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Out of Asia: Understanding the nexus between technology usage and research productivity in Japan, Singapore, and Taiwan

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ABSTRACT

Journal and conference publications are well-known measures of scientific and academic research productivity. Prior research on scientific productivity that studies dimensions such as research culture, technological support, and researcher collaboration focuses on Western world contexts. Asian countries, such as Japan, Singapore, and Taiwan have received attention recently for the quality of their educational institutions, which have increasingly emphasized research productivity. With a large number of established and funded public universities, these countries show a strong potential for future scientific research. Consequently, it is crucial to understand the factors that influence the research productivity of scholars in these countries. In this paper the focus is specifically on the research productivity of students and faculty members in three countries: Singapore, Taiwan, and Japan. We investigate an important factor that influences research productivity: technology usage, which we conceptualize as the summation of mobile phone and computer usage. In addition, we analyze the relationship between technology usage and international collaboration.

1. Introduction

The major responsibilities of faculty members in research-intensive universities include not only teaching but also high quality research (Crittenden, 1997). Prior studies on academic research productivity have focused on a multitude of factors that could impact the research outputs of faculty members, research staff, and students involved in research (Crittenden, 1997). The factors include a wide array of individual cognitive factors as well as factors related to institutional research environments. Factors related to the dynamics of group collaboration involving multiple researchers also become crucial (Hara, Solomon, Seung-Lye, & Sonnenwald, 2003). While prior work on academic research productivity is rich and covers a variety of factors (Marsh, 1987), understanding the role of technology usage as a key influencer of research productivity has become increasingly important (Marsh & Hattie, 2002). Technology, such as mobile phones, computers, Internet applications, and various other software, is commonly used to conduct research as well as to collaborate with other research partners. Additionally, the rapidly decreasing cost of these technologies renders them more affordable and hence easily accessible. Academic institutions, especially those focused on research, strive hard to make an excellent technological infrastructure available to faculty members as well as students (Neumann, 1992). The goal in making this infrastructure available is not only to facilitate education but also to support research and research collaboration.

The interest of social scientists in understanding the factors that influence the research productivity of faculty members and researchers is not a recent phenomenon (Barjak, 2006). However, much of this research and subsequent interest in collaboration and technological factors affecting research productivity is focused exclusively on Western countries (Barjak, 2006). While there is no doubt that the data used in such studies are rich and provide valuable insights, the applicability of the inferences made in these studies to countries in Asia is questionable. Countries such as China, Singapore, Japan, and Taiwan have a wide range of universities specializing in different disciplines and known for their excellence in technological advancements (Adams, King, Miyairi, & Pendlebury, 2010). Some governmental initiatives to undertake higher education reforms to increase research productivity and international collaboration are underway in Asia (Deem, Mok, & Lucas, 2008). While the kind of infrastructure capabilities that many universities in these countries offer are comparable to those in elite universities in any Western country, the cultural norms, the

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student-faculty relationship, and the research collaboration culture in these countries possess some interesting aspects that need further examination. The eventual influence of these wide arrays of factors on research productivity could provide some valuable insights on the research environment in these countries and a richer comparison of that to the research environment in Western countries.

In this paper we focus on a specific factor – technology usage and its influence on research productivity and international collaboration. Through an exploratory mixed-methods study consisting of survey-based and interview data, we try to understand the technology usage of faculty and graduate students in three key countries in Asia: Taiwan, Japan, and Singapore. We asked faculty members and students about their computer and cell phone usage, their collaborators, and their research productivity as determined by their journal and conference publications (Fox & Mohapatra, 2007; Hunter & Leahey, 2010). In order to explore the relationship between technology usage and research productivity, we pose three key research questions:

(1) Does technology usage play a role in influencing research productivity in Singapore, Taiwan, and Japan?
(2) How does the relationship between technology usage and research productivity for faculty compare to that of students in these countries?
(3) How does technology usage play a role in facilitating international collaboration in these countries?

