Sukwoong Choi
100 Main St, Cambridge, MA 02142
sukwoong@mit.edu

January 20, 2022

Dear Members of the NBER Innovation Bootcamp Committee,

I am writing to express my interest in applying for the NBER Innovation Bootcamp. I am a postdoctoral scholar at the MIT Sloan School of Management. I completed my Ph.D. from the College of Business, Korea Advanced Institute of Science and Technology (KAIST) in May 2019. My research interests are innovation and entrepreneurship, and my research goal is to conduct phenomenon-driven research topics in the innovation field and offer academic and policy implications. As an innovation scholar, I am interested in how new technologies are adopted by users and how they affect human decision-making or productivity. Currently, I am studying the economic effects of new innovative technologies in various contexts, including artificial intelligence (AI), algorithms, and quantum computing.

For example, by using the context of professional Go players, my job market paper examines how AI changes human learning in the labor market and leads to better decisions. In 2016 an AI-powered Go program (APG) unexpectedly beat the best human player, surpassing the best human knowledge and skills accumulated over thousands of years. To investigate the impact of APGs, we compare human moves to AI's superior solutions, before and after the initial public release of an APG. Our analysis of 750,990 moves in 25,033 games by 1,242 professional players reveals that APGs significantly improved the quality of the players' moves as measured by the changes in winning probability with each move. We also show that the key mechanisms are reductions in the number of human errors and in the magnitude of the most critical mistake during the game. Interestingly, the improvement is most prominent in the early stage of a game when uncertainty is higher. Further, young players—who are more open to and better able to utilize APG—benefit more than senior players, suggesting generational inequality in AI adoption and utilization. Second, my coauthored working paper investigates the effect of AI adoption on high-tech startups' productivity. We reveal that AI adoption at low levels is unrelated to revenue growth, but revenue growth increases with AI adoption intensity. It implies that the relationship between AI adoption and productivity empirically follows J-curve. Internal R&D strategy and complementary assets strengthen the J-curve relationship. Considering my research goal and experience, I am very sure that this bootcamp opportunity fits me perfectly.

In my Ph.D., I took courses focusing on technology management such as Innovation Strategy, Advanced Organization and Management Theories, Corporate Finance Theory, Research methodologies I, Research methodologies II, and Advanced Econometrics. I have attached a transcript at the end of my CV to list all my PhD courses. By joining this bootcamp, I would like to not only strengthen literature background of the economics of innovation but also catch-up new study of it. I would like to contribute to the conversation of innovation research by sharing related research with boot camp participants.

Enclosed you will find my CV, required documents. The recommendation letter will be sent by Neil Thompson (MIT). For my other references, you can contact Abhishek Nagaraj (University of California, Berkeley), Yong Lee (University of Notre Dame), and Hyo Kang (University of Southern California).

Thank you in advance for your time and consideration of my application. I look forward to hearing from you.

Sincerely,
Sukwoong Choi

SUKWOONG CHOI

100 Main St, Cambridge, MA 02142
sukwoongchoi@gmail.com

ACADEMIC APPOINTMENTS

Massachusetts Institute of Technology Cambridge, MA, July 2021 - Present
Sloan School of Management
Initiative on the Digital Economy (IDE)
Computer Science & Artificial Intelligence Laboratory (CSAIL)
Postdoctoral Scholar

University of Southern California Los Angeles, CA, July 2020 - July 2021
Viterbi School of Engineering
Technology Innovation and Entrepreneurship
Postdoctoral Scholar

University of Kentucky Lexington, KY, July 2019 - June 2020
Gatton College of Business and Economics
Department of Management
Postdoctoral Scholar

RESEARCH INTERESTS

[1] Research Topics: Innovation, Digitization, Artificial Intelligence (AI), Entrepreneurship
[2] Methodologies: Econometrics, Big-Data Analysis, Machine Learning, Social Network Analysis

EDUCATION

KAIST (Korea Advanced Institute of Science and Technology) Daejeon, Korea, June 2019
Ph.D., School of Business and Technology Management, College of Business

Northwestern University Evanston, IL, Jan 2019 - Mar 2019
Kellogg School of Management, Management of Organizations (MORS)
Visiting Ph.D. Student (Sponsored by Professor Hyejin Youn)

