmanship' data (i.e., internally and externally funded research grants) to map out the collaboration network within the institution. As a result of dedicated research funding, most of SHEI's researchers are active in research grant acquisition (i.e., collaborate with each other in bidding for research grants and subsequently conducting research). SHEI's provisional exploration focused on research development, particularly by facilitating more grant collaborations among researchers across departments.

The five-year grant data, available on SHEI's database, captured a total of 463 researchers (including 56 researchers, who had left SHEI at the point of data collection) taking part in 201 research grants. The data was exported to ORA NetScenes and we manually added researchers' profiles, such as departmental affiliation and academic appointments. The total number of collaboration links is 1,144. The number of researchers per grant is 2.02 (2) ± 0.2. The number of collaborators per researcher is 1.83 (2) ± 0.97. Except for new staff who had not attained any grants at the point of data collection, the data is generally representative of SHEI's staff profile in academic ranks (roughly 34% assistant professors, 27% associate professors and 3% full professors. Teaching staff, such as teaching fellows, are generally less involved in research grants).

Figure 1 shows an example of the social network diagram used by SHEI to map out the links between a Principal Investigator (PIs, A), a co-PI (B) and a collaborator (C) in a research grant. Their collaboration links are represented in Figure 1. Node A is connected to Nodes B and C, showing that Researcher A is in collaboration with Researchers B and C.
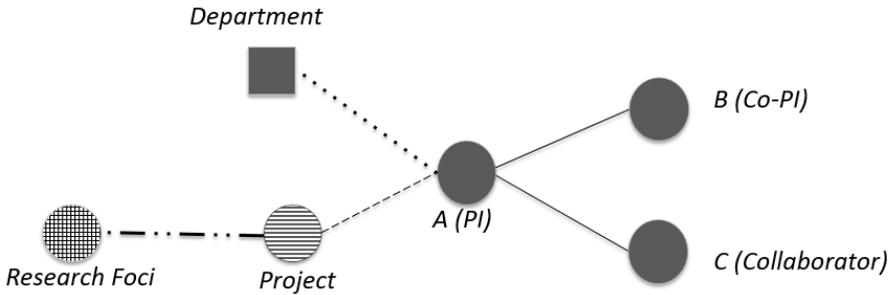
Figure captions
Circular Nodes refer to researchers; **Square Nodes** refer to departments; **Horizontally Lined Circular Nodes** refer to research grants; **Checked Circular Nodes** refer to research foci; **Solid Lines** refer to research grant collaborations between researchers; **Dotted Lines** connect researchers with their departments; **Dashed Lines** connect projects with their respective PI; **Dashed and Dotted Lines** connect projects with the research foci they contribute to.

Figure 1. An example of the social network diagram.

The tie between Researchers B and C (i.e., co-PI and collaborator) is a weak tie. In this paper, these ties are not included in the diagram for simplification. This is because the number of researchers per grant in SHEI is 2.02 (2) ± 0.2, suggesting that most projects only have a PI and a co-PI (or a collaborator). In this case study, the trail analysis also revealed that the inclusion of these weak ties had only negligible effects on the analytical outcomes. The limitations of making this simplification in the case of SHEI is discussed later.

In Figure 1, in addition to grant collaborations, researchers (e.g., Researcher A) are also indexed by the academic departments they belong to and the research grants awarded as PIs. Each grant is also indexed by the research foci. Research foci are research areas within a broad academic discipline, differing from academic departments. For example, in research on higher education teaching, creative thinking can be a research focus. A project on creative problem-solving in engineering contributes to research foci such as creative thinking, engineering education, etc. It is possible for researchers in both engineering and humanities departments to conduct research on creative thinking through STEAM (Science, Technology, Engineering, Art and Mathematics) education.

Four Research Collaboration-Building Scenarios

Four scenarios are presented, which describe how SHEI used SNA to identify opportunities to build collaborations within and between departments, as well as across SHEI. The analytics informs the formation of research development strategies (e.g., developing departmental collaboration), facilitating research community development and engagement, and supporting decision-making related to research talent retention. The scenarios are briefly summarized in Table 1.

Table 1. Summary of the Scenarios

SN	Purpose	Analysis	Findings	Strategies
1	Individual researchers' roles in research network/ community	Sphere of influence and cluster analysis	Identification of research stars (e.g., prominent researchers), collaboration hubs and brokering researchers	Staff reward, retention and succession planning
2	Departmental collaboration	The shortest path between two departments	The two research-intensive departments did not collaborate directly	Using research seminars and joint appointments to facilitate dialogues and idea exchange
3	Departmental research performance and growth	Collaboration networks at the departmental level, the department's sphere of influence	Staff members in a department were not PIs, but a few staff members participated in other departments' grants	Using a 'Start-up Grant' to assist the department's staff members to build research leadership
4	Growing organic research clusters	Cluster analysis	The existence of organic research clusters and the need to bridge structural holes	Facilitating dialogues, informal meetings

A socio-cultural context for understanding these scenarios is SHEI's proactive stance in anticipating and addressing issues while calibrating resources to optimize organizational performance. Such a disposition is not uncommon in Singapore higher education (Ng, 2013).

Scenario 1: Identifying and empowering research hubs and brokering researchers
This scenario explores the network roles played by individual researchers. In higher education management, there is a tradition and tendency to focus on grooming research 'stars' who are prominent researchers with a high potential in research productivity and leadership. From a social exchange theory perspective, research stars, while having high research capacities at the individual level, may not be playing a central role in research collaborations at the network level. In contrast, researchers who are hubs and brokers in research collaborations may play critical and central roles in cultivating vibrant research collaboration networks (i.e., networks of exchange relationships) within an institution, yet often they may not be identified and well recognized by the management.