A secondary goal of this study is to understand whether conventional knowledge about the influence of technology usage on research productivity from prior research (primarily based drawn on Western world contexts) differs from findings drawn from the three non-Western countries (Japan, Singapore, and Taiwan). We set out to explore the above research questions and gain deeper insights into the research environments at universities in these countries by conducting a field research study involving faculty and students in these three countries. The rest of the paper is structured as follows. We first describe prior literature on the role of technology usage in research productivity. Next, we give a brief overview of each location where we conducted field research and the current state of academic research environments in these countries. We then describe our research methodology, the data collection and analysis approach, and the results. We discuss the findings of this study in light of prior literature on technology usage and academic research. Finally, based on our findings, we also discuss implications for researchers, practitioners, and academic institutions.

2. Background

2.1. Technology usage and research productivity

For many years social scientists have enthusiastically researched the various factors that could influence the research productivity of faculty members and researchers alike (Barjak, 2006). Prior research on research productivity has conceptualized that there is a mutually reinforcing, symbiotic relationship between teaching and academic research (Marsh, 1987; Neumann, 1992). For institutions that have research as their primary focus, it is crucial to develop metrics to measure institutional research performance. A convenient way to measure academic research productivity is to consider the number of publications in prominent journals and conference publications and presentations (Marsh & Hattie, 2002). Quality of research output of faculty and graduate students has been studied and conceptualized in multiple ways in prior research (Marsh & Hattie, 2002). For example, previous studies have examined issues, such as the balance between research and teaching activities (Marsh, 1987), whether research and teaching activities should complement each other or conflict with each other, and whether the research aspect of a faculty member's career is even related to teaching activities (Webster, 1986; Braxton, 1996). The rationale behind reinforcing the relationship between teaching and research is sound and simple. While most studies on research productivity have primarily focused on aspects related to how an academic can conduct research and create a balance between research and other career demands, there are many other aspects related to research that can affect research productivity. Some of these include the research climate fostered by the organization (Govender, 2013), its technological infrastructure and research-related resources available (Govender, 2013; Lim, So, & Tan, 2010) collaboration effectiveness of the researchers (Boulter, 2007), and other individual cognitive factors (Katz & Martin, 1997; Mattessich, Murray-Close, & Monsey, 2001) as well. We consider technology usage by faculty members and students and conceptualize it as a determinant of research productivity. We believe that with the increasing accessibility of research-related resources through computers and the collaboration potential enabled by devices such as cell phones, research productivity could be strongly influenced by the use of such technologies.

In addition to many organizational and individual cognitive factors, prior research has considered contextual factors such as group collaboration, availability of resources, and technological infrastructure as key determinants of research productivity (Barjak, 2005, 2006; Cohen, 1996; Hara et al., 2003). These studies conceptualize scientific research as social rather than as just an individual undertaking that is strongly influenced by the collaboration and communication capabilities of the researcher (Barjak, 2006). Research productivity in these studies has been defined as the sum of journal and conference publications and has been measured using self-reported numbers. For example, Barjak (2006) examined the Internet and its influence on research productivity and found a positive relationship between the two. The author found that Internet technology was used for personal communication, information retrieval, and information dissemination. Similarly, Cohen (1996) and Hughes (1999) had comparable findings in their research studies that explored the role of computer-mediated communications in influencing research productivity. Prior research has also found that the communication capabilities offered by these advanced technologies enable researchers to collaborate with their research partners, thus assisting them in conducting their research more efficiently, leading to increased numbers of publications (Lee & Bozeman, 2005).

Evidently, the importance of technology usage and its relevance to research productivity is not a novel area of research, but it is still unexplored within the context of Asian countries. Asian countries vary largely from their Western counterparts both in terms of their organizational structures and interpersonal communications (Hofstede, 1991). As a result, it can be expected that research environments in these countries would also differ from those in the West. It also raises the question of whether the role of technology that has been found to influence research productivity positively in the West is likewise influential in Asian academic research institutions.

