

Spring 2023

PHBS MAGAZINE

Peking University
HSBC Business School

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Peking University HSBC Business School
University Town, Nanshan District
Shenzhen, 518055 China

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Peking University HSBC Business School



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Issue



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PHBS MAGAZINE

PHBS Magazine is published by Peking University HSBC Business School

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PHBS Magazine is published twice a year

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NEWS BRIEFINGS

1 PHBS Holds Inaugural Search and Matching Workshop in Asia-Pacific

The Inaugural Search and Matching Workshop in Asia-Pacific was held online on November 14 and 15, 2022. Hosted by the Sargent Institute of Quantitative Economics and Finance at PHBS, the workshop attracted more than 50 scholars from both Chinese universities, such as Tsinghua University and Fudan University, and foreign institutes, such as the University of Missouri, New York University, National University of Singapore, University of Queensland, Kyoto University, and the



Bank of Japan. The workshop featured two keynote speeches delivered by Gu Chao from the University of Missouri and Ricardo Lagos from New York University, and four sessions on empirical evidence, intermediation, digital currency, and labor. The Search and Matching Workshop in Asia-Pacific will be held biannually to provide a high-level platform for academic exchanges between researchers in the Asia-Pacific area.

3 PHBS Wealth Management Subsidiary Companies of Commercial Banks Competitiveness (2022H1) Rankings Released

On October 26, the PHBS Wealth Management Subsidiary Companies of Commercial Banks Competitiveness (2022H1) Top 10 Ranking was released. The ranking is jointly released by the PKU Financial Review, the HSBC Financial Research Institute at Peking University and PHBS Think Tank. Based on objective and available data, the ranking comprehensively reflects the development of China's bank wealth management in the new period, enhances public investors' understanding of the healthy development of the financial market, and contributes to the development of a harmonious financial environment.

2 The 3rd CUHKSZ-PHBS Economics and Finance Workshop held

Co-hosted by the School of Management and Economics (SME) of the Chinese University of Hong Kong, Shenzhen, the Peking University HSBC Business School (PHBS), and the Shenzhen Finance Institute at the Chinese University of Hong Kong, Shenzhen (SFI), the 3rd CUHKSZ-PHBS Economics and Finance workshop was held on November 12 and 13, 2022. Scholars from world-class universities conducted in-depth discussions on the latest academic topics in the fields of economics

and finance. Professor Wang Pengfei, vice Chancellor of Peking University Shenzhen Graduate School and Dean of PHBS, and Professor Wang Jian, associate director of the SFI, delivered opening remarks on behalf of the organizers. Initiated in 2021, the CUHKSZ-PHBS Economics and Finance Seminar is held every six months alternately by PHBS and the SFI, with the aim of inspiring scholars to promote cutting-edge academic research in the field of economics and finance, as well as promoting academic exchange and cooperation between PHBS and the SFI. Earlier this year, the 2nd workshop was held at PHBS and attracted more than 160 scholars from world-class universities in China, the United States, and Singapore, among others, to hold in-depth discussions.



NEWS BRIEFINGS



4 PHBS Think Tank and PHBS Sargent Institute Recognized as the Scientific Research Platform of the Guangdong Provincial Department of Education

PHBS Think Tank and SIQEF were selected by the Department of Education, Guangdong Province, to be one of the New-Style University Think Tanks of Guangdong and the key laboratory of philosophy and social sciences in ordinary universities in Guangdong, respectively. In the future, PHBS and its affiliated institutions will continue to leverage Peking University's scientific research advantages, make full use of Shenzhen's unique innovation environment and the favorable conditions in the Greater Bay Area, and serve to promote high-level academic research.

5 Chinese and International Students' Exchange Party Held on Campus

On October 22, the PHBS Student Union held a cultural exchange party at the multi-function hall of building 6, Yan Yuan to help international students returning post-pandemic, and the first cohort of PHBS undergraduates, more efficiently and effectively integrate into campus life. Students from a wide variety of countries, including Italy, France, the UK, Korea, Canada, and Mexico, gathered and exchanged ideas, promoting cultural integration on campus and the personal growth of both Chinese and international students.



6 Connect to Chinese Consumers from Digital Marketing Masterclass



The PHBS UK Campus provided students with the inaugural China Digital Marketing Masterclass to improve their understanding of China and introduce them to Chinese digital practices. During the class, the instructors also took participants, both online and in-person, on a deep dive into China's most popular social media platforms. Attendees also had the opportunity to discuss real-life cases and present their ideas. Every strand involved instruction from special keynote speakers with vast practical experience. Everything discussed in the keynotes was fed into the group discussions and case studies. Participants were also asked to hold group discussions and conduct case studies to understand practical marketing strategies and keep up with digital marketing trends.

NEWS BRIEFINGS

7 PHBS Wins the Convergence Media Award of PR Newswire Corporate Communication Awards 2022

The 2022 PR Newswire New Communication Forum was recently held in Shanghai, and the results of the widely concerned 2022 Corporate Communication Awards were announced during the forum. PHBS stood out to win the Convergence Media Award for its innovative communication forms, rich communication contents, and remarkable communication effects under the background of media convergence.