In the SHEI case, the collaboration hubs and brokering researchers were identified using the networks metrics and triangulated by the management's observation of their research collaboration activities. Research stars, on the other hand, were first identified based on their research performance and outputs (without using SNA) and then their network metrics were examined allowing comparison among the three types of researchers. Technical terms (e.g., between centrality, exclusivity and centrality hub) are included to provide analytical support in comparing the three types of researchers. Brief descriptions of the terms are included in this paper.

Four figures (Figures 2 to 5) are presented to illustrate Scenario 1. Figure 2 presents SHEI's overall network diagram based on grantsmanship data. In the figure, we also highlight the locations of three researchers being analyzed in Scenario 1. Figures 3 to 5 represent the degrees of influence of a research star, a research hub and a brokering researcher respectively. The research hub and brokering researcher are usually not research stars, nor leaders within the organizational hierarchy. These individuals, however, play important network roles in bringing researchers together.

The overall network diagram on research collaboration (Figure 2) reveals that a research star had a high degree of centrality, but only at the local cluster and was peripheral in the overall network.
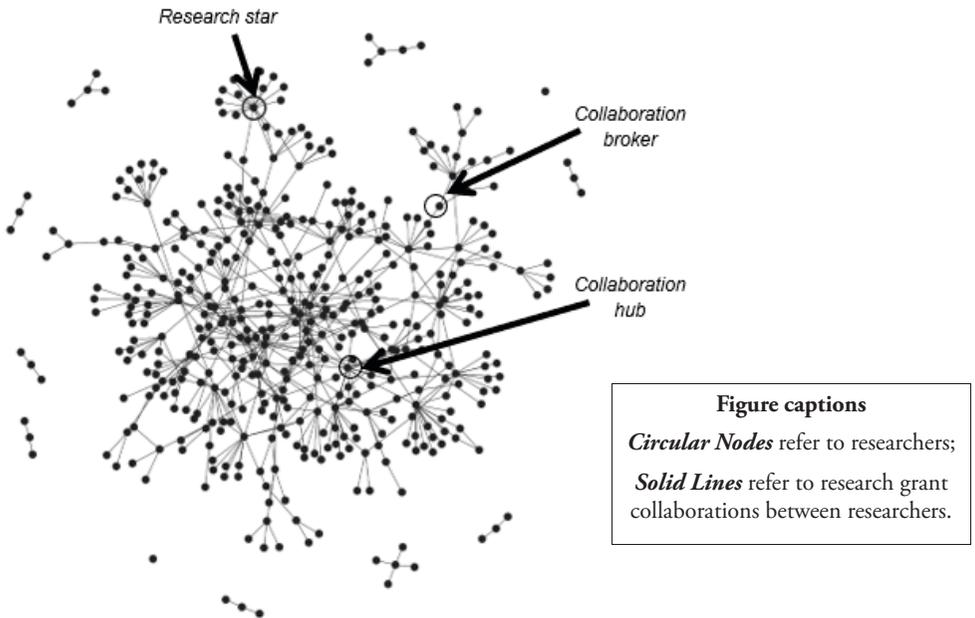

Figure captions
Circular Nodes refer to researchers;
Solid Lines refer to research grant collaborations between researchers.

Figure 2. Overview of the network diagram on research collaboration.

Figure 3a reflects that the research star was in collaboration with 11 researchers in the first degree of influence (i.e., researchers collaborated with the research star directly). At the third degree of influence (Figure 3c), the research star was connected to only 9.7% of SHEI's researchers represented in the network diagram. The low value (0.0002) of the centrality hub metric suggests that the research star was not collaborating with researchers, who had numerous collaboration links.
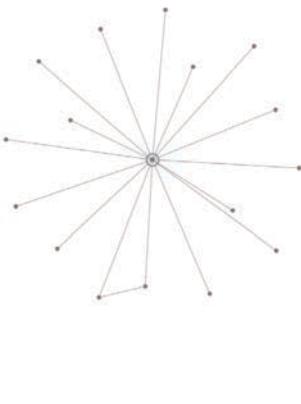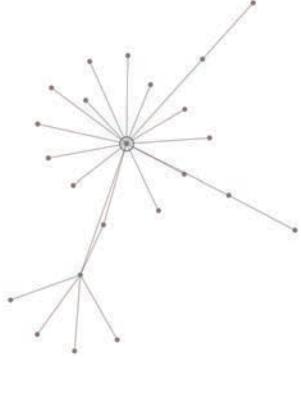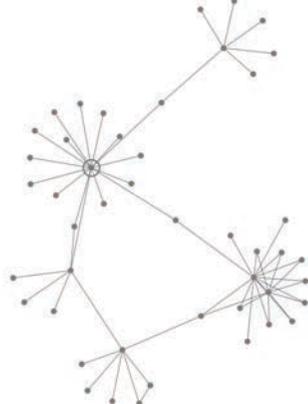
3a *First degree of influence*	3b *Second degree of influence*	3c *Third degree of influence*
Nodes connected: 16 (3.5%) *Between centrality: 0.9917*	*Nodes connected: 22 (4.8%)* *Between centrality: 0.9264*	*Nodes connected: 45 (9.7%)* *Between centrality: 0.6642*
Between centrality in the whole network: 0.0584 *Exclusivity (i.e., has ties that few others have): 0.0283* *Centrality Hub (i.e., connecting to a large number of others who have many links): 0.0002*		

Figure captions
Circular Nodes refer to researchers; *Solid Lines* refer to research grant collaborations between researchers.

Figure 3. A research star's sphere of influence.