University of California, Berkeley Berkeley, CA, Jan 2018 - June 2019
Haas School of Business, Management of Organizations (MORS)
Visiting Ph.D. Student (Sponsored by National Research Foundation of Korea)

KAIST (Korea Advanced Institute of Science and Technology) Daejeon, Korea, Feb 2012
B.S. Mathematical Science, B.E. Management Science

REFEREED JOURNAL ARTICLES

"Are Social Entrepreneurs More Risk-Averse?" (with N. Kim and W. Kim)
Applied Economics Letters (SSCI), 2019

"An Empirical Study on Successful Crowdfunding" (with D. Lee, J. Kim and W. Kim)
Asia-Pacific Journal of Business Venturing and Entrepreneurship (KCI), 2017 (written in Korean / Winner of the Best Paper Award)

WORKING PAPERS AND PROJECTS

[1] How Does AI Improve Human Decision-Making? Evidence from the AI-Powered Go Program (with J. Kim, N. Kim, and H. Kang) (Preparation to Submit)
- Winner for the Best Interdisciplinary Paper Award Strategic Human Capital in the SMS 2021
- Media Cover: MIT IDE Blog, State of AI Report 2021, The Chosun Ilbo (Leading Korean Daily Newspaper)

[2] When Does AI Payoff?: AI Adoption Intensity, Complementary Investments, and R&D Strategy (with T. Kim, W. Kim, and Y. Lee (*Equally contributed*)) (Under Review)

[3] It ain't over 'til it's over: Post-IPO VC ownership effect on innovation-enhancing investment of newly public firms (with T. Kim and H. Woo) (Under Review)

[4] International Alliance Formation: The Effect of Technology Competition Networks (with N. Kim and W. Kim) (Revise-and-Resubmit)

[5] The Dynamics of Entrepreneurship Research: A Topic Modeling Analysis and Research Agenda (with W. Kim and K. Lee) (Preparation to Submit)

[6] Stay the Course? The Effects of Government Matching R&D Funding on Tech Startups' Innovation (with Y. Lee, T. Kim, and W. Kim) (Working Paper)

INVITED PRESENTATIONS, CONFERENCES, AND ACADEMIC PROGRAMS

2022- (includes scheduled): Yonsei University; 3rd AI and Strategy Consortium; IP and Innovation (IPI) Seminar; *Cancelled due to Covid-19: 15th Digital Economics Conference (Toulouse, France)*

2020-2021: NBER Economics of Artificial Intelligence Conference; AOM Annual Meetings; SMS Annual Conference; MIT Inner Seminar; Doctoral Student Workshop on Economics of Artificial Intelligence; MIT IDE Fall Seminar; Conference on Artificial Intelligence, Machine Learning, and Business Analytics; *Could not attend due to Covid-19: DRUID (Copenhagen, Denmark)*

2019-2020 & before: AOM Annual Meetings (2020, 2017); SMS Annual Conference (2019, 2017); University of Kentucky Inner Seminar (2019); NBER Entrepreneurship Bootcamp (2018); STR Managing Your Dissertation Workshop (2018); INSEAD Doriot Entrepreneurship Conference (Poster, 2018); TIM Doctoral Student Consortium (2017); MIS summer program at Harbin Institute of Technology (2017); KAIST College of Business Inner Seminar (2017)

HONORS, GRANTS, AND FELLOWSHIPS

[1] Winner, Best Interdisciplinary Paper Award (Strategic Human Capital IG), SMS Conference (2021)
[2] Kauffman Foundation Entrepreneurship Research to Practice Bootcamp (2020) ($3,000) *Cancelled due to Covid-19*
[3] NBER Grant for Summer Entrepreneurship Boot Camp (2018) ($1,000)
[4] National Research Funding (NRF) of Korea Fellowship for Social Science Korea - All but Dissertation (2017) ($22,000)
[5] Winner, Best Paper Award, Asia-Pacific Journal of Business Venturing and Entrepreneurship (2017)
[6] KAIST, College of Business Graduate Fellowships (2012-2016)

TEACHING EXPERIENCE

Managing Social and Organizational Networks **(Undergraduate Course Instructor at Gatton B-School)** Spring 2020, Rating 4.2/5

Social Dynamics and Network Analysis **(MBA Course TA at Kellogg B-School)** Winter 2019
Innovation and Technology Management (Graduate Course TA) Spring 2016, Fall 2016
Econometrics (Undergraduate Course TA) Spring 2015, Fall 2015
Organization Theory (Graduate Course TA) Spring 2014
Research Methodology I (Graduate Course TA) Spring 2013, Fall 2013

OTHERS

Research Assistantship
RA for Abhishek Nagaraj, Assistant Professor of UC Berkeley, Mar. 2018 - Dec. 2018
Project Name: Improving data access democratizes and diversifies science. Published at Proceedings of the National Academy of Sciences (PNAS, Nagaraj, A., Shears, E., & de Vaan, M. (2020)).

