AN EVALUATION OF RESEARCHER MOTIVATIONS AND PRODUCTIVITY OUTCOMES IN INTERNATIONAL COLLABORATION AND PARTNERSHIPS AT A U.S. RESEARCH-INTENSIVE UNIVERSITY

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Abstract

This paper examines factors that influence faculty at a research-intensive U.S. public land grant university to engage in international collaborations and partnerships. Using a mixed-mode (web, mail, and telephone) survey, we collected data from 764 researchers at Washington State University, Pullman, Washington, USA, to provide a baseline and current context of demographic characteristics, motivations, barriers, and academic outcomes in relation to international research collaboration. Our results suggest that funding, reduced organizational and institutional barriers, effective institutional support, previous global experience, and research outcomes can encourage faculty to engage in international collaboration. We also found that faculty involved in international collaboration, on average, exhibited higher productivity and a positive correlation with scholarly output, especially through joint publications and student training. The results of this study may provide a reference for research-intensive institutions interested in optimizing their internationalization agendas through partnerships, and examining their policies, strategies, and messaging to increase faculty engagement in collaborative research that promotes co-creation, reciprocity, mutually beneficial partnership, and organizational transformation.

Keywords: academic faculty, partnerships, collaboration, strategy, international research, higher education

INTRODUCTION

As scientific and other fields of research become more global in nature with the hallmarks of easier data sharing, better communications, and more reliance on cross-disciplinary and country information exchange and interactions, it is important for research institutions to prioritize international research partnerships and collaboration. As a form of global interaction, international research collaboration (IRC) is an activity pursued jointly by researchers in various sectors whose primary institutional affiliations are in different geographical regions (Beaver, 2001; Jeffrey, 2003; Anderson, 2011; Payumo et al., 2017). Strategically, institutions and institutional administrators are vested in understanding the nature of research collaborations, the expansion of international research partnerships (IRPs), and the connection of these activities to faculty productivity and the resulting cooperation and competitiveness in the global world of research. As demand for more global partnerships in research and knowledge generation increases, institutional decision makers have a critical need to understand and manage the myriad of factors influencing the cooperative and competitive nature of research activity and faculty productivity to improve an institution's global research visibility. At the same time, institutional leaders must also strategically place global linkages at the center of their internationalization agendas and make *transactional* collaborations into *transformational* partnerships based on a model of co-creation, shared risks and responsibilities, interdependencies, and mutually beneficial partnerships (International Development Services, 2016).

Collaborations and partnerships are changing the global research landscape, allowing entry of new regional networks and reinforcing the capacity of emerging economies in solving complex global challenges (Adams, 2012). IRC and IRPs are also gaining recognition for their impact on research (Jeong, Choi, & Kim, 2014). Multi-institutional international collaboration is associated with higher numbers of citations of papers overall and citations in journals with high impact factors (Franceshet & Constantini,

2010; Goldfinch, Dale, & Rouen, 2003; Iribarren-Maestro, Lascurain-Sánchez, & Sanz-Casado, 2009), and with increased reputation and ranking (Lim & Boey, 2013; Phelps, 2013). Internationally launched policy initiatives (e.g. US-UK Global Innovation Initiative) are also changing the climate for funding access and opportunities for collaborative research; funding agencies make international collaboration with local researchers as part of the research team, as well as cost-sharing mechanisms, requirements for funding, which further stimulates and fosters development of true international partnerships among researchers (Bammer, 2008; Barquera, et al., 2018; Bockarie, Machingaidze, Nyirenda, Olesen, & Makanga, 2018). Awareness of these issues contributes to pronounced interest in how universities can further promote, stimulate, and support IRPs.

While IRCs and IRPs are increasing in number, most of the literature emphasizes an aggregate or macro perspective. Kang (2017), for instance, investigated the main factors influencing international joint research in Korea and how the government can facilitate this form of partnership. Focused on collaborative research in tuberculosis and plant biotechnology, recent studies of Molton et al. (2017) and Payumo and Sutton (2015) likewise focused on studying international collaboration at the national and regional levels, respectively. Jeong, Choi, and Kim (2012) examined possible drivers of international collaboration but likewise used national data focused at the project level. We, along with other experts, have also examined traditional and new metrics to measure the impact of international research collaboration at the institutional level (Payumo et al. 2017). These studies reinforced the importance and benefits of international collaboration in terms of tangible outputs (publications, extension/outreach materials, technologies, etc.); they did not, however, demonstrate individual motivations and the impacts of international collaboration at the scientist or researcher level or emphasize the importance of intangible outputs to influence the establishment of IRC and true research partnerships. To our knowledge, there has not been a publication of a profile or case study of a research institution's faculty to assess the link between international collaboration and tangible faculty-driven outcomes, and

intangible motivation factors. Further, the concepts of collaboration versus partnership based on mutual respect, accountability, and benefit (Gilbertson, Craft, & Potter, 2019; International Development Services, 2016) are generally used interchangeably and lumped under the heading of "collaboration," employing commonly used metrics and proxy metrics (e.g. co-authored publications) without deeper understanding at the individual and institutional levels.