The Corporate Communication Awards were launched by PR Newswire in 2013 to enhance the

awareness of enterprises, organizations and media about the concept of communication with quality content as the core. There are 10 awards to recognize the best in corporate communications in 2022 from different perspectives such as planning and production of content and brand impact. This year's award-winning institutions include China Academy of Fine Arts, Huawei Technology Co., Ltd., JD.com Group, Tencent Music, iqiyi, Shell China, Chongqing International Communication Center, China Offshore Oil Co., Ltd., overseas Chinese City Group, and so on.



8 PHBS Holds New Year Party



For many PHBSers, the New Year Party is the most anticipated event of the year and it lived up to its fame. On December 19, PHBS held its New Year Party themed “Brave the Rapids, Aim for the Sun.” Chinese and interna-

tional students, faculty, and staff all dressed up and converged to celebrate their achievements and enjoy a wonderful night. Kicked off by an opening video of heartfelt wishes and greetings from faculty and students, the party featured student performances, dean’s remarks, a banquet, and awards ceremonies. The choreographed moves of the dancers, chorus, and solos, all spoke of the many hours the students put into brainstorming and practicing before the event. In his remarks, Professor Wang Pengfei recalled the prosperous past year, while Professor Hai Wen highlighted the importance of hope and bravery, especially in these turbulent times of global epidemic and economic disturbance. At the start of the banquet, faculty, staff, and students made toasts and wished each other the best for the year ahead.

9 International Students Attend Career Development Workshop

Yuehai Enterprise Service (YHES) and PHBS jointly held a career development workshop on December 14 to help international students apply for local jobs, providing an in-depth understanding of the employment background and environment in Shenzhen. The workshop started with a keynote speech delivered by Li Kai, assistant dean of the Institute for Financial Stability and Development of Shenzhen. He talked about how to navigate a

career in a sustainable commercial world. After the speech, representatives of local enterprises introduced the local employment environment and workplace culture. Participating students came from a variety of countries across the globe, including the UK, Canada, Pakistan, Thailand, Malaysia, and Japan.

PHBS Holds Business Education Development Forum—

Celebrating The 120th Anniversary of Business Education at Peking University

By Annie Jin



1. Participants attend the forum
2. PHBS Associate Dean Ren Ting Presides over the Forum

Peking University HSBC Business School (PHBS) held the Business Education Development Forum on November 19, celebrating the 120th Anniversary of Business Education at Peking University. Over 8,000 people attended the event, including alumni, scholars, practitioners, and an audience from all walks of life, with many joining through livestreaming.



Professor Wang Pengfei gives opening remarks

Wang Pengfei, vice chancellor of Peking University Shenzhen Graduate School and dean of PHBS

Recalling the history of Peking University's business education and the development of PHBS, Professor Wang emphasized three key aspects: tribute, inheritance, and innovation. Facing the "great changes unseen in a century," he noted that it's our mission of the times to analyze the ever-changing situation and rise to the challenges. He hoped that counterparts in academia could work together and move forward hand-in-hand, to write a new chapter for Chinese business education and promote the great rejuvenation of the Chinese nation.



Professor Hai Wen delivers a keynote speech

Hai Wen, vice chairman of Peking University Council, former vice president of PKU, and founding dean and chair professor of PHBS

Professor Hai elaborated on the origin of modern business education, the current situation of global business education, and the prospect of Chinese business higher education, identifying the key criteria for a top business school. Speaking of the business education development in the Greater Bay Area, Professor Hai highlighted its vital role in training the visionary and principled entrepreneurs, who could serve as the essential factor and impetus for innovation. He held that business schools should gain insights into the real business world to provide practical solutions for enterprises, incorporate tech advances into business education, improve the quality of research and teaching, and enhance cooperation as well as exchanges among counterparts, in order to fuel the innovation and the long-term development of the Greater Bay Area.



Ma Weihua, a member of the United Nations Sustainable Development Goals Impact Steering Committee, chairman of the board of directors of the National Fund for Technological Transfer and Commercialization, chairman of Menglang Sustainable Digital Technology (Shenzhen) Co., Ltd.

Ma delivered a keynote speech entitled "Creating a Sustainable Development Investment and Financing Ecosystem." He spoke highly of the contributions that PKUers have made to the development of business education in China and provided an in-depth analysis of how to establish a sustainable investment and financing ecology. He concluded that it's the sacred mission and great responsibility of our generation to cope with climate change, achieve the "double carbon" goal, and promote sustainable development. "I believe that in this process, PKUers will be able to respond to the challenges with the pioneering and innovative spirit and make greater contributions to climate protection and the development of science and technology," Ma noted.

In the roundtable discussion on "Business Education, Innovation, and Development of the Greater Bay Area," deans and professors from leading universities converged to share their insights into the development trends of business education, especially how to translate cutting-edge research into business solutions, enhance interdisciplinary cooperation, and cultivate top business leaders for both the Greater Bay Area and the world.