Technology usage has been conceptualized in diverse ways in the information systems domain (Davis, Bagozzi, & Warshaw, 1989). As such, it has been the focus of many seminal pieces in the field (Bagozzi, 2007). One well-known conceptualization of technology usage is based on three dimensions: frequency, duration, and intensity (Adams, Nelson, & Todd, 1992; Venkatesh, Morris, Davis, & Davis, 2003). Frequency of technology usage refers to how frequently a technology is being used on a daily basis, duration reference to the amount of time spent in using that technology, and

intensity refers to the focus with which the technology is being used by an individual (Venkatesh et al., 2003). Some of the earlier literature in information systems has conceptualized technology usage as an influencer of system success in organizations (DeLone & McLean, 2003, 2004). In the context of our study, technology usage is the use of an implemented technology in an organization. The key argument is that if employees are able to use technology for work purposes, then that system is a success (DeLone & McLean, 2003).

Borrowing from the earlier definitions of technology usage (Venkatesh et al., 2003), we take into account the duration of use of technologies, such as computers and cell phones, by faculty members and students at universities. In addition, we consider the frequency of use in various locations such as labs, homes, and work offices. We further consider technology usage as a determinant of productivity and consider journal and conference publications as the metrics for our research productivity measurement.

2.2. International collaboration

An important facet of academic research is collaboration between scholars located at different universities or research institutions, often across geographic boundaries (Aytac, 2010; Wuchty, Jones, & Uzzi, 2007). In recent decades, the boundaries of academic research have blurred as scholars have found their international collaboration experiences to be fruitful (Wuchty et al., 2007). In fact, research has highlighted that such exchange of knowledge facilitated through collaborative research between faculty in different nations leads to better research outcomes in terms of number and quality of journal or conference publications (Aytac, 2010; Barjak, 2006; Walsh, Kucker, Maloney, Maloney, & Gabbay, 2000). In addition to gaining international visibility and recognition, international collaboration provides an inherent benefit to researchers, since they get access to more infrastructural facilities through their collaborators. International collaboration also helps researchers to gain exposure to international research outlets and conferences that they might not otherwise be aware of (Barjak, 2006). Rapid advancements in Internet technologies over the past many years have facilitated higher levels of international collaboration (Sooryamoorthy & Shrum, 2007), and Internet and cell phone technologies have created a borderless communication channel that has better facilitated collaboration. Recent research has highlighted that for those nations where research productivity is still gaining at a slow pace, it is important to leverage technologies in order to benefit from research in nations where advanced scientific research is well practiced and supported (Aytac, 2010; Sooryamoorthy & Shrum, 2007). We consider effectively leveraging available technological infrastructure as an important factor influencing international collaboration. As noted before, we consider well-known characterizations of technology usage and measure international collaboration in terms of the number of international collaborators that faculty and students have across their top projects (Barjak, 2006; Sooryamoorthy & Shrum, 2007). Broadly, we posit that technology usage is highly correlated with the extent of international collaboration an individual has. Further details on our proposition and the operationalization of international collaboration have been described in the methods section.

2.3. Country profiles

In terms of percentage of national budget allocation for research the three countries under consideration are ranked in the following order: Japan (1st), Singapore (2nd), and Taiwan (3rd) (Normile, 2005). With a strong drive to compete among global academic institutions, the governments in these countries have begun to pay close attention to university rankings (Deem et al., 2008) and have undertaken reforms and restructuring initiatives with the goal of making their higher education and research institutions globally competitive (Lo, 2009; Mok, 2007). As research productivity is an obvious yardstick in measuring university performance, these countries have started investing in research, especially in the domains of science, technology, and engineering (Deem et al., 2008). With these changes in mind, there is no doubt that the next few decades will witness rapid growth in the quality of research output at these universities.

In recent decades, Japan has emerged as a leader in the sciences and has heavily focused on research and technology innovation (Adams et al., 2010). However, despite its rapidly developing technology and research domains, Japanese research institutions and universities are still struggling to achieve global recognition (Normile, 2007). Some insiders attribute this to the hierarchical, insular, rigid, and patriarchal orientation of the Japanese scientific system (Youichi, 2000). Additionally, not many Japanese universities and research institutions actively recruit foreign researchers and academics. Further, Japanese policies surrounding tenure are different from the traditional policies in Western countries. For example, offering full-time professorships to international professors is still not an accepted practice. Other issues, such as the fact that the majority of courses and academic programmes are conducted in Japanese, are hindrances to attracting enough foreign students (Normile, 2007). Japanese academic institutions and Japanese society in general often exclude foreigners, which includes students and faculty. Based on the data we collected, none of the faculty participants in Japan earned their doctoral degrees outside of the country, whereas the number of doctoral degrees earned by faculty participants outside of the country in Singapore was 22 out of 24 and in Taiwan was 11 out of 30.