This exploratory research using Washington State University (WSU) as a case study was an attempt to understand these issues and to contribute to the literature on research partnerships by identifying key tangible and intangible motivational factors or determinants of IRC from the individual faculty members' perspective. We also reflect on some of the factors that are shaping the discussion of the importance of international collaboration; these factors are helpful for understanding and sustaining international partnership in research-intensive public universities.

This study aims to dissect the connection of faculty researchers' demographic characteristics, motivations, barriers, needs, and academic outcomes in relation to international research at a large public research institution in the United States. It seeks to complement existing research by providing a micro-level examination of faculty at a research university and the potential drivers of IRC and IRPs. This research is also based on a premise that variations exist in terms of support, interaction and encouragement at the institutional, college, and departmental levels, which can potentially influence a faculty researcher's international research engagement. Findings in this research should give administrators and other sponsors of research considerable optimism about the importance of IRC to the institution and to individual faculty members. The results of this study could also form the basis for a larger-scale study that could include several universities, national and international and even corporate and industry research entities, to evaluate the broader outcomes of internationalization through robust, equitable research partnerships.

In the literature review, we provide background on the factors involved in motivating and furthering research collaboration and partnerships, especially internationally. In the data section, we present our quantitative findings and provide descriptive insights into these factors. In the results section, we build on these insights to develop a model that relates to IRC and individual variables. Finally, we discuss the results, implications, and opportunities for future research in this area.

LITERATURE REVIEW

Research described as individual research leader-centric is now a thing of the past. Collaboration and partnership between scientists and researchers in multiple disciplines are increasingly becoming a central activity in research. This mutual engagement of participants in a coordinated effort rather than siloed, specialized knowledge-only approaches (Gilbertson, Craft, & Potter, 2019; Corbett & Kardos, 2019) to solve problems or develop opportunities together (Roschelle & Teasley, 1995) can even be considered a necessity for groundbreaking research in the 21st century. With rising research costs, concerns about financial shocks, rapidly changing technologies, complex research issues, global research trends, and demands for specialized knowledge and new ways of managing innovation, many academic institutions are turning to domestic and international partnerships to address problems and opportunities too complex to deal with on their own.

Many believe that collaboration and partnership, despite many of the challenges and trade-offs, can help increase productivity, maintain motivation, and stimulate creativity and risk-taking (Austin & Baldwin, 1992; Landry, Traore, & Godin, 1996; Lee & Bozeman, 2005; Kelly & Schaefer, 2017). In higher education, collaboration can maximize the use of limited resources and enhance the quality of teaching and research (Austin & Baldwin, 1992). The need for and impact of more collaboration in research have been tested theoretically as presented by group theory (Whitfield, 2008; Leite &

Pinho, 2016) and social network theory (Dall'Asta, Marsili, & Pin, 2012; Moolenaar, 2012). Recently, Eisler's (1988) cultural transformation theory framework was used by Gilbertson, Craft, and Potter (2019) to help promote systems thinking and to explain the transition from single-discipline (power over) domination toward a more mutualistic partnership model. In this model, these authors suggest that researchers adopt a more long-term, flexible approach, working together with shared goals, values, and results.

Previous literature has been instrumental in refining and testing our hypotheses in this study. For instance, the work of Austin and Baldwin (1992), Bayer and Smart (1988), and Fox and Fayer (1984) has long claimed the greater frequency of partnership for science-related or data-intensive disciplines compared to word-intensive disciplines such as the humanities and social sciences. Several groups (e.g. Pain, 2014, and Disis and Slattery, 2010) highlighted the value of multidisciplinary approaches to address complex problems and encourage more collaboration and multidisciplinary research. The work of Chang and Huang (2015) tested and highlighted the effects of resources such as facilities, manpower, and funding in encouraging more foreign partners and in playing an influential role in the international collaboration and partnership network. Additionally, the work of several authors (Puuska, 2010; Abramo, D'Angelo, & Murgia, 2012; Lariviere et al., 2012) and the recent publication of Elsevier's *Gender in the Global Research Landscape* (Elsevier B.V., 2017) recognized gender disparity in research output and collaboration patterns.