Programming
Languages: R, Python, Java
Statistical packages: Stata
Network Analysis: iGraph (R/Python), NetworkX (Python), UCINET, Gephi

Academic Service
Peer-Review Referee: Journal of Business Venturing, Journal of Strategy and Management, Applied Economics Letters
Academy of Management, TIM Reviewer 2016-2021
Academy of Management, STR Reviewer 2016-2021

Military Service
Serving a military service at KAIST as the Technical Research Personnel during 3 years (2014-2016)

REFERENCES

Neil Thompson (PI), Initiative on the Digital Economy, MIT, neil_t@mit.edu
Abhishek Nagaraj, Haas School of Business, UC Berkeley, nagaraj@berkeley.edu
Hyo Kang, Marshall School of Business, University of Southern California, hyokang@marshall.usc.edu
Yong Suk Lee, Technology, Economy, and Global Affairs, University of Notre Dame, yong.s.lee@nd.edu
Namil Kim, School of Management, Harbin Institute of Technology, namil.kim@hit.edu.cn

Last Updated: January 07, 2022

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Submission : University

Issued date : 2022/01/08
Expiration date : 2022/04/08

KAIST
KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY

291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea

ACADEMIC TRANSCRIPT

Student No. : 20137071
Name in Full : SUKWOONG CHOI
Degree Program : Integrated Master's and Doctoral Degree(Doctor)
Date of Birth : October 7, 1986

PhD
Department : School of Business and Technology Management
Date of Admission : February 6, 2012
Degree Conferred : August 16, 2019
Degree : Doctor of Philosophy
Diploma No. : 과기원 2018 (박) 675

Code	Title	Credit	Grade
< Spring 2012 >			
*MSB500	Advanced Statistics for Management	3.0	A0
*MSB538	Organization Management	3.0	B+
*CC020	Ethics and Safety I	1AU	S
CC511	Probability and Statistics	3.0	A+
	Term Earned 9.0 Term GPA 3.86 (95.11/100)		
< Fall 2012 >			
*MSB535	Corporate Finance Theory	3.0	A-
*MSB601	Research Methodologies I	3.0	A-
CC010	Special Lecture on Leadership	0.0	S
*CC500	Scientific Writing	3.0	S
	Term Earned 9.0 Term GPA 3.70 (93.33/100)		
< Spring 2013 >			
ITM800	Special Topics(3) in Management of Technology<CTO Seminar>	3.0	A0
*MSB701	Advanced Econometrics	3.0	A0
*MSB702	Research Methodologies II	3.0	B+
*MSB838	Advanced Organization and Management Theories	3.0	A+
	Term Earned 12.0 Term GPA 3.90 (95.56/100)		
< Fall 2013 >			
*HSS583	Graduate English Presentations	3.0	A-
ITM667	M&A and Corporate Restructuring	3.0	A0
*MSB830	Advanced Performances Management	3.0	A+
	Term Earned 9.0 Term GPA 4.00 (96.67/100)		
< Spring 2014 >			
MSB980	Ph.D Dissertation Research	12.0	S
	Term Earned 12.0 Term GPA - (-)		
< Fall 2014 >			
MSB980	Ph.D Dissertation Research	12.0	S
	Term Earned 12.0 Term GPA - (-)		
< Spring 2015 >			
MSB980	Ph.D Dissertation Research	12.0	S
	Term Earned 12.0 Term GPA - (-)		
< Fall 2015 >			
MSB980	Ph.D Dissertation Research	12.0	S
	Term Earned 12.0 Term GPA - (-)		
< Spring 2016 >			
MSB980	Ph.D Dissertation Research	12.0	S
	Term Earned 12.0 Term GPA - (-)		
< Fall 2016 >			
MSB980	Ph.D Dissertation Research	12.0	S
	Term Earned 12.0 Term GPA - (-)		
< Spring 2017 >			
MSB980	Ph.D Dissertation Research	12.0	S
	Term Earned 12.0 Term GPA - (-)		
< Spring 2019 >			
MSB980	Ph.D Dissertation Research	12.0	S
	Term Earned 12.0 Term GPA - (-)		
	- End of Record -		

