Scientific Ambidexterity and Doctoral Mentoring: Does Academics' Involvement or Non-Involvement in Commercial-Science Activities Configure Aspects of Doctoral Mentoring in Selected East-Asian Doctoral Science Programs?

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ABSTRACT

In this study, we introduce and elaborate on the novel concept of *scientific ambidexterity* (SA): the ability of academics to engage and perform in both academic and commercial science activities, simultaneously. To advance understanding of SA's impact on the socialization of future scientists (i.e., doctoral students) to scientific life, we construe SA at the micro-level; we adduce evidence from the front-line of action (i.e., the scientific laboratory) through face-to-face interviews with professors and doctoral students in selected East Asian universities.

In conceptualizing and operationalizing SA, we utilize and hybridize two core concepts germane to science policy, and science and technology studies: (i) *research collaboration* and (ii) *techno-scientific productivity*. We classify the former as either within-sector research collaboration (i.e., collaborations within academia) or cross-sector research collaboration (i.e., collaborations outside academia, specifically commercial or with industry). For the latter, we focus on the production of top-journal publications (a core productivity metric in academic science), and the generation of patents (a core productivity metric in commercial science). We operationally define SA as the simultaneous research engagement in academia and in industry, and generation of publications and of patents.

Our hypothesis is: academics who exhibit SA have different mentoring practices, patterns of mentor-mentee interaction, and provide difference research experiences compared to those who do not manifest SA.

INTRODUCTION

In this study, our objective is to explore and report on the relationship between academics' production of top publications and generation of patents, and their involvement in academic and in commercial research collaborations in the one hand; and their interactions with doctoral students, mentoring practices, and provisions provide research experiences to their doctoral students, on the other hand. Toward this end, we adduce data from a sample of chemical science professors in selected elite universities in the East Asian region. With this objective in mind, we are set on providing answers to the research questions: **Does scientific ambidexterity among academics (defined as academic scientists' engagement in both commercial science research collaboration and commercial science patent generation) impact how they mentor future scientists?** More specifically, does academics' involvement or non-involvement in commercial-science activities alter aspects of their doctoral mentoring? Our central hypothesis is: *ambidextrous academics differ from their non-ambidextrous counterparts in terms of mentor-mentee interaction, mentoring practices, and the research experience that they provide their doctoral students.*

METHODS

- Face-to-face interviews with n=105 chemical science professors in selected elite doctoral training institutions in Japan, Singapore, and Taiwan.
- Principal component analysis (PCA) to reduce the dimensionality of MMI, DMP and DTP.
- A set of normal error regression analyses to build prediction models.

Table 1: Descriptive Statistics

Basic Statistics

Selected Variables	N	Mean	SEM	SD
Japan (1=yes, 0=no)	104	0.34	0.05	0.47
Singapore (1=yes, 0=no)	104	0.34	0.05	0.47
age (in years)	104	46.94	0.95	9.74
Male (1=yes, 0=no)	104	0.88	0.03	0.33
Child (1=yes, 0=no)	104	0.75	0.04	0.44
No of professional scientists supervised	102	2.43	0.60	6.09
Consulting (1=yes, 0=no)	103	0.43	0.05	0.50
Associate Professor (1=yes, 0=no)	104	0.32	0.05	0.47
Full Professor (1=yes, 0=no)	104	0.43	0.05	0.50
Has collaborators in academia (1=yes; 0=no)	104	0.74	0.04	0.44
Has collaborotors in industry (1=yes; 0=no)	104	0.31	0.05	0.46
SA in Collaboration (1=yes; 0=no)	104	0.25	0.04	0.44
Has publications in high impact journals (1=yes; 0=n0)	104	0.92	0.03	0.27
Has generated patents (1=yes; 0=no)	104	0.31	0.05	0.46
SA in Productivity (1=yes; 0=no)	104	0.30	0.05	0.46