Empirical evidence for increased research partnership is the observed growth in co-authored publications (Sooho & Bozeman, 2005; Sonnenwald, 2007). This documented outcome of collaboration (whether domestic, inter-institutional, intra-institutional, or international), along with personal experiences and successes, mentoring, chance events, and diverse perspectives, may influence individual scientists to pursue more partnerships (Carpi & Egger, 2009; Huang, 2014). Hence, cooperation, collaboration, and partnership are deemed important, with high value accruing to scientists' career

success (Van Rijnsoever, Hessels, & Vandeberg, 2008; Lee & Bozeman, 2005). However, many studies, including Sutton (2003) and International Development Services (2016), find research collaborations plentiful but thin in substance, very transactional, and not helping to transform individuals, institutions, and higher education as a whole. A recent editorial in The Lancet Global Health (2018), as well as Bockarie, Machingaidze, Nyirenda, Olesen, and Makanga (2018) and Hedt-Gauthier et al. (2018), recognized the need to address "parachute and parasitic research", especially in global health collaborations. A campaign for a new framework for collaboration and partnerships is championed by the *Interdisciplinary Journal of Partnership Studies*, Science of Team Science, KPMG International, and research funders, among others, to mitigate the widening inequity gap that promotes domination in research collaborations. Understanding of the persistence, benefits, factors, and current call for action linked to greater research collaboration and sustained partnerships is important in terms of our conceptual view of IRPs as the fourth age of research (Adams, 2012; Adams, 2012; Gershenson, 2012; Witze, 2016; Wagner, Park, & Leydesdorff, 2015). All these claims may also make IRC and IRP more attractive for academic institutions and individual researchers.

DATA, METHODOLOGY, AND DESCRIPTIVE STATISTICS

To test our hypotheses, we designed a mixed-method survey questionnaire targeting academic research faculty members at WSU. The survey, designed and managed by WSU's Social and Economic Sciences Research Center, was primarily administered as a web survey and supplemented with mail and phone follow-up to maximize response rates. The survey, estimated to take 15-20 minutes, was launched in February 2014 and ran for three months.

In the survey, we defined academic research faculty as academic staff responsible for planning, directing, and undertaking research activities, and international research faculty as researchers engaged in international research-related grants and contracts

and/or with internationally co-authored publications and/or co-inventions. These faculty members included professors of various ranks (assistant, associate, and full) with tenure, tenure-track, or non-tenured contracts and appointments (Payumo et al., 2017).

The survey had five sections. The first section collected data on academic disciplines and whether researchers were involved in basic research, applied research, or both, and whether the respondent participated in interdisciplinary research. Classification of academic disciplines was guided by the standard definitions of the National Science Foundation (National Science Foundation , 2013). The second section explored the extent of involvement in IRC and IRP. The third section addressed international research experience, motivations, perceptions, and attitudes towards research collaborations. The fourth section addressed faculty awareness and use of tools to promote and measure the outcomes of research partnerships and support from institutional offices for international affairs and research. The fifth section addressed socio-professional indicators including gender, citizenship, international education, country of birth/origin, and international experience. The data was analyzed using SPSS version 16.0, and descriptive and analytical tests. The relationship of relevant variables was analyzed using logistic regression.

A total of 2,738 out of the 3,506 academic faculty at WSU who were contacted to participate were eligible to be included in the survey. A total of 764 questionnaires were collected, corresponding to a response rate of 27.60% (764/2738) with a computed American Association of Public Opinion Research Response rate of 4.

More than half of the respondents were male (59.70%, 360/603) U.S. citizens with their entire education completed in the U.S. (60%, 363/605). Most (81.83%, 500/611) had a doctoral degree. There was wide diversity in number of years the respondents had been in paid positions at WSU, ranging from less than one year to more than 20 years. Slightly

less than half of the respondents were tenured (47.90%, 292/609), while the rest were on tenure-track (12.20%, 74/609) or non-tenured (39.90%, 243/609) positions. Table 1 provides a summary of these descriptive statistics.

Table 1. Descriptive statistics of demographic variables.

Measure	n	%
Gender		
Male	360	59.70 %
Female	243	40.30 %
Citizenship		
U.S. citizen (education completed abroad)	27	4.46%
U.S. citizen (2+ years of global experiences)	30	4.96%
Naturalized U.S. citizen	52	8.60 %
International born/non-U.S. citizen	133	21.98%
U.S. citizen (all education completed in the U.S.)	363	60.00%
Highest level of education		
Bachelor's (BA/BS)	1	0.16 %
Master's (MA/MS)	86	14.08 %
Doctorate (PhD/EdD/DSc)	500	81.83 %
Other	24	3.93 %
Number of years at WSU in paid faculty position		
Less than 1 year	81	13.26 %
1-5 years	129	21.11 %
6-10 years	112	18.33 %
11-15 years	86	14.08 %
16-20 years	46	7.53 %
More than 20 years	126	20.62 %
Not in a faculty position	31	5.07 %
Tenure status		
Fully tenured	292	47.95 %
In a tenure track position	74	12.15 %
Not tenured	243	39.90 %