In comparison, Figure 4 refers to a researcher who was playing the role of a collaboration hub (identified using the centrality hub metric). Figure 4c shows that the collaboration hub researcher's third degree of influence covered 31.6% of the total researchers in SHEI. The researcher's centrality hub metric (0.0319) was significantly higher than that of the research star in Figure 3 (0.0002). The collaboration hub researcher's location in the overall collaboration

network (as shown in Figure 2) also suggests that this category of researcher was central in the research collaboration network.
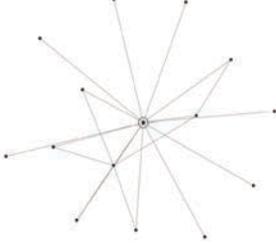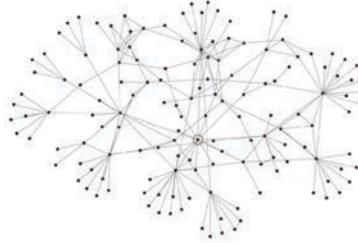
4a *First degree of influence*	4b *Second degree of influence*	4c *Third degree of influence*
Nodes connected: 14 (3.0%) *Between centrality: 0.8974*	*Nodes connected: 55 (11.9%)* *Between centrality: 0.6156*	*Nodes connected: 146 (31.6%)* *Between centrality: 0.4094*
Between centrality in the whole network: 0.1270 *Exclusivity: 0.0098* *Centrality Hub: 0.0319*		

Figure captions **Circular Nodes** refer to researchers; **Solid Lines** refer to research grant collaborations between researchers.

Figure 4. A collaboration hub's sphere of influence.

Figure 5 shows the characteristics of another type of researcher, the brokering researcher who served in a coordinating role (identified as high in centrality hub metric but low in nodes connected in the first, second and third degrees of influence). SHEI's purpose was to identify key individuals at the institution to reward and retain. It is important to note that when using network metrics to identify brokers, SHEI did not set specific cutoff points and used qualitative observation of everyday research activities as a complement.

The brokering researcher in Figure 5 was connected to a very small percentage (i.e., 0.6%) of researchers in their first degree of influence (Figure 5a). This is much lower than that of the research star in Figure 3a (i.e., 3.5%) and of the research hub in Figure 4a (i.e., 3%). However, the brokering researcher had a very high overall centrality hub metric value (0.5914), particularly when compared to the research star in Figure 3 (0.0002) and the collaboration hub in Figure 4 (0.0319). The overall network diagram (Figure 2) reveals that the brokering researcher played a significant coordination role in linking a research cluster to the rest of the research community.
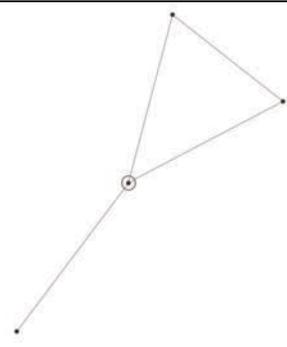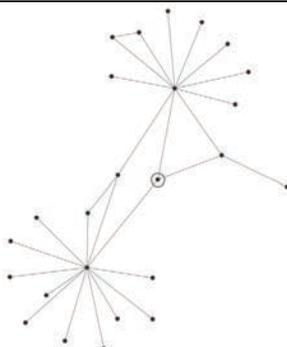
5a *First degree of influence*	5b *Second degree of influence*	5c *Third degree of influence*
Nodes connected: 3 (0.6%) *Between centrality: 0.6667*	*Nodes connected: 24 (5.2%)* *Between centrality: 0.0870*	*Nodes connected: 50 (10.8%)* *Between centrality: 0.0473*
Between centrality in the whole network: 0.0055 *Exclusivity: 0.0003* *Centrality Hub: 0.5914*		

Figure captions

Circular Nodes refer to researchers; ***Solid Lines*** refer to research grant collaborations between researchers.

Figure 5. A brokering researcher's sphere of influence.

Scenario 1 suggests that a HEI's research environment includes at least three important types of researchers: (a) research stars who have high individual research capacity, (b) collaboration hubs which bring researchers together, connecting them into organic research clusters, and (c) brokering researchers who bridge structural holes so that two otherwise separate clusters are connected and coordinated.

These three types of researchers play different network roles in growing an institution's research capacity and research culture. For example, a researcher shared how much she appreciated a collaboration hub who connected her with other researchers:

I am interested in a certain research methodology. If I find someone who is doing some work on this, now I can find this opportunity (through the informal group with xxx as the hub) to connect with them so in that way, by building this social connection via this (informal group), I can also strengthen my position within the network. (Excerpt 1, a researcher)

A different collaboration hub also shared that:

> *Actually quite a lot of times people met through this (i.e., my networks), and then they work together. They would have met (each other) anyway (i.e., in other occasions), but (it would) probably take them a lot more time (to build the trust, if it is not through this informal group).* (Excerpt 2, a collaboration hub)

Scenario 1 informed SHEI on faculty staff development, recognition, reward and retention, because replicating a collaboration hub in a HEI is not easy, as suggested by a challenge highlighted by a collaboration hub:

> *My main challenge is that I have to be typically the one initiating (interactions)... It is not a fully organic group that happens fully (from) bottom-up... If I'm not around, then I don't have people who are as motivated as me to keep the work, to keep the (informal) group always alive.* (Excerpt 3, a collaboration hub)

The above sharing reveals the contribution of a collaboration hub, which is not easily visible to the management. Traditionally, universities focus on developing and retaining research stars. This scenario suggests that identifying, developing, rewarding and retaining the other two types of researchers (i.e., brokering researcher and collaboration hubs) may have the potential to positively influence research collaboration as a form of social exchange.