Since the early 1990s, Singapore's government has put forward comprehensive educational reforms geared towards developing world-class universities and research facilities (Lee & Gopinathan, 2008). In addition to offering financial flexibility to key public universities, such as National University of Singapore [NUS] and Nanyang Technological University [NTU], the reforms have been geared towards hiring quality researchers from around the world to conduct research at institutions in Singapore (Lee & Gopinathan, 2008). The goal is to develop research institutions that can eventually help Singapore become a central player in advanced sciences and related disciplines (Normile, 2011). One of the major aspects of the financial market in Singapore (and consequently a major investment in research) is the biotechnology industry. Biotechnology is the fourth largest industry in the country and as a result warrants major government investments (Normile, 2011). Responding to the increasing internal demand for high-quality research in the sciences and motivated to achieve recognition as a leading research-focused economy, Singapore has recruited top-notch scientists from around the globe to its life science research organizations in the last decade (Normile, 2011).

Taiwan's higher education system has undergone substantial expansion since the 1990s (Lo, 2009). From a mere 50 higher education institutions in 1991, Taiwan expanded to 163 institutions in 2007, benefiting from substantial investments from the private sector (Lo, 2009). In order to boost research at these institutions, the Taiwanese government initiated the Academic Excellence Programme in 1998 with an initial investment of NT$4.3 billion that was allocated to three research projects out of the 19 grant applications (Taiwan Ministry of Education, 2003). After the overwhelming success of the first round initiative, the second round from 2002 to 2006 was further expanded to twelve projects out of 148 applications (Taiwan Ministry of Education, 2003). These initiatives are geared towards effective development of the research infrastructure, which includes libraries and laboratories. A secondary goal of these initiatives is to foster cooperation and knowledge

exchange among prolific researchers, leading to an increase in research productivity (National Science Council, 2005). In the past decade, Taiwan has allocated over $300 million per annum to strengthen its scientific research infrastructure and workforce further (Normile, 2005). Funds were allocated to top research universities (e.g. National Taiwan University) and research institutions (e.g. Academia Sinica) to remain competitive with counterpart institutions in Japan (e.g. University of Tokyo and Tokyo Institute of Technology) and in Singapore (e.g. NUS and NTU). These investments have helped Taiwan maintain a rapidly growing population of scientists and researchers in their knowledge economy (National Science Council, 2005; Normile, 2005). As a result, Taiwan recently ranked among the top one percent of research universities in the world. Unlike Singapore but similar to Japan, professors and scientists in Taiwanese research training institutions are predominantly locals, who have either earned their doctorates in the United States or in Taiwanese universities. Like their professors, graduate students are also predominantly locals with a few coming from other parts of the greater East Asian region (e.g. China, Indonesia, and the Philippines).

3. Methods

We employed mixed methods (Feilzer, 2010) to collect both qualitative and quantitative data from the life science programmes at elite research universities in the East Asian region. This is a part of a larger study (see e.g. Nentwich, 2003). We conducted on-site face-to-face surveys and in-depth interviews with faculty members and students in university laboratories in Japan, Singapore, and Taiwan. Although other countries, such as China, India, and Korea, have strong scientific productivity, we chose these three countries as we have reliable connections in them.

The data were solicited from a sample of life scientists – primarily biochemists, geneticists, and molecular biologists – in Japan, Singapore, and Taiwan. Due to monetary constraints associated with conducting international social research, our sample size was limited to 30 faculty scientists and 70 students per country. In each country our local coordinator drew a sample of scientists from lists generated from departmental websites at each of the institutions and universities we surveyed.