RESULTS

We found heterogeneity across individuals in terms of the association of their primary area of research and international engagement. When asked what motivates them to pursue IRC, respondents mainly indicated the common interest and research synergy to expand international reach and partnership with international colleagues or peers; this

suggests the need to approach IRC and IRP from a complementary viewpoint to match knowledge and research-related capabilities for strategic alliances. Interestingly, these leading motivations are not publication-centered as much as they are oriented toward finding "like-minded others" and expanding the breadth of research. When asked how they identified IRC partners, respondents mainly identified peer-to-peer inquiries and networking at meetings and conferences, suggesting that it would be useful to provide greater opportunities for face-to-face or peer-to-peer interaction at international venues. As expected, funding and the link to scholarly program and interests were identified as critical factors in establishing IRC.

Respondents with U.S. federal grants reported these grants as the predominant source of support for IRC; this is consistent with the findings of other institutions. However, it was surprising that a significant number of respondents used personal funds for international activities, demonstrating a commitment that IRC activity is an important personal and professional investment. Additionally, respondents identified a range of positive outcomes from IRC, suggesting benefits to individual faculty members as well as to the university's research, teaching, outreach, and technology transfer missions.

Respondents, however, reported eight barriers to IRC, and time and cost are two of those big challenges. Research in international settings can present obstacles that can delay the completion or increase the costs of a project and affect long-term collaborative research and partnership. These obstacles include increased costs to transport samples, costs of permits, costs associated with data quality or data rework, travel costs for face-to-face meetings, slow response times with collaborators, and slow response or postponement of research activities as a result of slow or restrictive clearance processes for visas or other administrative requirements. Factors that can influence time include unstable conditions and political disruptions in countries, university staff untrained in or unfamiliar with processing international-related activities like travel and funding, and inflexibilities at the university administrative

levels. The other barriers identified by respondents included legal issues and agreements; organization and culture of the university; international activity not encouraged by the university, college or department; cultural differences; ethical standards and research culture; and intellectual property risks.

We tested all survey variables, and conducted further analysis of the variables that reached statistical significance and/or influenced our model. Our initial econometric model was based on the assumption that IRC (our dependent variable) is more likely to happen in scenarios in which the research was:

- STEM-related,
- multi-disciplinary,
- a mix of basic and applied work,
- funded by a federal grant awarded in the last five years, through a university institutional grant, or through gifts or donations from private individuals, non-governmental organizations (NGOs), and/or private sector funds,
- conducted by researchers who established IRC through networking at meetings, peer to peer inquiries, and/or the assistance of their Office of International Programs; were of male gender; had substantial international background (experience, naturalization, or foreign-born); had spent more years in paid faculty positions; and/or had more publications.

We used a binary logistic model to test for the impact of all significant explanatory variables on predicting the probability of the presence of IRC, an important step in establishing IRP. IRC was scored 1 if researchers indicated they had IRC in the five-year survey period in their current position at WSU, at previous universities, or at other organization(s); otherwise, IRC was 0. This allowed us to see ways in which each given attribute affected the response of the dependent variable IRC, while controlling for the number of other predictors. The effect of each variable on the dependent variable was expressed and evaluated in terms of the odds ratios.

The logistic model (see Figure 1 for the conceptual framework) was run to test the following hypotheses:

H1: STEM research is positively associated with IRC.

H2: Multi-disciplinary research is positively associated with IRC.

H3: Other faculty outcomes are positively associated with IRC.

H4: Use of tools or mechanisms for identifying international research opportunities are positively associated with IRC.

H5: Male gender is associated with IRC.

H6: Length of respondent experience is positively associated with IRC.

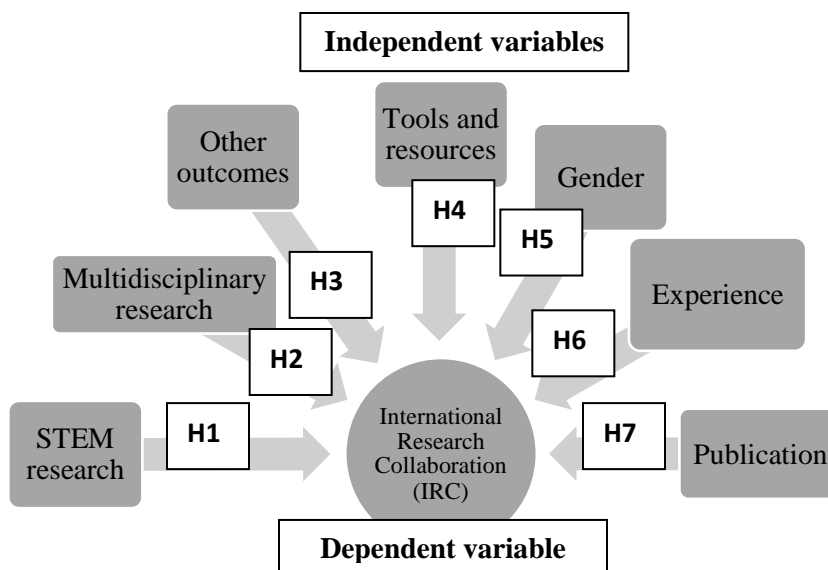H7: Number of respondent publications is positively associated with IRC.