Roundtable discussants: Wang Fan, assistant president of Sun Yat-sen University and dean of the School of Management; Wang Cong, associate vice-president and presidential chair professor of the Chinese University of Hong Kong, Shenzhen; Xie Danyang, dean and chair professor of Hong Kong University of Science and Technology (Guangzhou) Society Hub; Wu Liansheng, deputy dean and chair professor of the Business School at Southern University of Science and Technology.



The following roundtable discussion focused on "Enterprise Development and Business Leader Cultivation." Practitioners from different industrial sectors exchanged their views on the close correlation between business education and enterprise develop-

ment, and how to improve the talent cultivation ecosystem in the face of digitalization and internationalization.



In addition, a special exhibition "the 120th Anniversary of Peking University Business Education and the 18th Anniversary Exhibition of the HSBC Business School" was held at PHBS. Divided into three parts, "Strategies for National Stability," "Education for Prosperity," and "A Chapter of Innovation," the exhibition showed the history of Peking University business education, particularly the development roadmap of PHBS.

The special exhibition

Two PHBS Master's Programs Ranked 1st in Asia and Top 20 Globally

By Annie Jin

In the recently-released QS Business Master's Rankings 2023, two Peking University HSBC Business School (PHBS) programs, Master of

Finance and Master of Management, were placed in the global top 20 for their subject area and 1st in Asia.



The Master of Management ranked 17th globally placing in the top 10% of 176 management programs



The Master of Finance ranked 20th globally placing in the top 11% of 189 finance programs

“It is the first time that PHBS degree programs have been formally listed in an international ranking system,” remarked PHBS Associate Dean Young Joon Park, regarding it as a significant achievement for the school’s future development and talent recruitment.

Indeed, with specialized master’s degrees becoming an increasingly popular option for students, the rankings serve as a reliable indicator for anyone considering a master’s degree in these subject areas.



This year's QS Business Master's Rankings highlighted the best graduate master's programs across the world by evaluating over 600 programs from around 40 countries. Each ranking is compiled on the basis of five key metrics, including employability, thought leadership, class and faculty diversity, return on investment, and alumni outcomes. Data was collected in early 2022, using three surveys: the QS Global Employer Survey, the QS Global Academic Survey, and a survey completed by the business schools themselves, covering quantitative indicators such as the salary of graduates, class profile, and other institutional data.

“This year's QS Business Master's Rankings highlighted the best graduate master's programs across the world by evaluating over 600 programs from around 40 countries.”



“Though a young school, PHBS has exhibited its excellent quality and high standard of education to the academic society and employers,” Park noted. Although the pandemic has had a substantial impact on the labor market, PHBS graduates continue to stand out during fierce job hunting. According to the

school's annual employment report, the employment rate of MA graduates has bucked the trend and achieved a "triple jump" of 95.4%, 96.6%, and 97.6% in the past three years, which speaks volumes for the school's reputation in terms of talent cultivation and employability.



Located in Shenzhen, PHBS was founded in 2004 with the vision to build on Peking University's inspirational traditions and develop as a center of international excellence in business education. Prior to the QS Business Master's Rankings, the school's Master of Economics program was conferred EPAS accreditation by the European Foundation for Management Development (EFMD) in 2011. In addition, PHBS has been accredited by AACSB in 2018 and AMBA in 2019, the two largest and most influential business school accreditation organizations.

Powered by exceptional faculty from the world's leading universities, PHBS offers over 130 graduate level courses per year conducted in English, and its programs are tailored to provide students from home and abroad in-depth Chinese educational experiences with a global perspective. The school continues to grow strong academically, as recent years have wit-

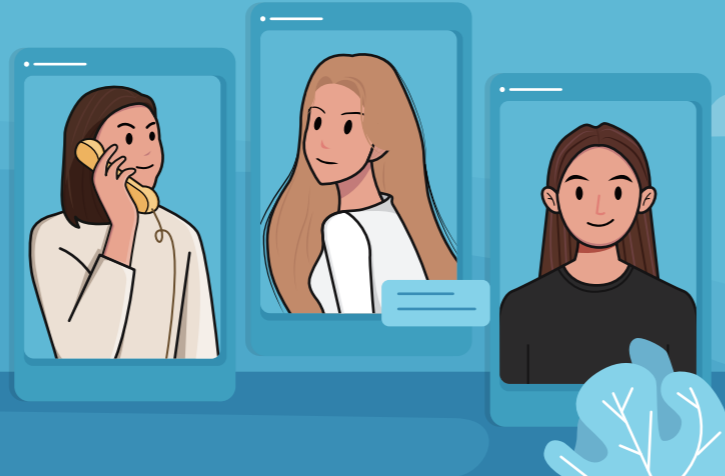
“Though a young school, PHBS has exhibited its excellent quality and high standard of education to the academic society and employers.”

nessed an increasing number of its faculties' publications in the world's top academic journals. Nevertheless, “being recognized in a global ranking also comes with more pressure,” Park admitted, pointing out that the school will continue to develop its programs to further excel in the international arena.