Scenario 2: Identifying collaboration opportunities between two departments
Research increasingly requires interdisciplinary collaboration. Contrasting ideas and dispositions between researchers in two departments may lead to more research innovation and productive research partnerships (i.e., more rewards in social exchange). Yet, identifying collaboration opportunities should not just be based on intuition. How could institutions identify collaboration opportunities?

In Scenario 2, SHEI analyzed the social network diagram to identify collaboration possibilities between departments A and B. This was accomplished by tracking the shortest path in the social network diagram between the two departments. SNA was supplemented with the examination of the research foci of departments A and B (conducted without the use of SNA), which revealed that the two departments had similar research foci (e.g., creative thinking), but different research methodologies.

Figure 6 visualizes the collaborative relationships between the two departments by mapping the shortest paths between them. Pseudonyms have been included for the individual researchers for easy referencing.
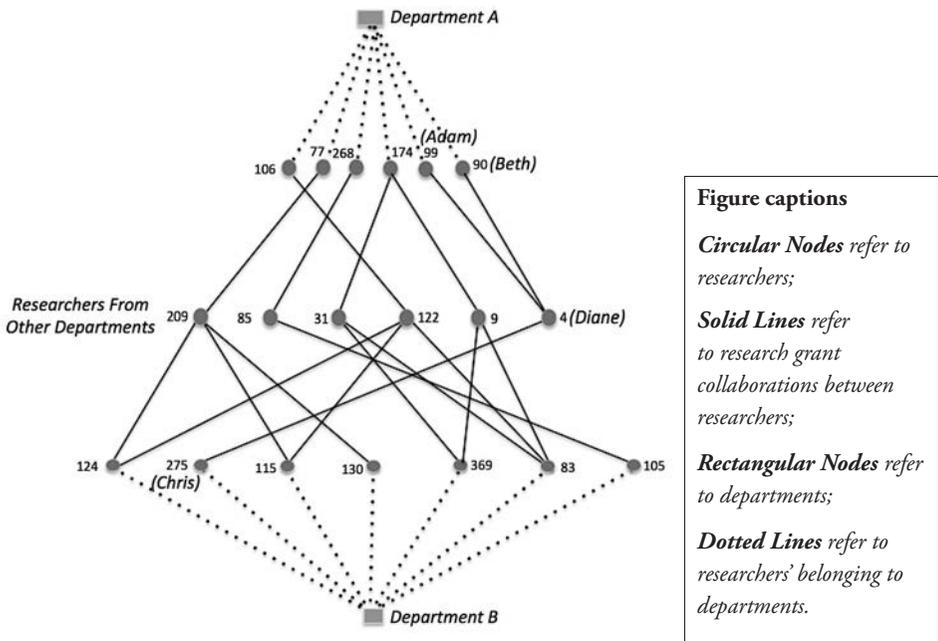
Figure 6. Collaboration between two departments.

In the figure, Researchers 106, 77, 268, 174, 99 (Adam) and 90 (Beth) belong to department A, and Researchers 124, 275 (Chris), 115, 130, 369, 83 and 105 belong to department B. Analysis revealed that the researchers in departments A and B did not collaborate with each other directly. Rather, the collaboration path went through Researchers 209, 85, 31, 122, 9 and 4 (Diane), who are from other departments.

The fact that researchers from other departments worked with researchers from both departments A and B suggests a possibility for the two departments to collaborate directly. For example, Figure 6 shows that Diane from a third department worked in collaboration with Adam and Beth from department A and Chris from department B. How can a direct collaboration be facilitated between departments A and B?

As SHEI's strategic response, departments A and B jointly organized a series of research seminars. Their collaboration partners in other departments attended as participants. The seminars were held to foster dialogues and promote the collaboration of research ideas between the departments. A researcher in department B shared the benefit gained from attending the seminars:

Our relationships grow because we learn about each other and we have an opportunity to find out who we really are, what our interests are and what personality and character we have. (These) would pave the way for working together in future. (Excerpt 4, a researcher)

The manager who organized the seminars found it "*important for departments A and B's collaboration partners in other departments to take part in the seminar* because *(they) make researchers in departments A and B feel more at ease*". The manager also found it beneficial in creating opportunities for repeated interactions among researchers. In this endeavor, the focus was on establishing routines and choosing sharing topics of common interest.

For anything to be really successful, (it) is (necessary to) create a routine or put a habit in mind. If I can set up a routine where it becomes a habit to have (the seminar) once a month, then we will have in our back of mind that we have some norm or expectation that this will happen....

... The fact (is) that people are very busy. The institution is huge, and if you attend everything that sounds interesting to you, you will be attending stuff all the time. When people are super busy, you need to be very selective (in choosing the sharing topics of the seminars you organize). The other day there was this one (researcher) talking about xxx data analysis. I know many people are not going to be interested in that. So some people just don't show up. (Excerpt 5, a manager)

With these intentional strategies, the seminars gradually led to greater mutual understanding and trust amongst the staff members in the two departments. To further nurture the potential for collaboration, three of the staff members received joint appointments by both departments. A researcher holding the joint appointment shared their role in bridging the two departments:

I'm not an expert at each of the unique areas, but what I bring along with me is my flexibility or adaptability. I can more or less understand what your project's trying to do and be able to plan out and strategise what are the kinds of things that we all can do together. (Excerpt 6, a researcher)

Another researcher, who received a joint appointment presented a challenge she faced in coping with her own academic development. SHEI managed this challenge through other strategies, such as recognizing, developing and providing socio-emotional support to the researchers.

It's like you're Jack-of-all-trades, master of none. In fact, it's not a very settling feeling. (Excerpt 7, a researcher)

Scenario 2 reveals how SHEI develops collaborations between two departments. SHEI leveraged the two departments' common collaboration partners in a third department, using joint seminars and joint appointments and creating opportunities for repeated interactions amongst the researchers in the two departments. These interactions facilitated direct collaboration, while also providing socio-emotional support. Joint seminars as a social facilitator of exchange will be discussed later in the section.