Figure 1: Theoretical Model

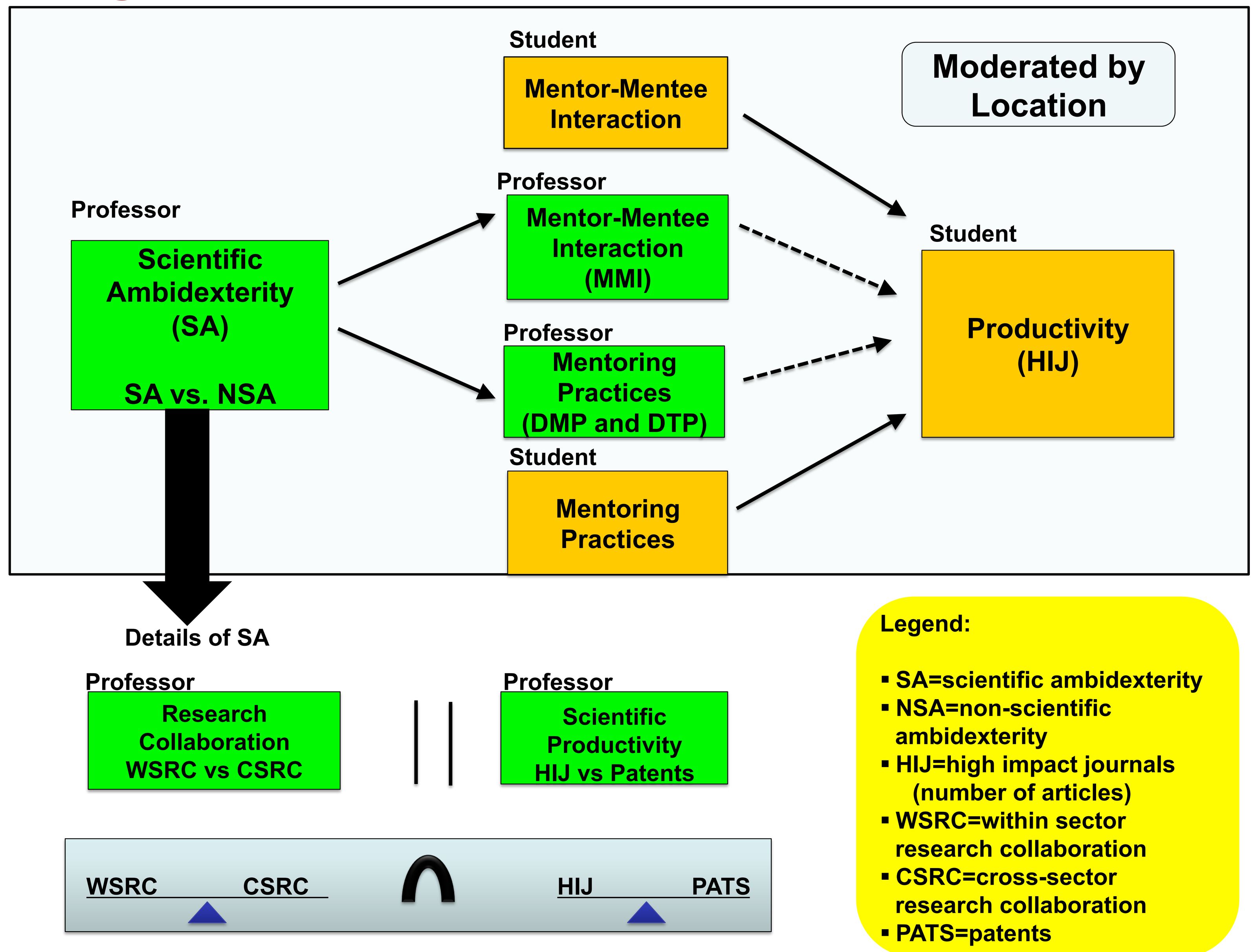

Table 2, 3 & 4: Principal Component Analysis

Table 2	Components		
Mentor Mentee Interactions (MMI) 8 Original Items	MMI1 Quality	MMI2 Formality	MMI3 Intensity
Face to Face.......Technology-mediated	**0.89**	-0.07	0.00
Frequent............Seldom	**0.84**	0.05	-0.07
Structured...........Unstructured	0.11	**0.77**	-0.06
General/Broad.....Specifics/Detailed	-0.18	0.01	**0.71**
Planned.............Unplanned	-0.19	**0.76**	0.16

Table 3	COMPONENTS				
Doctoral Mentoring Practices (DMP) 15 Original Items	DMP 1 Career Preparation	DMP 2 Professional Socialization	DMP 3 Research Concerns	DMP 4 Research Co-authorship	DMP 5 Data Analysis
Mentor discusses career aspirations and plans of students	0.31	**0.70**	0.14	-0.21	-0.10
Mentor monitors students work progress	0.02	0.01	**0.83**	0.08	0.02
Mentor discusses students' concerns and problems about research	-0.03	0.10	**0.79**	0.15	0.25
Mentor co-authors research paper or book chapter with students	0.08	0.08	0.32	**0.72**	-0.09
Mentor analyzes data and performs calculations side-by-side	0.08	0.01	0.08	0.04	**0.81**
Mentor helps students draft their curriculum vitae	**0.77**	0.00	-0.18	0.12	0.09
Mentor helps students prepare for a job-talk or presentation	**0.72**	0.02	0.04	0.33	-0.04
Mentor helps students search for job positions and announcements	**0.73**	0.28	0.13	0.06	0.05
Mentor socializes students to member of the professional community	0.12	**0.73**	-0.09	0.40	-0.03

Table 4	COMPONENTS				
Doctoral Training Practices (DTP) 17 Original Items	DTP1 Publication Training	DTP2 Laboratory Mgmt.	DTP3 Leadership Mgmt.	DTP4 Data Analysis	DTP5 Organ. Training
Presents research at conferences	0.07	0.16	**0.79**	0.24	0.02
Organizes professional meetings conferences	0.18	0.17	0.01	0.13	**0.75**
Performs data analyses	0.09	0.11	-0.04	**0.81**	0.05
Writes and submits grant proposals	0.27	0.07	**0.75**	-0.06	0.08
Presides or takes the lead in a research lab meeting	0.13	0.15	**0.72**	-0.10	0.00
Writes papers for submission to scholarly journals	**0.73**	0.12	0.28	0.21	0.06
Drafts letters to the editor for submission of manuscripts	**0.85**	-0.08	0.04	-0.09	0.26
Drafts responses for revised and resubmitted manuscripts	**0.88**	0.06	0.20	-0.06	0.04
Writes operating manuals for lab instruments and equipment	0.18	**0.78**	0.15	0.02	-0.10
Has senior students help junior students in their research	-0.13	**0.84**	0.01	0.09	0.16