Figure 1. Conceptual framework and proposed relationships

The results of the model are presented in Table 2. Several effects were consistent and statistically significant: research is multi-disciplinary; research is both basic and applied; research is funded by an international (not US, not university) grant; research is funded by an NGO; networking at conference meetings is a way to identify IRC; peer-

to-peer inquiries are a way of identifying international collaborators; international background (substantial international education, experience, naturalized US citizen or foreign-born); and number of publications all count.

In predicting IRC, number of publications (X2=50.25; P<0.01), research funded by an international grant (X^2=20.09, P<0.01), use of peer-to-peer inquiries to identify IRC (X^2=13.03, P<0.01), and international (X^2=8.94, P<0.01) were found to be most significant (Table 2). STEM research was a marginally significant variable (P=0.07). All other variables were moderately significant and were important in predicting IRC at the P=0.05 level. All variables included in the final model improved the fit as measured by the r^2 =0.394.

Table 2. Binary logistic estimation of the determinants of IRC.

Variable	B	S.E.	Wald X^2	df	P value	Odds Exp(B)
Dependent Variable: IRC						
Independent Variables:						
STEM as a field of research[1]	0.42	0.24	3.22	1	0.073*	1.53
Research multi-disciplinary	0.45	0.21	4.83	1	0.028**	1.58
Research basic and applied	0.43	0.22	3.87	1	0.049**	1.53
Research funded by international grant (not US or university)	1.95	0.43	20.09	1	0.000***	7.02
Research funded by an NGO	1.70	0.67	6.51	1	0.011**	5.48
IRC identified through networking conference meetings	0.59	0.26	5.28	1	0.022**	1.80
IRC identified through peer-to-peer inquiries	0.89	0.25	13.03	1	0.000***	2.43
Faculty with substantial international education, experience, naturalized, or foreign-born [2]	0.36	0.12	8.94	1	0.003***	1.43
Publication count	0.14	0.02	32.12	1	0.000***	1.15
Constant	-2.23	0.31	50.25	1	0.000	0.11
-2 Log Likelihood	577.36					
Cox Snell R Square	0.29					
Nagelkerke R Square	0.39					
Model	159.34			17	0.000***	

[1] STEM includes Computer & Information Sciences, Engineering, Life Sciences, Mathematics, Physical Sciences, Psychology, Social Sciences. Non-STEM includes: Education, Humanities, Business, Communications, Social Sciences. [2] Compared to U.S. citizen with all education completed in the U.S.* Significant at 10%, ** significant at 5%, *** significant at 1%

The significant association between the leading three predictors and IRC were consistent with general perceptions; the predictor with the highest log odds showed that respondents were seven times more likely to be engaged in IRC if they had research funded by an international grant, and five times more likely if they had research funded by an NGO. Informal communications in the form of peer-to-peer inquiries to identify IRC opportunities showed respondents almost 2.4 times more likely to have IRC. Having a significant international background increased the odds of IRC somewhat more than publication count (log odds of 1.41 and 1.14 respectively). Research funding associated with international sources and use of informal communication mechanisms (peer-to-peer and networking at conferences) to identify IRC were leading factors associated with the probability of engaging in IRC.

DISCUSSION

We obtained and analyzed survey data from approximately 27% of academic researchers at Washington State University (WSU) to map and examine the major predictors of international research collaboration (IRC) – an important step in establishing true and sustained international research partnership (IRP). This study provides an expanded outlook of international collaboration as a valuable resource to the institution and to individual faculty members. It contributes to the further understanding of international engagement by highlighting the connection between key variables of interest such as academic field, faculty researcher rank, gender, and the motivations and barriers that influence researchers as individuals.

Through this study, we also confirmed some relevant input-output relationship between the above factors and how they can be used to forecast IRC. Using logistic regression,

we found that the likelihood of IRC increases when research is related to STEM (basic and applied) and involves a multidisciplinary team, when research is funded by an international grant or through an NGO, when opportunities for networking and peer-to-peer connections on IRC partner identification exist, when researchers have substantial international education and experience, and when there are publications and scholarly output from the collaboration. This relationship suggests that these factors can serve as major predictors of IRC.