Scenario 3 reviews departments as the unit. The analysis suggests a formative way to evaluate departmental research performance for the purpose of fostering research leadership in collaboration.

Traditionally, departments are compared in terms of their grant attainment, which is calculated based on a principal investigator (PI)'s home department. For example, researcher A belongs to department X. She is the PI of a $500,000 grant and a co-PI of a $700,000 grant. Based on PI status, only the $500,000 grant is considered as contributing to department X's grant income and performance.

Using this traditional evaluation method, only one research grant was attained by department C of SHEI, because only one staff member of the department held a grant as PI. Compared to other departments, department C was viewed as seriously underperforming in research.

SHEI, using the grantsmanship data, constructed a network diagram at the department level (see Figure 7). The nodes are the departments, with the links representing research grant collaborations between departments. For example, if researcher 1 of department X and researcher 2 of department Y are the PI and co-PI of a research grant, departments X and Y are linked, reflecting a collaboration link based on the research grant.
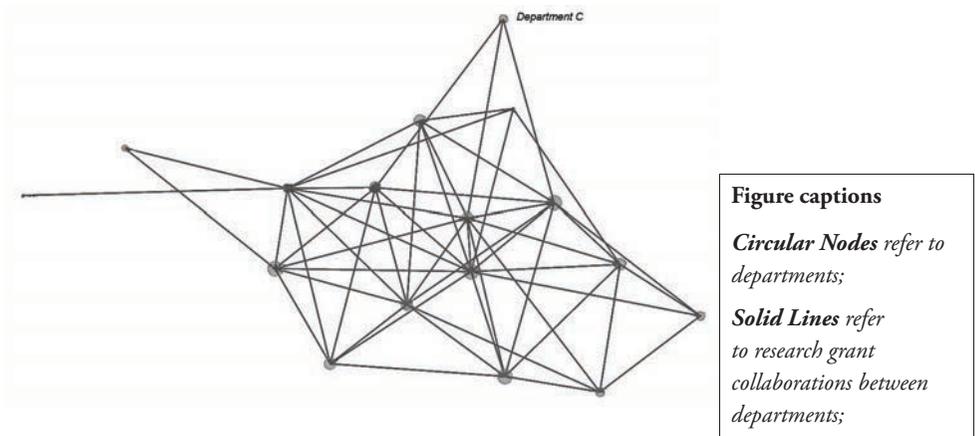

Figure captions

Circular Nodes refer to departments;

Solid Lines refer to research grant collaborations between departments;

Figure 7. Centrality of inter-department collaborations.

In Figure 7, department C is not an isolated node. Although it is at the periphery of the inter-department collaboration map, department C has research collaborations with three other departments, suggesting that staff members of department C may have served as co-PIs and collaborators on grants awarded to staff members in the other three departments. In terms of interdisciplinary collaboration across departments, department C performed better than a number

of other departments. This finding is contradictory to the perception by SHEI's management.

The further analysis presented in this scenario only reflected the second degree of influence. Analyzing additional degrees of influence is possible, but extremely complex based on the patterns presented in the data.

Figure 8 shows department C's degrees of influence in research participation. Figure 8a presents department C's first degree of influence (i.e., researchers in department C). Figure 8b shows the department's second degree of influence (i.e., department C staff who have collaborative activities external to the department.). Pseudonyms have been assigned to designated researchers.
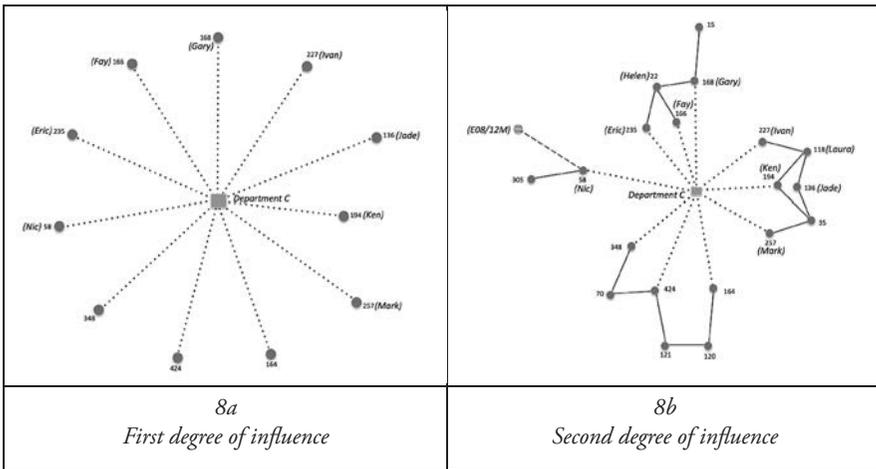

| 8a | 8b |
| First degree of influence | Second degree of influence |

Figure captions
Circular Nodes refer to researchers; *Square Nodes* refer to departments; *Horizontally Lined Circular Nodes* refer to research grant; *Solid Lines* refer to research grant collaboration between researchers; *Dashed Lines* connect projects with their respective PI.

Figure 8. Collaboration across departments (first and second degrees of influence).

Figure 8b reveals that only researcher 58 (Nic) is directly connected to a grant, which indicates that Nic is the PI of a project (E08/12M). Additionally, some staff members in department C collaborated with corresponding staff members in other departments. For example, researchers 235 (Eric), 166 (Fay) and 168 (Gary) in department C worked collaboratively with researcher 22 (Helen) from another department; researchers 227 (Ivan), 136 (Jade) and 194 (Ken) worked with researcher 118 (Laura) from another department.