Navigating Challenges —A Focus on International PHBSers

By Annie Jin

The uncertainties worldwide are not something to be ignored. Despite these unprecedented times and their impact, PHBS students – like students all over the world – have been able to continue their studies and learn important life lessons on navigating challenges and unknowns, and how to be better prepared for the future. Today, we will focus on three international students, all of whom have deep bonds with China and the unique experience at PHBS.



served as a plus for PHBS, because it could give him more insights into the Chinese business world. However, the Covid-19 pandemic broke out before his story with PHBS could unfold. Though it took some time for Anton to get used to online courses and restrictions, he felt grateful to be one of the few who managed to study on campus.

“I have met students and professors who are awesome, intelligent individuals passionate about business studies. These people have good personal traits and are great to study with,” remarked Anton, “PHBS people are the key factor in making the school what it is.” He added that courses, such as operations management, organizational behavior, managerial economics, entrepreneurship, and strategic management, changed his perception and developed his ability to think critically as a manager.

When asked about future plans, Anton said he wanted to be a product manager in the software development industry, creating digital products that help people, and especially organizations, to meet their needs. “The Software-as-a-Service (SaaS) model makes the line between 2B and 2C products less obvious,” he said, referring to his hope to create products that facilitate smooth collaborations and

productive communications.

In the face of this ever-changing era, Anton shared his hopes for the school and other PHBSers:



“Peking University in general and PHBS in particular are continuously getting better as shown by university rankings. I believe that PHBS has multiple traits which make it different

from other schools, and that's why we all love it. Its advantages include culture, location, professors, and networking opportunities. PHBS people are the key factor making PHBS what it is. In the face of the challenges that this time imposes on us, I hope that each and every PHBSer can achieve their own goals and, consequently, further improve the reputation of PHBS by their achievements.”

✦ Anton Ergahsev



Anton Ergahsev, pursuing a master's degree in management at PHBS, has been passionate about Chinese language and culture since a very young age. During his undergraduate study at Capital Normal University, Anton kept exploring and learning, which initiated his interest in business-related subjects and led him to pursue a master's degree in Shenzhen.

“I had a few friends from Peking University, and they strongly recommended that I consider PHBS. After looking at the official PHBS website and communicating with some alumni, I confirmed that PHBS would be a great place for my future studies.” Anton added that locating in Shenzhen also

Anton Ergahsev has an after-class discussion with professors

✦ Daria Gurianova



Daria's life has been connected to China since 2015, when she travelled here for exchange programs during summer holidays. After her last exchange in Guangzhou, Daria decided to pursue a master's degree in China. “PHBS is a great fit for me and gives great business vibes,” Daria said, referring to the school's reputation worldwide and its location in Shenzhen, a rapidly developing city of many growing businesses and opportunities.

Since the Covid-19 pandemic, PHBS has moved its classes online for international students, offering live-streamed lectures with presentation slides, other teaching materials, group discussions, and Q&A sessions. “For sure, it's a very unique experience.

Daria Gurianova plays guitar in the countryside back home

I cannot deny that I prefer studying offline, but the experience has brought me some patience and in some way stress resistance,” Daria admitted, appreciating how online classes were held at PHBS. She felt that “it”’s also important to say that professors were very considerate and had a good understanding of our situation. They were ready to help us in need.”

Daria’s enthusiasm was not only in class, but also in the school’s diverse activities and events, including forums, ceremonies, and commencement. She picked up the word “community” to describe the school, just as she said at the opening ceremony, “we are one community, we are PHBS!” She added that, “I have meet amazing people and learned a lot from them. Professors, classmates, and friends keep motivating me to see and do more.” During leisure time, Daria has loved sharing her life vlogs, music, and study experience on social media, all full of passion and brilliance.

In the face of the ever-growing uncertainties in this era, life for Daria is not about rigidly following the traditions. She said, “As was shown in practice, the best thing we can do is to learn how to adapt to the new realities we may face. It’s always good to keep, remember, and follow traditions, but it’s also crucial to go with the flow.” In the future, Daria

hopes to maintain her enthusiasm and make her career path adventurous. “I just want to become a professional in what I do, and be someone to be relied upon.”

Reflecting on the past and looking forward to the future, she’s good at learning from setbacks and seeing positive possibilities:



“There is always something we can become better at, even online. For example, all of the communications were done online through various meeting platforms, and international students became especially skilled in that.

Even though it was hard to always stay motivated, we helped and kept supporting each other through all this time, so that we could make more than expected from an online environment. Communication is the key no matter where you are or what you do. This experience has been very important for us.”



Eléna Potapieff with friends after the commencement

✦ Eléna Potapieff

Eléna is a very recent graduate at PHBS and her decision to pursue a master’s degree in China was not a random decision but more a gradual process over several years. A glance at Eléna’s experience revealed that her initial interest in China began in eighth grade when she started learning Chinese for its advantage in the job market. This fueled her curiosity about Chinese culture and led to a three-year undergraduate program in Beijing. With growing exposure to China, Eléna discovered a new way of living and thinking, and decided to pursue a master’s degree.