3.1. Procedures and measures

In May–July 2009, we collected data from 30 faculty scientists and 70 students in four research universities in Taiwan. In June–July 2010, we surveyed additional 30 faculty scientists and 70 students in three research-university campuses in the Tokyo metropolitan area. Furthermore, in July–August 2010, we surveyed 24 faculty scientists and 70 students at three research institutions in Singapore. Due to coordination issues, we were unable to fulfil the target sample size for scientists in Singapore. As such, our final sample size was $n = 294$. The quantitative surveys covered questions regarding demographics, research area, research productivity, collaboration, support networks, technology usage, mentoring practices, and interaction with students (or advisors). More specifically, in order to understand technology usage, our survey included items asking the participants to identify the usage of technologies such as mobile phones and computers for research-related activities. Drawing from prior research, research productivity was conceptualized as a cumulative construct, combining the number of conference and journal publications (Cohen, 1996; Fox & Mohapatra, 2007; Hunter & Leahey, 2010; Lee & Bozeman, 2005). Technology usage was measured using multiple items in the survey; participants were asked to specify the approximate number of hours they used cell phones and computers in laboratories, work places, and at home (Sooryamoorthy & Shrum, 2007; Venkatesh & Morris, 2000; Venkatesh et al., 2003). These conceptualizations were used for both faculty members and students. International collaboration was measured by asking faculty and students about their three major projects and whether the projects had local or international collaborators or both. In order to understand whether international collaboration plays a role in influencing research productivity, we asked students and faculty the number of top journal publications they had in their respective fields. Although most participants responded to this without hesitation, we clarified that top journals as journals with impact factors of at least 4.00 whenever participants asked.

3.2. Analysis and results

We used correlation analysis to test the validity of our propositions. In conducting the analysis, the primary goal was to understand the relationship between the role of technology usage and the research productivity of (a) faculty members and (b) graduate students. We conducted the analysis for each of the three countries – Japan, Taiwan, and Singapore – as well as for the combined data for all three. In addition, we conducted correlation analysis for the relationship between technology usage and research productivity for faculty members and students separately as well as cumulatively. To provide further depth to our analysis, we also conducted correlation analysis to understand the influence of technology usage separately on journal and conference publications. As noted before, research productivity was conceptualized a cumulative measure of the total number of journal publications and conference publications within the last 2 years. We conducted a two-tailed correlation analysis, resulting in the correlation coefficient and the associated level of significance for the correlation. The paragraphs below summarize our findings and results.

The results are presented in Tables 1–6. Table 1 shows the average numbers of hours of technology usage for research (computer and cell phone usage combined) and of publications for faculty and students. Results from Table 1 show that Japanese faculty had a significantly higher number of publications than Singapore, which was followed by Taiwan. In contrast, Singapore faculty were found to have a higher number of top journal publications than Japanese and Taiwanese faculties. Also, the students and faculty in Singapore were found to utilize technology resources for more hours than the Japanese and Taiwanese faculty. Table 2 presents the results for faculty members from the three countries considered separately as well as cumulatively. Table 3 depicts the results for students from the three countries considered separately as well as cumulatively. Table 4 provides the cumulative correlation results for faculty members and students with regard to the relationship between technology usage and publications (journal, conference, and total). Tables 5 and 6 focus on international collaboration. Interestingly, as seen in Table 2, none of the correlations for the relationship between technology usage and publications (journal, conference, and total) were found to be significant for faculty members. These results are in sharp contrast to the results for students (Table 3). For students, except for those in Singapore, the correlations between technology usage and publications (journal, conference, and total) were found to be significant.

When cumulating the data from the three countries (Table 4), the results were as follows. Significant correlations were found between technology usage and journal publications as well as technology usage and total publications (i.e. journal and conference publications cumulative). More specifically, the correlations between computer technology usage and (a) journal publications, (b) conference publications, and (c) total publications, were all found to be significant for students (Table 3) and were found to be insignificant for faculty members (Table 2). These results indicate

Table 1
Averages for technology usage and publications.

Means	Japan	Singapore	Taiwan
Number of hours of technology usage per week for faculty	31.59	37.93	30.13
Number of hours of technology usage per week for students	19.57	29.35	40
Number of articles in journals for faculty	17.73	10.75	6.47
Number of articles in top journals for faculty	4.73	7.00	1.50
Number of journal publications for students	0.26	0.53	0.36
Number of conference publications for faculty	6.3	7.08	1.29
Number of conference publications for students	0.62	0.54	0.64
Number of total (journal + conference) publications for faculty	24.03	17.83	7.76
Number of total (journal + conference) publications for students	0.88	1.07	1.00

Table 2
Correlation results for faculty members.