Figure 8b suggests that some of department C's researchers, for example, Ivan, Ken and Jade

who collaborated with a common PI, Laura, might be able to bring researchers in department C together to form a research team and to develop the department's research strength.

To enhance the department's research capability, SHEI encouraged the selected researchers in department C to make use of a start-up grant scheme to facilitate researchers in the department collaborating together. The intention was to create an opportunity for the task and relational features (i.e., collaborative work in grant and social relationships among researchers) to reciprocally enhance each other. This strategy may have resulted from a researcher's discontent with superficial social interactions with other researchers in the department.

> *I don't see any (structure) that exists to bridge people. It's basically just, if you see people along the hall way, you say hi and hello and that's it... But you see, these kinds of interaction are not really (developed and) sustained. It's when you have a joint endeavor, that's when it gets (developed and) sustained.* (Excerpt 8, a researcher)

She further articulated a need to create accountability structures to sustain the joint endeavour.

> *Because everyone has time constraints. Usually, the interactions will just fizzle over time. But if you (are subject to) a structured accountability structure, you tend to continue your collaborations. I feel that that's a good way to ensure that you're continually in contact with people and the network gets sustained.* (Excerpt 9, a researcher)

In Scenario 3, SHEI engaged researchers in department C in a start-up grant as the joint endeavor (i.e., to facilitate social exchange) and used the grant (e.g., progress reports, final report, etc.) as the accountability structure to sustain the interactions. With support from the management, the joint endeavor eventually led to a competitive grant awarded to Ivan of department C as the PI.

Scenarios 2 and 3 deal with formal research structures (e.g., departments in SHEI), but management often needs to attend to informal research clusters, which are organic in nature. An informal organic network cluster entails a collection of individuals with dense connection patterns internally and sparse connections externally. It is different from traditional clustering (e.g., based on department and/or research foci) grouped by management. Organic research clusters are analyzed in Scenario 4.

Scenario 4: Identifying and developing organic research clusters
Scenario 4 reveals how SHEI examined organic research clusters, which emerged from researchers' grant collaborations. Some technical details on the clustering methods are provided, though a deep understanding of these details is not critical for this paper.

ORA's Newman's clustering algorithm method was used to determine clusters. Newman Modularity (ranging from -1 to 1) of 0.806 indicates good clustering. Excluding seven splinter clusters (i.e., dyad and triad groups), a total of 19 clusters were identified. The sizes of these clusters range from 4 to 52 with a median of 23. They are generally within the upper critical masses (i.e., 4 to 48) as identified by Kenna and Berche (2012). Other methods were also explored but did not yield satisfying clusters (e.g., low Newman Modularity, splinter clusters with one mega cluster of 429 members, etc.).

Figures 9 and 10 are two organic research clusters being identified. Cluster 1 (Figure 9) has a relatively higher density and appears to be one coherent body (i.e., researchers are more equally connected with each other). In contrast, cluster 2 (Figure 10) has less density and seems to comprise three to four loosely connected small groups. Pseudonyms have been given to certain researchers.
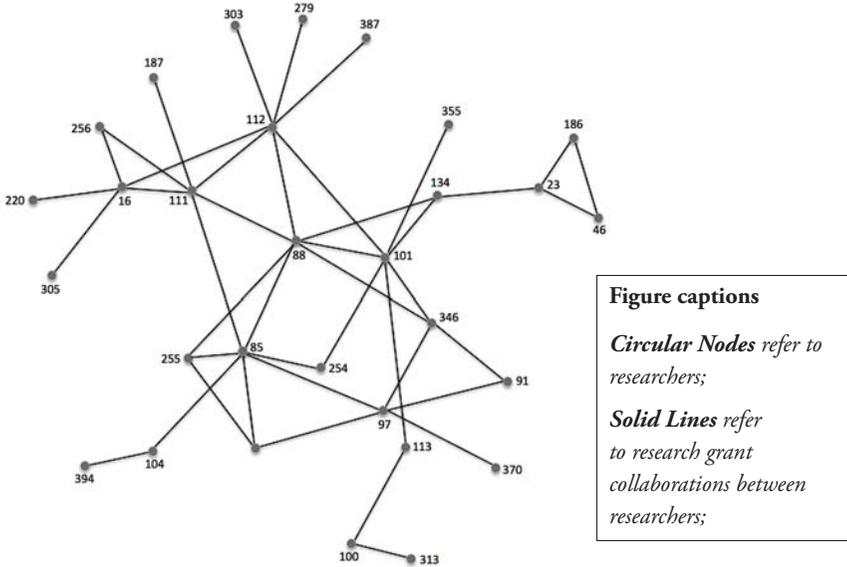

Figure captions

Circular Nodes *refer to researchers;*

Solid Lines *refer to research grant collaborations between researchers;*

Figure 9. Organic research cluster 1.

Figure captions

Circular Nodes *refer to researchers;*

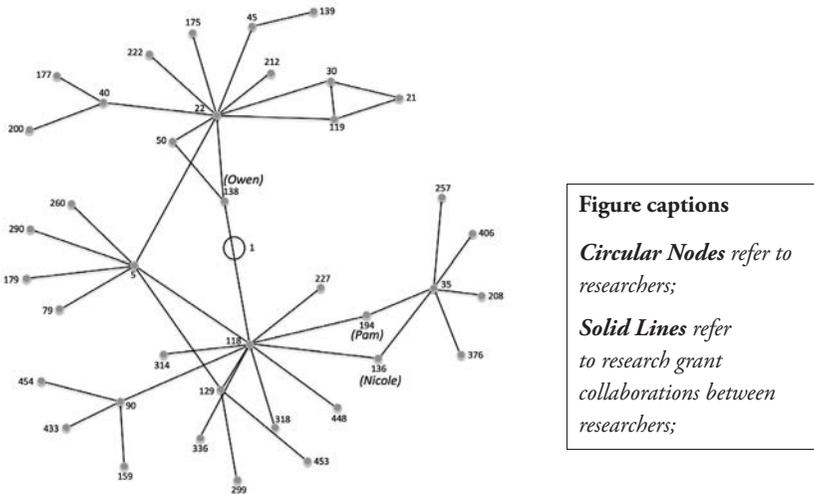**Solid Lines** *refer to research grant collaborations between researchers;*

Figure 10. Organic research cluster 2.