With the aim of working in China, Eléna said PHBS quickly became her top option: “The perfect mix presented itself with PHBS: offering on the one hand, the renown and culture of PKU, and on the other hand, a center of international excellence in business education within the dynamic city of Shenzhen.” At the intersection of dramatic changes following Covid-19 outbreaks, she was one of the few international students who attended on-campus, online, and hybrid classes.

“The first semester on campus exceeded my expectations. It was a gathering of people from all over the world, fostering intellectual and cultural exchange. Between classes, group projects, and outings, we formed a close-knit group,” Eléna recalled. Though subsequent semesters were held online due to the pandemic, she said PHBS showed great understanding, arranging classes to accommodate the time difference of international students: “The professors remained attentive to provide the best learning conditions for their students, despite the new way of teaching and communicating. And the mutual help continued among the students.”

Unlike most PHBS graduates who chose to work at leading companies in the financial sector, Eléna will start her career in a Shenzhen tech company, as being in Shenzhen has allowed her to experience the technology development first-hand.

As the PHBS chapter closed for Eléna, she stepped out of the campus and felt grateful for the opportunities that have come from this experience:



“I particularly appreciated the stimulating atmosphere at PHBS. There is a spirit of continuous improvement and open-mindedness. The cultural mix creates a common curiosity among students to learn about others. We have spent many hours discussing cultural similarities, differences, and peculiarities. In addition to this cultural awareness, we have also developed our analytical and critical thinking skills through professors’ guidance. I also liked the sense of community at PHBS: students support each other socially and academically.”

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Erdi Tac:

Adapt or Perish — A High-Tech Enthusiast's Story in Shenzhen

By Annie Jin

Graduated from Bilkent University with a bachelor's degree in electronics engineering, Erdi Tac pursued his master's degree in management at Peking University HSBC Business School (PHBS). Drawn to diverse opportunities, Tac, like many international alumni, has been navigating his career in China since his graduation in 2017.

A glance at Tac's background reveals that his initial interest in China stemmed from his exchange experience at the City University of Hong Kong. This fueled his curiosity about China and eventually led to his deep bond with Shenzhen. "Why does no one talk about this place, it's the future," said Tac flabbergasted, recalling several visits to Huaqiangbei, one of Shenzhen's notable retail areas, with one of the world's largest electronics markets. In the eyes of an engineering student back then, "it was like heaven."

"A glance at Tac's background reveals that his initial interest in China stemmed from his exchange experience at the City University of Hong Kong. This fueled his curiosity about China and eventually led to his deep bond with Shenzhen."



Realizing that Shenzhen is like a magnet attracting global talent because of its entrepreneurial vibe, he started looking for opportunities to study here. He found that two alumni from his undergraduate university were already studying at PHBS,

Peking University's young business school in South China's Shenzhen. It quickly became his top option, but coming to a place so different did require "a leap of faith."



Erdi Tac attends the school's 15th anniversary ceremony

Engineering plus management

Like most international students, Tac had always heard about how good European and American schools are, but hadn't researched what schools in Shenzhen had to offer. "It was a bit like walking the less chosen road, and the usual doubts came with it," Tac admitted. Making a shift from engineering to management in a foreign land was also a bold choice, but he saw it as inevitable because his background, Shenzhen, and natural interest came together to create chemistry.

"My previous knowledge would have hit the ceiling if I had tried to run a business," he noted, as his undergraduate education was more about technical skills rather than practical and theoretical training

in business. Tac felt that education in management was a must for entrepreneurship and it turned out PHBS could provide a perfect setting for this — Located in China's first Special Economic Zone, and adjacent to the Asian financial hub of Hong Kong, the PHBS Shenzhen campus has a unique opportunity to leverage its location in the Greater Bay Area.

Indeed, for Tac, the most important lessons he learned were actually outside the classroom. As Shenzhen is the cradle of China's entrepreneurial companies, PHBS regularly invites entrepreneurs and business leaders from well-known Shenzhen-based companies such as Huawei, Vanke, and Tencent to provide special lectures and participate in international forums. Tac said students also had opportunities to make company visits, where they

deepened their understanding of actual business practice.

Further, the management program at the school is not just confined to classroom teaching, but also focuses on team work. “There is almost no individual assignment; we always work as a team,” Tac explained. For each assignment and class, teams were comprised of different people, which meant Tac had to work with classmates who had different working styles. He thought it was a rewarding experience, adding that “at the end of the first year, I gained the ability to work with any kind of person, because PHBS has students from all over the world and different parts of China. Imagine the diversity of cultural backgrounds!”

Recalling memorable moments beyond academics, Tac said there were quite a few, for instance, partying with friends in dorms, working together



Erdi Tac dresses up with his friends to perform at “Night On Mirror Lake” for New Year, 2015

on projects until the early morning, or going out on Friday nights. “Oh, I also love the new year parties, just because we all can dress up in suits, drink, and take photographs as if we were in Hollywood galas.”



2016 Hult Prize Finals in Shanghai ; from left to right, Jason L. Yu, Xavier Lemyre, Hamza Ayub, and Erdi Tac

Fueling the dream

Many Chinese universities have internationalized in recent years to attract talent from all over the world. Furthermore, various levels of government are pioneering business incubators and special economic zones. PHBS, in particular, is providing rare opportunities for young entrepreneurs via business competitions and seminars.