Relationship being tested	Japan	Singapore	Taiwan	Cumulative results for the three countries
Correlation between technology usage and journal publications	0.223	−0.054	0.338	0.159
Correlation between technology usage and conference publications	0.183	0.109	0.14	−0.12
Correlation between technology usage and total publications	0.203	−0.08	0.25	0.023

Table 3
Correlation results for students.

Relationship being tested	Japan	Singapore	Taiwan	Cumulative results for the three countries
Correlation between technology usage and journal publications	0.154*	0.013	0.262*	0.155*
Correlation between technology usage and conference publications	0.99***	0.13	0.25*	0.15**
Correlation between technology usage and total publications	0.98***	0.08	0.28*	0.16*

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 4
Correlation results for faculty and students combined.

Relationship being tested	Japan	Singapore	Taiwan	Cumulative results for the three countries
Correlation between technology usage and journal publications	0.351**	0.141	0.056	0.121*
Correlation between technology usage and conference publications	0.64***	0.22*	0.06	0.056
Correlation between technology usage and total publications	0.55***	0.179	0.064	0.103*

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 5
Proportion of international collaboration and number of journal publications.

Means	Japan	Singapore	Taiwan
Collaboration inside country	0.77	0.79	0.70
Collaboration outside country	0.57	0.83	0.23
Number of articles in top journals	4.73	7.00	1.50
Number of articles in journals	17.73	10.75	6.47

that students are better able to leverage technology to improve their research productivity than faculty members. Also, results in Table 4 indicate that among the three countries in this study, Japanese students and faculty members are best able to leverage technology to improve their research productivity.

Next, we wanted to investigate whether technology usage is correlated to the extent of international collaboration. Table 5 presents the analysis of the proportion of international collaboration across the three nations and the mean number of self-reported journal publications. The first two rows in Table 5 capture the fraction of international and local collaborators faculty had in the three countries. As noted in Table 5, it was found that faculty in Singapore had the highest proportion of international collaboration (0.83) as compared to Japan (0.57) and Taiwan (0.23). The next two rows in Table 5 show the mean number of top journal and total international journal publications, respectively, for each country. It is interesting to note that Singapore, which had the highest proportion of international collaboration, was found to have the highest mean for top journal publications (7.00). In contrast, Taiwan had the lowest proportion of international collaboration as well as the lowest mean of top journal publication (1.5). These numbers conform to the findings of prior research that suggests international collaboration is crucial in improving research productivity (Aytac, 2010; Sooryamoorthy & Shrum, 2007).

Based on our review of prior literature, we posit that technology usage plays a critical role for faculty to leverage the benefits of international collaboration. We argue that higher levels of technology usage for international collaboration would lead to greater numbers of publications in journals, especially top journals in the respective fields of respondents. Table 6 shows the correlation

Table 6
Correlation between technology usage and international collaboration for faculty members.

Relationship being tested	Japan	Singapore	Taiwan
Correlation between technology usage and international collaboration for faculty	0.976***	0.998***	0.994***

*** $p < 0.001$.

analysis for the relationship between technology usage and international collaboration for faculty across the three nations. Results show that technology usage and international collaboration are highly correlated. Analysing the results of Tables 5 and 6 combined, it is evident that faculty in Singapore were able to leverage technology usage for international collaboration effectively, which led to a higher number of top journal publications. Results for Japan and Taiwan were similar. Japanese faculty were also able to leverage technology usage for improving international collaboration, which led to a high number of journal publications. In contrast, Taiwanese faculty had lower level of technology usage for international collaboration, which also influenced their number of journal publications.