A more detailed examination of cluster 2, complemented by observing the roles played by researchers in everyday research activities, revealed that researchers 136 (Nicole), 138 (Owen) and 194 (Pam) were playing important bridging roles. In the event that these researchers leave the institution, cluster 2 is likely to become fragmented. This may affect SHEI's research capacity at an interpersonal level (Huang, 2014) and undermine SHEI's research productivity. A more quantitative way of analyzing structural holes and identifying bridging nodes was carried out by ORA's built-in functions but not, for the sake of brevity, presented in this paper.

To deal with the risk of fragmentation of cluster 2, SNA was used by SHEI again, as a complement to observations of everyday research activities, to identify opportunities to build research collaborations upon the existing clusters. As illustrated by the two dotted lines in Figure 11, if collaborations can be fostered between researchers 35 (Quinn) and 22 (Rachel) and between Quinn and researcher 5 (Stuart), the research cluster will have a much higher density. These are the ties that may have high leverage effects to optimize research collaboration.
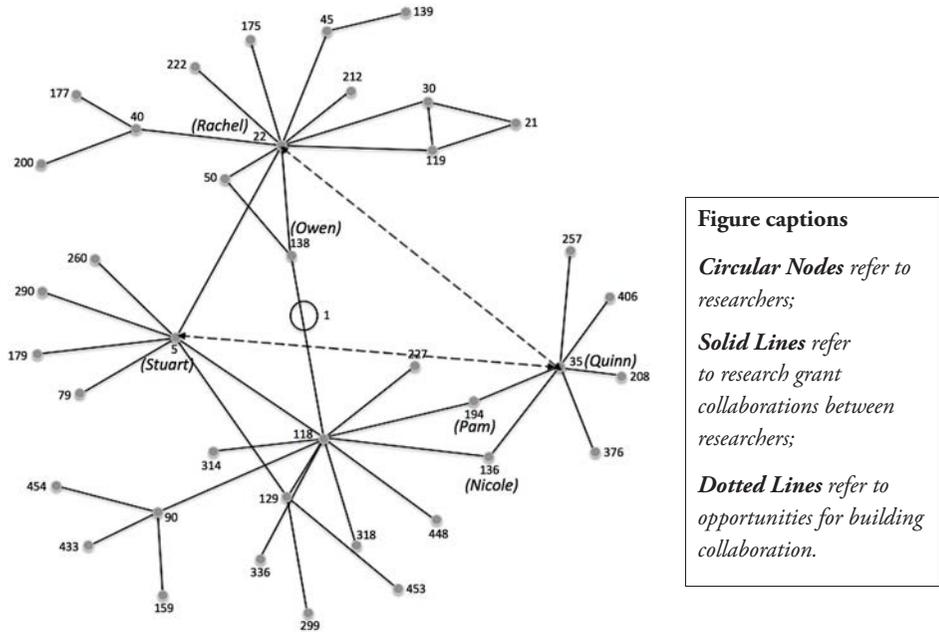

Figure captions

Circular Nodes refer to researchers;

Solid Lines refer to research grant collaborations between researchers;

Dotted Lines refer to opportunities for building collaboration.

Figure 11. Collaboration between two departments.

With the findings from the SNA analysis, SHEI examined contextual factors, such as the researchers' research interests and subject areas, to evaluate whether the building of these two suggested collaboration ties would be feasible. While identifying opportunities for building collaborations, SHEI also considered potential negative impacts of the collaboration building

efforts on existing collaboration networks. This review of collaborations was to prevent researchers (such as Owen, Pam and Nicole) from potentially feeling their research collaboration was being threatened or discouraged.

When facilitating the interactions among selected researchers, one researcher and manager highlighted the need to create an informal non-threatening environment:

> *There needs a certain level of comfort (among people) ... I rarely send something formal. Because I feel that it looks much more intimidating, much more rigid... I intentionally try to create an environment where you can say anything you want. Sometimes I tend to say very stupid things so that people just laugh, just to be a group of friends. This (environment) is not something formal where you need to behave yourself or give politically correct answers or anything like that.* (Excerpt 10, a manager)

Eventually, with funding support to facilitate dialogue between selected staff members, Quinn and Stuart collaborated together for publication and jointly submitted a research grant proposal.

In summary, through four scenarios, this paper describes a provisional exploration in which a social network perspective, supported by SNA as the analytical tool, was adopted by SHEI to build research collaborations strategically. Building collaboration among heterogonous researchers (Challenge 1) was carried out by leveraging the existing collaboration ties within their sphere. In this way, coercing collaboration was avoided (Challenge 2). Strategic opportunities were identified through analytics to progressively optimize collaborations (Challenge 3).

Conclusion and Discussion

Using research collaboration as an example, this paper presents how SHEI adopted a social network perspective and made a provisional exploration of the utility of social theories and tools for enhancing research collaboration within the institution. The paper responds to Kezar's (2005) advocacy for higher education management to better enable and enhance collaborative work in the knowledge economy.