“I had it in mind to start my own company, but I didn’t know how to in China. PHBS helped me find the answer” said Tac, recalling how the school encouraged and supported his team Skynet Global to compete in the HULT Prize, the world’s largest social start-up competition spearheaded by the Clinton Global Initiative in partnership with student teams from universities across the globe.

The team of four PHBS students, Erdi Tac, Xavier Lemyre, Hamza Ayub, and Jason L. Yu, won that year’s first prize by putting forward a well-illustrated proof of concept and a prototype that the team developed on its own. “It was such a ride working together with a team of great friends,” Tac added. “Each one of us was known to be very good at our assumed roles”— a Turkish engineer, a French-Canadian economist, a Pakistani marketer, and a Chinese-Bolivian international business specialist.

“Indeed, the cultural diversity demonstrated by team Skynet Global is on the rise in China and speaks volumes especially about the evolution of PHBS, known for its highly competitive admission standards, and its role in the international arena to groom the business experts and entrepreneurs of the future.”

“Three months’ worth of traveling to several trade fairs, suppliers, and countless sleepless working nights were all tested in eight minutes of a well-prepared presentation. It was like putting pieces of a puzzle together,” Tac recalled vividly. Though they had to work till late at night after school, on top of the student duties, he missed those moments as “every bit of it was freaking exciting and fun!”

Indeed, the cultural diversity demonstrated by team Skynet Global is on the rise in China and speaks volumes, especially about the evolution of PHBS, known for its highly competitive admission standards, and its role in the international arena grooming the business experts and entrepreneurs of the future.

Entrepreneurship is the way to go

“I’ve been totally into entrepreneurship since then,” Tac admitted, telling how he jumped right in even before his graduation and worked with two startups. Unlike those larger enterprises, startups have chaotic environments where Tac experienced the famous roller-coaster and learned very valuable lessons. Furthermore, as he recalled, “When no one knows what to do, I can almost always think of examples of similar issues I’ve read about and analyzed in different courses.”

With a keen eye for the world’s latest trends, Tac clarified his future plan: devoting to high-barrier technology like artificial intelligence and focusing on language learning. “I remained loyal to the plan for the last three years, finally mastered the technology, and found an unmet need, as well as an excellent co-founder. The result is Cathoven A.I.” The start-up aims to create smart tools for language teaching apps.

The way Tac expanded his skillset did benefit him during the later waves of the Covid-19 pandemic. “With the pandemic, everything is going digital,” he said, describing the education industry he’s in right now. With this sudden shift away from the

classroom in many parts of the globe, there has been high growth in education technology and tremendous policy changes. “We all had to adapt. Even the giants made complete strategy changes.” Fortu-

nately, being on the side of high technology, the effects Tac experienced were positive. “The number of new users has been soaring every single month since then.”



Representing China as the Shenzhen Hub curator, Erdi Tac attends exchange sessions with exemplary leaders and fellow shapers during the 2022 Global Shapers Community @ the United Nations in Switzerland

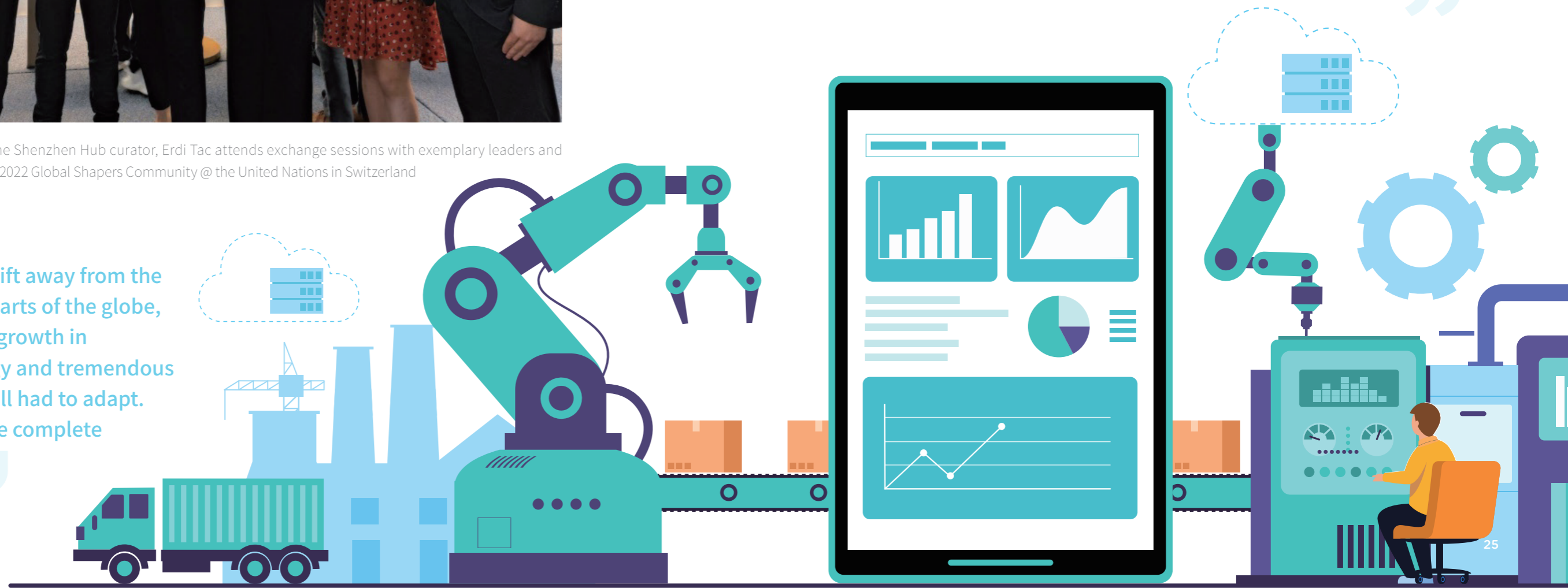
During the pandemic in 2020, Tac was also chosen to join the World Economic Forum’s Global Shapers Community Shenzhen Hub, which he is now leading. It’s a network of young people that comes together to drive dialogue, action, and change for the world’s most challenging problems. It spans over 350 cities and 170 countries. Tac thought if he is building something “it should have a good impact on society and Global Shapers help you get into that shape.” Recently he joined the annual meeting in Switzerland with the leaders from all around world.