4. Discussion and implications

The results of our research provide several insights and have some important implications. One of the major findings of this study is the difference in technology usage between faculty members and students. Although faculty in all three countries had excellent publication records, the correlations between technology usage and publications (journal, conference, and total) were found to be not significant for each of the three countries (Table 2). Even for the three countries cumulatively (Table 2), the correlations for faculty members with respect to the relationship between technology usage and research productivity was found to be not significant. While technology usage should not be considered as the single correlate or predictor of research productivity, it is still a key influencer (Barjak, 2006). It is common for researchers to collaborate with each other using computer-based tools or software that enable document sharing, voice calling, and video conferencing (see e.g. Hara et al., 2003; Nentwich, 2003). These rich modes of communications enabled by computer technology lead to effective collaboration between research team members (Dennis, Fuller, & Valacich, 2008; Daft & Lengel, 1986). Moreover, increase in use of modern technologies such as mobile phones and computer software, which enable easy and rich communication between people, are known to improve collaboration capabilities and sharing of information (Dennis et al., 2008; Daft & Lengel, 1986). Along with the rich media capabilities that these technologies offer, it is convenient for users of these technologies to access useful resources and easily collaborate with any research partners (Barjak, 2006; Dennis et al., 2008). In addition, with the extent of financial investments that universities or educational institutions make in improving the technological infrastructure, it faculty members should leverage such technological resources for research benefits.

Moreover, the results of this research provide some intriguing insights about the relationship between research productivity and technology usage for students. The results for students are in sharp contrast to the results for faculty members. For Japan, Taiwan, and also at the cumulative level (see Tables 2 and 3), the correlation coefficient for the relationship between technology usage and (a) journal publications, (b) conference publications, and (c) total publications was found to be statistically significant. Interestingly, results for students from Singapore were not significant, indicating a resemblance with faculty members in Singapore, for whom the correlation results were insignificant as well. There are some interesting inferences that can be made from these findings.

In contrast to faculty members, the results indicate that students not only use technological resources for more hours, but are also able to leverage them better for their research. From the survey results and interviews, it was also noted that students not only used computer resources but also use mobile phones for collaboration purposes. For Japan, the correlation coefficients are strong ($r = 0.99$, $p < 0.001$, for conference publications), indicating a strong influence of technology usage on research productivity. Another interesting aspect of the results for Japan is that only the correlations for students were significant. The correlation coefficients for faculty members were not significant. The finding does highlight the fact that Japanese faculty members do not leverage the available technology resources for improving their research productivity. The results for Taiwan have similar implications. In fact, during the qualitative interviews, some faculty members in Taiwan expressed concerns for students being over-reliant on computers while some emphasized the benefits of using information technologies for research and collaboration.

The cumulative findings for the three countries (Tables 2 and 3) emphasize the fact that faculty members are not using technology resources to leverage research productivity benefits as much as students are. These results resonate with prior research in the information systems domain that discusses the differences in technology usage with age (Daft & Lengel, 1986). Prior research has shown that variables such as gender and age are key to understanding technology usage (Venkatesh & Morris, 2000; Venkatesh, Morris, & Ackerman, 2000). Younger people (like students) have been found to be more capable with the use of advanced technology as compared to older age. While the generalizability of these findings is difficult to establish, the results from the three Asian countries considered in this study confirm the findings of prior work.

Our third research question highlights an important factor influencing research productivity, that is, international collaboration. As discussed, recent research has emphasized that international collaboration, if leveraged appropriately, can lead to improved research productivity (Aytac, 2010; Sooryamoorthy & Shrum, 2007). The results of our study are consistent with these findings. We introduce an important dimension – technology usage, which facilitates international collaboration. The results of our study highlight that technology usage is highly correlated to international collaboration (Table 6). In addition, results in Table 4 emphasize that faculty that are able to leverage this technology-mediated international collaboration are related to an increase in their journal publications, especially in top journals for their respective fields. In summary, a higher level of technology usage not only facilitates international collaboration but can also lead to improved research productivity.

5. Limitations

The findings of this study should be interpreted in light of certain limitations. First, while we propose the research questions in this study as being applicable to other elite universities in Asian countries in general, our data was collected only in three countries within the East Asian region. There are other countries in Asia such as China, India and Korea that have highly vibrant economies and emerging research environments. Consequently, while our results for Japan, Singapore, and Taiwan have some interesting insights, the

generalizability of these findings needs further examination. Other countries within Asia, such as China, India, and Korea, might have different research and collaboration environments that influence research productivity. In addition, since the focus of this study is on the technology resources such as computers and cell phones, it is essential to consider other external factors such as infrastructural facilities made available by the university and the funds available to build such infrastructural capabilities. These factors might differ from one country to another. As a result, these external factors might influence the availability of technology resources for faculty and students and in turn affect the collaborative capabilities and research productivity in those countries.