As a practice-driven exploration, 'importing' social theories and tools has a different approach compared to social scientists' theory-driven 'exporting' of social theories to higher education for application and development. Each has a complementary role in advancing higher education as an emerging field of research. As an innovative work 'importing' social theories to higher education, while this provisional exploration may not be adequately sufficient or conclusive, nonetheless offers a useful point of departure in building what Huang and Hung (2018) envisioned as the science of research management, the body of scientific knowledge on research management.

'Importing' Theories to Advance Higher Education Research

This provisional exploration is timely and offers a useful context for taking a critical lens on 'importing' social theories. First, social network analysis is an analytical tool for applying social theories (Martin & Wellman, 2010). Using the tool, interpreting findings and forming

administrative strategies should be explicitly informed by social theories. For example, in this provisional exploration, SHEI used start-up grants, joint seminars and joint appointments creating useful social facilitators of exchange among researchers. Bringing the theory 'importing' work further, SHEI's strategies may be critically challenged with questions such as what are the mechanisms that accelerate research collaboration, in what conditions could their effectiveness be further enhanced and more. Manipulating environments is another way to influence exchange relationships (Baldwin, 1978). Thinking along this line, what research policies and environments could higher education management manipulate to enhance research collaboration? Raising these questions with critical examination advances the 'importing' of theories to higher education.

Next, it is important to critically assess the theories and tools being 'imported'. For example, the network perspective adopted for this paper tends to place emphasis on the properties of relations among individuals (Kadushin, 2011) and neglect the characteristics of the individuals themselves (Martin & Wellman, 2010), such as individuals' research skill and foci. SHEI made necessary adaptations by considering researchers' research interest, when identifying who to choose for building collaborative ties, coping with some researchers' negative feelings that their existing collaboration ties were threatened by management's attempts to build new or structured collaboration ties, etc.

These adaptations must be critically evaluated as well. For example, SHEI simplified the network data by not including the weak ties among co-PIs and collaborators within projects. While not normal, nor advisable to exclude this data, the decision was justifiable because most projects in the dataset had only two team members. If most projects have more than two team members, weak ties among researchers in the same project are important data for enhancing collaboration across projects. In this case, different types of collaborative relationships (e.g., PI to collaborator versus co-PI to collaborator) and the same type of association in different projects could have different degrees of strength. This requires advanced network analysis.

Finally, 'importing' theories—making necessary adaptations and critically evaluating them—potentially leads to a body of literature contributing to 'home-grown' theories in higher education. This attends to Cornelissen and Durand's (2014) caution of one-side 'borrowing' without reciprocally developing 'home-grown' theories to 'export' out. For example, according to Molm (2001), based on the mutual dependence of exchange structure, social exchange may include direct exchange (i.e., A provides value to B, and B to A), generalized exchange (the benefit received by B from A is not reciprocated with B directly giving to A, but indirectly by B's giving to another member of the same network) and productive exchange (both parties in a relationship must contribute in order for either to obtain benefits, such as research collaboration or co-authoring). While generalized exchange and direct exchange are dominant in the literature of social exchange theory, productive exchange is of particular interest to research collaboration. 'Importing' the social exchange theory not only informs research and practice in higher education but also creates an opportunity to study productive exchange in the context of research collaboration and contribute back to social exchange theory.

'Importing' Theories to Impact Higher Education Practice

For 'importing' social theories to impact higher education management practice, some important challenges need to be considered. Higher education needs to be receptive to changes induced by 'imported' theories. For example, if social network analysis is to be adopted as a new management practice in higher education, data availability and analytical capacity become critical in higher education management. Terenzini (2013) and Volkwein (2008) highlight data-collection capability and analytical capability as the HEI's analytical intelligence. Such intelligence contributes to new potentials in higher education.

Cultural and mindset changes induced by the 'imported' theories can be controversial in higher education. In this paper, social network theories and tools are not used just to identify and evaluate collaboration patterns that are hard to detect in conventional approaches. SHEI takes a proactive stance to use social theories and tools to identify opportunities to influence and enhance collaborations within the institution. It further extends Harris' (2010) recognition of the significant roles that administrative leaders play in developing cultural and belief systems to support interdisciplinary collaboration.

However, not all institutions would agree with SHEI's approach. Some institutions may conceive research collaboration as a bottom-up activity (De Zilwa, 2007) requiring minimal top-down intervention. Other institutions may be driven by more urgent imperatives to directly intervene in the assembly of research teams in order to submit research proposals. These institutions may find SHEI's provisional exploration inappropriate for their institutional culture and needs. While such cultural differences and management choices should be respected when 'importing' theories from other disciplines, we reason that there is a need for more innovation and open-mindedness in higher education. Acknowledging and working on these differences helps to advance higher education as an emerging field of research.

Limitation

A key limitation of this paper needs to be highlighted. Often, the HEIs need to constantly adjust their administrative strategies to achieve their missions effectively. After enacting the four administrative strategies presented in this paper, SHEI implemented other strategies such as structural changes, which made it difficult to collect robust direct evidence on the effects of the four strategies implemented. This limitation makes SHEI's exploration provisional and not conclusive. The administrative strategies are only suggestive, not normative. If SHEI held the four strategies constant without introducing new strategies to respond to the change of its environment, this work could be considered ethically questionable because this is not how HEIs function. Future research in higher education needs to effectively balance research rigor with institutional adaptations.

In summary, in the knowledge economy, it is imperative for higher education management to better enable collaborative work. Using research collaboration as an example, this paper presents a provisional exploration of the utility of social exchange theory and social network analysis for

enhancing collaborative work within a HEI. Research collaboration enriches higher education management's thinking for facilitating collaboration work, which contributes to the institutional management, knowledge and research themes of higher education research and offers a useful point of departure in building the science of research management (Huang & Hung, 2018).

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