Our study and results come with caveats and should be interpreted with consideration of some limitations. Since we surveyed the population of WSU researchers, we did not compute for the sampling error for the survey results. We tried to mitigate the common method bias (all measures drawn from the same survey) by using different question formats that included binary questions and rating scales. The survey was also structured so that the questions addressing the dependent and the independent variables were located on different pages. A related concern is the difference in opinion between IRC-engaged researchers and non-IRC-engaged researchers; while results for IRC-engaged researchers were the major focus of our analysis, we also analyzed comparison data for non-IRC-engaged researchers to address potential systematic bias in our study. Despite these limitations, our results may have important implications particularly for universities and the strategic development of international research partnerships.

This study's results also suggest that when encouraging IRC, administrators, especially those who are newly championing an internationalization agenda in their institutions, should first seek to understand and target the motivational processes and interests of researchers. Institutions can have the greatest impact by supporting faculty in obtaining funds for international research – a leading factor predicting successful outcomes from IRC. With most of the funding for research coming from U.S. federal grants, institutions can consider diversifying sources of funding to incentivize and support transformational global collaborations.

International engagement bridges science and other disciplines to distant localities, potentially involves team members with varied backgrounds and diversity of thoughts and ideas, and extends research to more varied environments and circumstances. It also has the potential for increasing publication and scholarly outcomes. Our study corroborates these concepts and, indeed, identified joint publications as a strong predictor of IRC. This relationship should be widely acknowledged at the department, college, and university levels, given that publications are an important indicator in university rankings. An inclusive institutional co-authorship policy recognizing global collaborators will help address exploitative research and domination claims and promote co-creation, long-term collaborative research, and equitable partnership.

Interestingly, despite the recognition of gender differences in international engagement (Abramo, D'Angelo, & Murgia, 2012; Lariviere et al. 2012), our hypothesis that male gender is associated with IRC was not supported. This means that all our respondents, regardless of gender, engaged in IRC hence, institutions should encourage both women and men researchers to engage in IRC. This study also found that 64.5% of respondents recognized the importance of student training in addition to publications, suggesting that student training can also be one of the important international research metrics for universities. Length in a faculty position and international experience (education, length of time in a foreign institution, foreign nationality) were also major determinants for IRC. One strategy that an institution can implement is to selectively hire and integrate faculty with foreign experience to foster inter-university partnerships through collaborative teams involving experienced faculty to increase IRC. Various initiatives linked to the factors identified in this study could be used to encourage early-career faculty towards IRC in addition to capturing and transferring the lessons learned from seasoned faculty and providing more opportunities to gain international experience for all researchers.

Eight problems associated with IRC were acknowledged and rated by respondents. At the individual level, two of these problems (requires more time and cost, and legal

issues and agreements) were noted but did not enter the logistical model as predicting IRC. However, both should be considered as needing active counter-strategies to support faculty through these administrative and logistical hurdles for long-term collaborative research and partnership.

Like Melvin (2000), we find that describing international collaboration and the motivations for researchers engaging in IRC is nuanced. Classifying the main reasons for collaboration and the benefits of IRC provide a specific understanding of what faculty think about IRC and what it looks like at the operational level. Characterizing the international engagement of faculty, and understanding their research interests, skills, resources, motivations, expectations, and perspectives can contribute to better insights of the challenges and the incentives needed to promote IRC (Bummer, 2008). In our literature search, some researcher opinions suggest that broadening the capacity of science and research to include ways not previously identified in a field of research requires international engagement. Some authors go even further in their comments and suggest that significant investment in IRC in math and hard sciences is needed for the university to progress to the next level in research. These are helpful guidelines for university administrators and officials advocating for international engagement.

Our survey results point to WSU researchers' underlying awareness of the need for and mutual benefits of tangible outcomes, largely as measured by joint research publications and the training of students. More importantly, our results provide evidence for the recognition of collaborative research toward a more partnership-based system that can tackle pressing global problems and impact lives across countries and at the local level. WSU researchers recognized the importance of having a shared interest with international colleague; research synergy and complementarity; expanding research endeavors internationally; personal commitment; and sensitivity to partner needs. All these factors are reflective of a new framework of collaboration that can influence a more symbiotic approach to transformational global partnership.

Our findings are a step toward better understanding of the complex factors that interact in and accentuate international collaboration. The international collaboration analysis using co-authorship data for WSU can generate an author-level analysis to understand the growth of collaboration and determine whether long-term collaborative research and partnership have existed between WSU researchers and their collaborators. An analysis of IRC and IRP from the perspective of WSU collaborators across the globe is also a worthwhile follow-up study. This research could also form the basis of larger-scale research that includes more universities, both national and international, and industry and non-governmental sectors, to evaluate the broader outcomes of internationalization initiatives built on partnerships.