Table 5, 6 & 7: Normal Error Regression Analyses

Table 5: Regression Analyses Mentor-Mentee Interaction (MMI) Predictors	MMI 1 Quality β	SE	MMI 2 Formalization β	SE	MMI 3 Intensity β	SE
Japan (1=yes, 0=no)	0.38**	.27	.18	.31	-.18	.29
Age squared (quadratic term)	-0.12	.00	.02	.00	.45***	.00
No. of professional scientists supervised	0.40***	.02	-.02	.02	-.09	.02
Associate Professor (1=yes, 0=no)	-0.03	.37	.19	.42	.51**	.40
Scientifically Ambidextrous in collaborations(1=yes; 0=no)	**-0.11**	**.26**	**-.13**	**.29**	**.33****	**.28**
Scientifically Ambidextrous in productivity (1=yes; 0=no)	**0.13**	**.21**	**-.17**	**.24**	**-.14**	**.23**
Adjusted R^2 (%)	18.30		-0.80		8.30	

*,**,*** denote significance at the .05, .01, and .001 levels respectively

Table 6: Regression Analyses Doctoral Mentoring Practices (DMP) Predictors	DMP1 Help in Job Search β	SE	DMP2 Professional Socialization β	SE	DMP3 Research Concerns β	SE	DMP4 Research Co-Author β	SE	DMP5 Data Analysis β	SE
Japan (1=yes, 0=no)	-.18*	.29	.28*	.25	.17	.27	.37**	.29	-.02	.28
Singapore (1=yes, 0=no)	.11*	.37	-.08	.33	.26	.35	.57***	.38	.06	.36
Age (linear term)	-.34	.02	-.13	.02	-.36*	.02	.21	.02	.19	.02
Age squared (quadratic term)	.45	.00	.11	.00	.23	.00	-.08	.00	.32*	.00
Male (1=yes, 0=no)	-.02	.31	-.06	.27	.21*	.29	.07	.31	.04	.30
SA in collaboration (1=yes; 0=no)	**.33**	**.29**	**.31****	**.26**	**.10**	**.28**	**-.19**	**.30**	**.01**	**.28**
SA in productivity (1=yes; 0=no)	**-.14**	**.23**	**-.16**	**.20**	**-.08**	**.22**	**-.03**	**.24**	**-.11**	**.23**
Adjusted R^2 (%)	5.20		29.80		11.40		6.00		14.70	

*,**,*** denote significance at the .05, .01, and .001 levels respectively

Table 7: Regression Analyses Doctoral Training Practices Predictors	DTP1 Publication Training β	SE	DTP2 Lab Mgmt β	SE	DTP3 Leadership Mgmt β	SE	DTP4 Data Analysis β	SE	DTP5 Org. Training β	SE
Japan (1=yes, 0=no)	.16	.31	.16	.30	.33**	.25	.54***	.27	-.09	.30
Singapore (1=yes, 0=no)	.19	.40	.08	.39	-.41**	.33	.46**	.36	-.23	.39
No. of professional scientists supervised	.07	.02	.04	.02	.09	.01	-.27**	.02	.10	.02
SA in Collaboration (1=yes; 0=no)	**-.13**	**.30**	**.03**	**.29**	**.17**	**.24**	**-.08**	**.26**	**.09**	**.29**
SA in Productivity (1=yes; 0=no)	**.09**	**.25**	**-.17**	**.24**	**-.09**	**.21**	**-.23***	**.22**	**.01**	**.25**
Adjusted R^2 (%)	-6.60		0.10		29.90		18.30		-0.20	

*,**,*** denote significance at the .05, .01, and .001 levels respectively

CONCLUSIONS

Overall, our findings indicate that academics' scientific ambidexterity is linked with doctoral mentoring, but not to the extent that every axis of scientific ambidexterity influenced and shaped every aspect of doctoral mentoring. Between scientific ambidexterity in research collaboration and scientific ambidexterity in techno-scientific productivity, the former has more to do with mentor-mentee interaction, with doctoral mentoring practices, and with doctoral research experience than the latter. In other words, between the collaborative and the productivity axes of ambidexterity, it is axis of collaboration that has greater impact on doctoral mentoring.

POLICY IMPLICATION

In terms of science policy implications: with the increased tightening bond between academic and commercial science -- really among the strands of the *Triple Helix* of academia, government, and industry -- there is a need to review and rethink how we train and mentor future scientists – in this case, doctoral students. That way, students are by no means socialized to the thinking that academia is the one and only one destination -- *the premium destination* -- for doctoral (or Ph.D.) degree holders; and that appointments, engagements, and jobs in industry, in government, or in non-government organizations are equally feasible, respectable, and viable paths to scientific life.

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