Earned(Doctor)	135.0 credits	GPA(Doctor)	3.88/4.3	Convert into a percentage(Doctor)	95.33/100

This official transcript was produced on
January 8, 2022

Taesik Lee, Ph.D.
Associate Vice President of Academic Affairs, KAIST

○ Grades and Grade Points : A+=4.3, A0=4.0, A-=3.7, B+=3.3, B0=3.0, B-=2.7, C+=2.3, C0=2.0, C-=1.7, D+=1.3, D0=1.0, D-=0.7, S=Satisfactory, U=Unsatisfactory, R=Retaking, W=Withdrawal
○ Convert into a percentage : 60 + {(GPA-0.7)/(4.3-0.7)} x 40 ○ * : English Course ○ †: Credits transferred from other/foreign universities

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1) Research statement

My research goal is to conduct phenomenon-driven research topics in the innovation field and offer academic and policy implications. As an innovation scholar, I am interested in how new technologies are adopted by users and how they affect human decision-making or productivity. Currently, I am studying the economic effects of new innovative technologies in various contexts, including artificial intelligence (AI), algorithms, and quantum computing. Here I want to introduce my current studies after joining the MIT. There projects are working in progress.

Context 1: AI at the hospital

Beyond AI research I mentioned in my cover letter, I am initiating the other AI project. The second study is about ***how AI complements human skills and disrupts the way professionals work.*** We specifically study the emergency rooms in university hospitals. Physicians in emergency rooms may not have specialized knowledge and skills and frequently request multidisciplinary collaboration across different departments, which could take several days, if not weeks. For example, when patients take chest x-rays, physicians must wait until they hear from radiologists. The introduction of the AI-powered x-ray triage solution could change how physicians and radiologists work in the hospital.

We work with Lunit, a medical AI software company devoted to providing AI-powered health care. In 2021, Lunit received the US FDA's 510(k) clearance for its AI-based chest x-ray triaging software, *Lunit Insight CXR Triage*, and breast cancer triaging software, *Lunit INSIGHT MMG*, respectively. The research team also works with one of the best and largest university hospitals in South Korea. This university runs three hospitals in South Korea, and one of them adopted Lunit's AI solution hospital-wise while the remaining two did not. We plan to conduct (1) observational studies with detailed data on patients, physicians, and their communications and (2) field experiments as the two remaining hospitals plan to adopt Lunit's AI solution in the next few months.

The research team already had several meetings with Lunit and the vice president at one of the university hospitals and reached an agreement to conduct large-scale observational studies and field experiments. Both Lunit and the hospital are highly keen to support academic research to understand the impact of AI on patients and hospitals. We expect to perform the data analysis and field experiments in the second and third quarters of 2022.

Context 2: Quantum Computing

Quantum computing has gained attention as a potential technology to replace classical computing due as Moore's law comes to an end. And the conventional wisdom is that quantum computing is more efficient than classical computing, which would provide big economic and environmental benefits. The reality, however, is more subtle. Whether quantum is better depends on the problem being tackled and the scale of that problem. If businesses, consumers, governments, and investors are to be given practical guidance on which areas will be transformed by quantum computing, we need to understand these questions:

- ***When are quantum algorithms than their classical counterparts?***
- ***How big do problems need to be for any quantum advantage to overcome the head start of classical computing?***
- ***Which applications will be able to take advantage of quantum algorithms?***

By understanding the answers to these questions, businesses can be given practical guidance on when quantum computing is more beneficial than classical computing, and about which applications/industries will be affected. In addition, these answers will also tell us the (now more limited) areas where can expect large increases in computing power without the environmental sustainability challenges facing classical computing.

To answer these questions, we have investigated two notable quantum algorithms: 1) Glover's algorithm and 2) Quantum Fourier Transform algorithm (QET). By comparing the speed of supercomputers[1] to that of quantum computers, we can calculate the ratio and estimate the problem size at which the quantum computer starts faster. Based on the estimated problem size, we infer the number of logical and physical qubits and guess the expected year for the quantum advantage.