Looking forwards, Tac is well prepared for this ever-changing era by having the mindset of adapting to the situation, and moving on to the next course of action as soon as possible. “Everyone has a plan until they get punched in the face,” Tac concluded, quoting the famous boxer Mike Tyson. As technology continues to shape the business landscape, Tac remains on track to leverage the entrepreneurial vibe and resources in Shenzhen, China's front-runner in tech innovation and PHBS's home.



“As technology continues to shape the business landscape, Tac remains on track to leverage the entrepreneurial vibe and resources in Shenzhen, China's front-runner in tech innovation and PHBS’ s home.”

“With this sudden shift away from the classroom in many parts of the globe, there has been high growth in education technology and tremendous policy changes. We all had to adapt. Even the giants made complete strategy changes.”



Karol Mazur

College Education and Income Contingent Loans in Equilibrium



Karol Mazur

Assistant Professor
Research Interests:
Macroeconomics,
Development,
Human Capital,
Labor Markets

In many countries, student loans are very important for financing higher education. As such, the policy is often seen as a way of improving access of students to education, especially for those from disadvantaged backgrounds. However, investments in higher education can be risky, e.g. due to uncertainty about successful college graduation and about potential future income. In the US, the level of outstanding student debt is currently close to \$1.8 trillion and almost half of all college students drop out of school before earning a bachelor's degree. Trying to address the dropout issue, the US government reformed the higher education finance system in 2009 by introducing a major program of income contingent loans.

In their recent paper, "College Education and Income Contingent Loans in Equilibrium," published in the *Journal of Monetary Economics*, Karol Mazur, assistant professor of economics at Peking University HSBC Business School, and Kazushige Matsuda, associate professor of economics at Kobe University in Japan, examine the welfare effects of this reform in a quantitative economy with moral hazard, endogenous selection, general equilibrium, and incomplete markets.



“

Setting a sufficiently high poverty level line can increase the welfare gains of the reform by as much as 25%, and reducing the repayment ceiling to 25% of the status quo may increase the welfare effects by up to 15%.”

The study shows that the implementation of an income-contingent loan policy in the US has reduced the risks associated with student debt repayment, and consequently, with enrolling into college. As such, the reform has increased the enrollment rate by about 5% and the graduation rate by about 2%. Importantly, it turns out that the moral hazard (due to the insurance eroding incentives for studying in college or providing labor supply after it) and adverse selection (due to attracting lower ability students to enroll into college) induced by this policy in equilibrium are of secondary importance. Intuitively, moral hazard is mild because it is largely dominated by market incentives embedded in the significant wage premium that is available upon successful college graduation (currently about 190%). Similarly, adverse selection is non-existent as there is excess demand for additional human capital due to the lack of insurance contracts for college dropouts and income shocks. Relatedly, as the policy increases the equilibrium supply of human capital for pro-

duction, the reform is almost self-financing, requiring only very small tax increases.

The study also finds that the endogeneity of the skill premium slightly increases the policy's effectiveness. Finally, Mazur and his co-author examine how the parameters of the income-contingent loan program affect its welfare implications. For instance, they show that setting a sufficiently high poverty level line can increase the welfare gains of the reform by as much as 25%, and reducing the repayment ceiling to 25% of the status quo may increase the welfare effects by up to 15%.

Overall, the welfare gains associated with the reform introduced in 2009 by the US government are equivalent to a lifetime consumption increase of about 1% for the average member of society. Results of this research suggest that income-contingent loans not only stimulate the equality of opportunity, but also improve both economic efficiency and social insurance.