REFERENCES

Abramo, G., D'Angelo, C. A., & Murgia, G. (2013). Gender Differences in Research Collaboration. *Journal of Informetrics 7(4)*, 811-822.

Adams, J. (2012). Collaborations: the Rise of Research Networks. *Nature 490*, 335-336.

Adams, J. (2013). The Fourth Age of Research. *Nature 497*, 557-560.

Anderson, M. (2011). International Research Collaborations: Anticipating Challenges Instead of Being Surprised. *The Europa World of Learning*, 1-11.

Austin, A., & Baldwin, R. (1992). Faculty Collaboration: Enhancing the Quality of Scholarship and Teaching. *ERIC Digest*.

Bammer, G. (2008). Enhancing Research Collaborations: Three Key Management Challenges. *Research Policy 37(5)*, 875-887.

Barquera, s., Schillinger, D., Aguilar-Salinas, C., Schenker, M., Rodriguez, L., Hernandez-Alcaraz-C, & Sepulveda-Amor. (2018). Collaborative Research and Actions on Both Sides of the US-Mexico Border to Counteract Type 2 Diabetes in People of Mexican Origin. *Globalization and Health 14(84)*, 1-10.

Bayer, A., & Smart, J. (1988, April). Author Collaborative Styles in Academic Scholarships. *Annual Meeting of the American Educational Research Association*. New Orleans, Louisiana, United States: American Educational Research Association.

Beaver, D. (2001). Reflections on Scientific Collaborations (and its Study): Past, Present, and Future. *Scientometrics 52(3)*, 365-377.

Bockarie, M., Machingaidze, S., Nyirenda, T., Olesen, O., & Makanga, M. (2018). Parasitic and Parachute Research in Global Health. *The Lancet Global Health*, e964.

Carpi, A., & Egger, A. (2009). The Culture of Science: Scientists and the Scientific Community. *Vision Learning POS-2 (6)* .

Chang, H., & Huang, M. (2015). The Effects of Research Resources on International Collaboration. *Journal for the Association of Information Science and Technology*, 2489-2510.

Corbett, A., & Kardos, L. (2019, June 6). *Research Connecting Countries by Leading Research Lesson Learned from the Global Innovation Initiative*. Retrieved from International Institute of Education (IIE) : https://www.iie.org

Dall'Asta, L., Marsili, M., & Pin, P. (2012). Collaboration in Social Networks. *Proceedings of the National Academy of Sciences 109(12)*, 4395-4400.

Disis, M., & Slattery, J. (2010, March 10). The Road We Must Take: Multidisciplinary Team Science. *Sci. Transl. Med 2 (22)* .

Eisler, R. (1988). *The Chalice and the Blade: Our History, Our Future*. New York, NY: Harper & Row.

Elsevier B.V. (2017). *Gender in the Global Research Landscape*. Amsterdam: Elsevier B.V.

Fox, M., & Fayer, C. (1984). Independent and Cooperation in Research: The Motivations and Costs of Collaboration. *Journal of Higher Education 55(3)*, 347-359.

Franceshet, M., & Constantini, A. (2010). The Effect of Scholar Collaboration on Impact and Quality of Academic Papers. *Journal of Informetrics*, 540-553.

Gershenson, C. (2013). Collaborations: The Fourth Age of Research. *Complexity at Large*, 1-5.

Gilbertson, M., Craft, M., & Potter, T. (2019). Planetary Grand Challenges: A Call for Interdisciplinary Partnership . *Interdisciplinary Journal of Partnership Studies*, 1-17.

Goldfinch, S., Dale, T., & Rouen, K. (2003). Science from the Periphery: Publication, Collaboration and 'Periphery Effects" in Article Citation Rates of the New Zealand Crown Research Institutes 1995-2000. *Scientometrics 57(3)*, 321-337.

Hedt-Gauthier, B., CAirhihenbuwa, C., Bawah, A., Burke, K., Cherian, T., Connelly, M., . . . Volmink, J. (2018). Academic Promotion Policies and Equity in Global Health Collaborations. *The Lancel 392(10158)*, 1607-1609.

Huang, J. S. (2014). Building Research Collaboration Networks - An Interpersonal Perspective for Research Capacity Building. *Journal of Research Administration 15(2)*, 89-112.

International Development Services. (2016). *Unlocking the Power of Partnership - A Framework for Effective Cross-Sector Collaboration to Advance the Global Goals for Sustainable Development*. Amstelveen, The Netherlands: KPMG International Cooperative.

Iribarren-Maestro, I., Lascurain-Sánchez, M., & Sanz-Casado, E. (2009). Are Multi-Authorship and Visibility Related? Study of Ten Research Areas at Carlos III University of Madrid. *Scientometrics 79(1)* , 191-200.