Our findings show that different quantum technologies will achieve the quantum advantage differently. For superconducting qubits, Glover's algorithm requires 52 logical qubits and 884 physical qubits, and the QET algorithm requires 31 logical qubits and 527 physical qubits. It means that Glover's algorithm will be faster within 2-3 years and will be applicable to searches of databases larger than 10^{14}, whereas the QET algorithm will be faster within 2-3 years will be applicable to problems larger than 10^{9}. On the other hand, for trapped-ion qubits, Glover's algorithm should have 70 logical qubits and 1,190 physical qubits and the QET algorithm should have 39 logical qubits and 663 physical qubits. Glover's Algorithm will be faster over 7 years and will be applicable to searches of databases larger than 10^{19} while the QET algorithm will be faster over 6 years and will be applicable to problems larger than 10^{11}. We plan to extend this approach to other quantum algorithms including factoring, simulation, and linear algebra.

2) The reasons for wanting to attend this boot camp

I have three reasons for wanting to attend the boot camp. First, I would like to strengthen the background of literature for the economics of innovation by participating in this. The doctoral course I took was not enough to deal with the economics of innovation in depth because it was an interdisciplinary department. I was able to learn various backgrounds, but I felt that I lacked a deep understanding of the innovation field. In addition, I wonder the distinguished scholars consider which papers as crucial papers in our field. Thus, it must be a great opportunity to improve my knowledge about our field.

Second, this boot camp will be a great opportunity to meet juniors and prominent scholars in the field of innovation. Since it was a rare opportunity to establish a relationship due to COVID-19, I was desperate to discuss my research with them in the same field. With meeting them in person, I want to learn the research trend of this field and hope to find future collaborators. Moreover, when you meet researchers in the same field, there are mentors when reading their papers or writing my papers, so it can be a motivation to study well. Lastly, I want to share my research and get feedback with the audience in this field of innovation. Because of its rich knowledge of new innovative technologies such as AI and quantum computing, I can share new knowledge of these innovations with participants, too. Particularly, because I think of this year my job market year, I want to promote my research and myself a lot by joining this boot camp and the NBER Summer Institute Innovation Policy meeting.

[1] Classical Computing's operations per second is equal to 2.2 petaflops (10^{15}) - median of top 500 super computers.

NEIL THOMPSON

January 18, 2022

NBER Innovation bootcamp organizers,

I'm writing to voice my strong support for Sukwoong Choi and his application for the NBER Innovation Bootcamp.

Sukwoong is a postdoc in my lab, which sits in both the MIT Sloan School of Management and the MIT Computer Science and Artificial Intelligence Lab. This gives him an unusual view on IT innovation that combines the technical details of how it progresses and the big-picture economics, business view of how important it is.

Sukwoong's insights and worldview come through in his research, which make him an excellent candidate for your program. For example, his work on:

(1) **A.I.:** Sukwoong has done important work on AI and how humans are now learning from AI systems. This was done through a clever design where he and his co-authors re-played human-played games of Go, at each stage asking what move an AI systems would do in that situation. They find a remarkable change; after humans can practice against superhuman AI systems, their play evolves to be more like the AI systems. In a world where more and more AI systems are likely to be outperforming humans, this will become an increasingly important area of study.

(2) **Algorithms:** Sukwoong is working on a project with me where we look at the importance of algorithm improvement to firm performance. Traditional measures of firm IT improvement have fully neglected this impact, which is a major omission since for big data problems the gains from algorithm improvement can rival those from hardware improve, i.e. Moore's Law.

(3) **Quantum Computing:** Sukwoong is also working on a project in my lab where we are looking at quantum computing and which areas of the economy it will impact. Since quantum computing is the presumed successor to Moore's Law for propelling computing progress, this question is central to the shape of IT innovation in coming decades.

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neil_t@mit.edu | www.neil-t.com | www.Business-Experiments.org | @ProfNeilT

NEIL THOMPSON

In addition to the contribution that Sukwoong will make to the bootcamp because of his excellent, cutting-edge research, he will also contribute as an excellent compatriot. In his time in my lab, I have found Sukwoong to be congenial, diligent, and a pleasure to have around.

For all these reasons, I commend Sukwoong to you and hope that you'll find a place for him in the program.

Sincerely,



Neil Thompson

MIT Computer Science and Artificial Intelligence Lab
MIT Sloan School of Management