Another limitation of our study is our subjects and their academic departments. All subjects considered for this study were from the life sciences departments in their respective universities. It is likely that the disciplinary culture in one particular scientific domain might differ from another, as shown by Walsh and Bayma (1996). For example, while much research work in life sciences departments might be carried out in labs, the research work in departments such as management or sociology might be carried out in real-world settings. Consequently, aspects such as required technological infrastructure, extent of virtual collaboration, and use of technology vary across departments. These aspects might have an influence on correlations between technology usage and research productivity. For example, for researchers engaged in field studies that involve survey data and qualitative data, the use of technology resources such as computers might be limited only to certain phases of their research process. This might be in contrast to research work in sciences where technology resources might be heavily used to run computer modelling and simulations.

6. Conclusion

The results of this study have several implications for researchers and practitioners alike. For researchers, this study opens several future research avenues. One of the key findings of this study is the difference in technology usage among students and faculty members and also the strong correlations between technology usage and research productivity. In this research we conceptualized technology usage as the number of hours that technological devices such as computers and mobile phones were used. In the information system literature, the technology usage construct has been extensively studied and has been conceptualized in richer ways. For example, apart from the duration of technology usage, some other parameters such as the frequency and intensity of use (Venkatesh et al., 2003) have also been considered measures for technology usage. More recently, the extent of individual engagement during technology usage and the extent to which an individual explores the features of the technology for obtaining benefits have been proposed as finer measures of technology usage rather than the traditional measures such as frequency, duration, and intensity of use (Burton-Jones & Straub, 2006). Future research can consider such more nuanced conceptualizations of technology usage to understand its impact on research productivity. In addition, while research productivity in this paper has been measured on the basis of number of conference and journal publications, future research can consider specific aspects of research practices that lead to better productivity and the role of technology in executing such research activities effectively. This could provide insights on what specific aspects of research technology is most useful for. Such research could also highlight aspects of research productivity, such as international collaboration, that are more influenced by technology as compared to other aspects.

The results of this study have several implications for academic institutions and practitioners involved in technology-related decision-making in academic research. One of the key findings of this study is that faculty are not using technology to the extent that students are using to increase research productivity. Educational institutions can investigate the reasons why faculty members are unable to leverage the available technology for their benefit. Academic institutions can work with faculty members to demonstrate the ways in which they can effectively use technology for research purposes. In addition, if technology access or training is an issue, institutions can address such issues by conducting workshops or providing advanced training. Moreover, academic institutions can work with faculty members to understand which of the technological resources are unused. By knowing about such technologies that are not used, the academic institutions can avoid any unnecessary monetary investments made in procuring technology or purchasing software licenses. Alternatively, academic institutions can also make decisions about making the technological resources available to only those who need it, thus reducing unnecessary expenses.

With the emergence of advanced computer- and Internet-enabled technologies, it has become imperative for academic institutions to ramp up their technological infrastructure in order to support research initiatives. While availability of technological resources is seen as a key factor in evaluating academic institutions, research productivity is another essential parameter that is considered in many of the ranking metrics used for academic institutions. Consequently, the relationship between technology usage and research productivity is a crucial one to understand. In this paper, we specifically focused on academic institutions located in three countries in Asia: Taiwan, Japan, and Singapore. Using a mixed-methods approach consisting of interviews and surveys of faculty and students at these universities, we tried to understand the relationship between technology usage and research productivity. The results of the study indicate a strong correlation between the two factors. It was found that students at the academic institutions in the three countries were able to leverage the available technologies to gain research benefits. It was found that students that were using technology more were more productive. On the other hand, while the faculty members at these institutions were productive, they were not using technological resources to increase research outputs. The correlation between their use of technology and research productivity was found to be not significant. The findings also indicate strong correlation between technology use and international collaboration. The findings have implications for future research as well as practical implications for academic institutions.

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