Jeffrey, P. (2003). Observations on the Process of Cross-Disciplinary Research Collaboration. *Social Studies of Science 33(4)* , 539-562.

Jeong, S., Choi, J. Y., & Kim, J.-Y. (2014). On the Drivers of International Collaboration: The Impact of Informal Communication, Motivation, and Research Resources. *Science and Public Policy 41(4)*, 520-531.

Kang, J. (2017). The Effect of International Joint Research to the Research Performance: The Case of the Global Research Laboratory and the Basic Research Laboratory Programme. *Science, Technoogy and Society 22(3)*, 473-489.

Katz, J., & Martin, B. (1997). What is Research Collaboration? *Research Policy 26* , 1-18.

Kelly, K., & Schaefer, A. (2017, December 10). *Creating a Collaborative Organizational Culture*. Retrieved from UNC Kenan-Flagler Business School:www.kenan-flagler.unc.edu

Landry, R., Traore, N., & Godin, B. (1996). An Econometric Analysis of the Effect of Collaboration on Academic Research Productivity. *Higher Education 32(3)*, 283-301.

Lariviere, V., Ni, C., Gingras, Y., Cronin, B., & Sugimoto, C. (2013). Bibliometrics: Global Gender Disparities in Science. *Nature 504 (7479)*, 211-213.

Lee, S., & Bozeman, B. (2005). The Impact of Research Collaboration on Scientific Productivity. *Social Studies of Science 35(5)*, 673-702.

Leite, D., & Pinho, I. (2016). Theoretical Approaches to Research Collaboration Networks. In D. Leite, & I. Pinho, *Evauating Collaboration Networks in Higher Education Research* (pp. 25-39). London: Palgrave Macmillan, Cham.

Lim, C.-H., & Boey, F. (2013). Strategies for Academic and Research Excellence for a Young University: Perspectives from Singapore. *Ethics in Science and Environmental Politics* , 113-123.

Molton, J., Singh, S., Chen, L., & Paton, N. (2017). International Tuberculosis Research Collaborations within Asia. *BMC Research Notes 10(1)*, 1-5.

Moolenaar, N. (2012). A Social Network Perspective on Teacher Collaboration in Schools: Theory, Methodology and Applications. *American Journal of Education*, 7-39.

National Science Foundation . (2013, May 21). *Science and Engineering Indicators 2016*. Retrieved from National Science Board Web site: https://www.nsf.gov/statistics/nsf13327/pdf/tabb1.pdf

Pain, E. (2014, July 17). Better Recognition for Multidisciplinary Research. *Science* .

Payumo, J., & Sutton, T. (2015). A Bibliometric Assessment of ASEAN Collaboration in Plant Biotechnology. *Scientometrics 103(3)* , 1043-1059.

Payumo, J., Sutton, T., Brown, D., Nordquist, D., Evans, M., Moore, D., & Arasu, P. (2017). Input-Output Analysis of International Research Collaborations: A Case Study of Five U.S. Universities. *Scientometrics 111(3)* , 1657-1671.

Phelps, S. (2013). Emergence of Social Networks via Direct and Indirect Reciprocity. *Autonomous Agents and Multi-Agent Systems*, 355-374.

Puuska, H. (2010). Effect of Scholar's Gender and Professional Position on Publishing Productivity in Different Publication Types. Analysis of Finnish University. *Scientometrics 82(2)* , 419-437.

Roschelle, J., & Teasley, S. (1995). The Construction of Shared Knowledge in Collaborative Problem Solving. In C. O-Malley, *The Construction of Shared Knowledge in Collaborative Problem Solving* (pp. 69-97). Berlin, Heidelberg: Springer.

Sonnenwald, D. (2007). Scientific Collaboration: A Synthesis of Challenges and Strategies. *Annu. Rev. Inf. Sci. Technol. 41* , 643-681.

Sooho, L., & Bozeman, B. (2005). The Impact of Research Collaboration on Scientific Productivity. *Social Studies of Science 35 (5)* , 673-702.

Sutton, S. (2010). Transforming Internationalization through Partnerships. *International Educator 19(1)*, 60-63.

The Lancet Global Health. (2018). Closing the Door on Parachutes and Parasites. *Lancet Global Health 6*, e593.

Van Rijnsoever, F., Hessels, L., & Vandeberg, R. (2008). A Resource-Based View on the Interactions of University Researchers. *Research Policy 37*, 1255-1266.

Wagner, C., Park, H., & Leydesdorff, L. (2015). The Continuing Growth of Global Cooperation Networks in Research: A Conundrum for National Governments. *PLoS ONE 10(7)*.

Whitfield, J. (2008). Collaboration: Group Theory. *Nature 455*, 720-723.

Witze, A. (2016, January 19). Research Gets Increasingly International. *Nature News*, pp. 1-3.

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