▲ Tang Chuang

A Dynamic Model of Owner Acceptance in Peer-to-Peer Sharing Markets



Tang Chuang

Assistant Professor
Research Interests:
Sharing Economy,
Quantitative Marketing,
Digital Marketing

In the paper “A Dynamic Model of Owner Acceptance in Peer-to-Peer Sharing Markets” forthcoming in *Marketing Science*, PHBS Assistant Professor Tang Chuang and his coauthors, Yao Dai at The Hong Kong Polytechnic University, and Chu Junhong at The University of Hong Kong, develop a framework to uncover the tradeoffs faced by owners on peer-to-peer sharing platforms when making acceptance decisions, which can be used by owners to optimize their decisions and by platforms to improve their operations.

Peer-to-peer sharing platforms have emerged as important marketplaces to facilitate resource sharing. In contrast to the conventional rental business, these platforms match individual customers with their peers instead of firms and may draw renters who demand a great variety of products and accommodate owners who possess products of great heterogeneity. Such a platform-based business model has been experimented in a wide range of product categories including accommodation, cars, apparel, and accessories, with Airbnb, Getaround, Turo, and StyleLend emerging as leading platforms.



“

Tang and his coauthors develop a new framework to uncover the tradeoffs faced by owners when making acceptance decisions, which can subsequently be used by owners to optimize their decisions and by platforms to improve their operations.”

In a typical peer-to-peer sharing platform, owners list their resources on the platform and exchange the idle usage time with usage fees paid by prospective renters, who do not own resources but are in need of them. Renters visit the platform and seek to satisfy their needs with its resource listings. A match between an owner and a renter starts with the renter searching for an ideal rental option. Once an option is identified, the renter then sends a rental request to the owner, stating when the resource is needed and for how long, together with a deposit larger than the total payment that will be held by the platform. The request exclusively books the usage of the resource during the requested time period temporarily. The owner, upon receiving the request, decides whether to accept it at their own discretion. If the owner accepts the request, the total payment will be made by the renter and dispensed to the owner, and the balance will be released to the renter after the transaction is complete. Alternatively, the owner

may reject the request and release the usage period to other renters. In this case, the renter needs to find an alternative for the needs, either from within their platform or elsewhere.

When a renter requests an owner’s resource, the owner needs to decide whether to accept the request: accepting it helps the owner fill the idle periods of the resource and generate a payoff, but reduces the flexibility to serve a future request for a longer duration.

Tang and his coauthors develop a new framework to uncover the tradeoffs faced by owners when making acceptance decisions. The authors explicitly model the preferences and decisions of two distinct types of owners using a latent class approach. Myopic owners make their acceptance decisions for each incoming request in isolation, whereas forward-looking owners make their acceptance decisions for the current request after taking into account how the decisions affect the availability of

the car and the arrivals of future requests.

They apply the model to unique data from a leading peer-to-peer car sharing platform in China, obtain similar sizes of both types of owners, and find that female, experienced, and younger owners are more likely to be strategic. The results also reveal the differentiated preferences of the two types of owners toward their renters. Building on model estimates, they find that the option value of an available day for forward-looking owners is found to first increase then decrease, and the most important day for a five-day window is the third day. In addition, the increase in this value prior to this most important day is slow, whereas the decrease afterward is rapid. The results allow forward-looking owners to determine, within their ranges of maneuver, which of the days available in

the future for prospective renters could be better forgone, and assess the associated loss in revenue, should own usage of the car or other conflicts in usage arise. The platform could ideally also make use of this information in its practice of optimal (re)allocation of rental requests.

The authors conduct two counterfactual analyses. The first analysis shows that if the platform imposes minimum rental duration, strategic owners may become more reluctant to accept requests, even if the current availability state entails a higher expected payoff. The second analysis shows that with better understanding of its owners, the platform can greatly improve the matching efficiency by optimal (re)allocation of rental requests, a move that benefits almost all participants in the business.



Insight

- RMB Will Become Increasingly More Important in Sovereign Debt Markets
- Sources of Artificial Intelligence



Oleg Itskhoki:

RMB Will Become Increasingly More Important in Sovereign Debt Markets



Oleg Itskhoki is a Russian-origin, naturalized U.S. American economist specialized on macroeconomics and international economics. He won the John Bates Clark Medal in 2022, which is awarded to economists under forty, second only to the Nobel Memorial Prize in Economic Sciences.

In the interview with PKU Financial Review, Oleg Itskhoki, winner of the John Bates Clark Medal in 2022, professor of economics at University of Califor-

nia, Los Angeles, states that, there is high likelihood that renminbi will keep gaining shares in international trade invoicing in line with China's role in global trade, provided continued economic growth of the Chinese economy. It is harder to foresee the increased role of renminbi as international funding currency for multinational firms in the immediate future, yet renminbi will likely become increasingly more important in sovereign debt markets.



Oleg Itskhoki

Winner of the John Bates Clark Medal in 2022
Professor of Economics at the University of California, Los Angeles

“Global economic prosperity in the coming decades will depend a lot on the ability of these large countries to come to an agreement regarding the rules and restore principles of cooperation in the area of international trade and investment.”

Q: We learned a lot from your paper "Granular Comparative Advantage". Taking French data as an example, you pointed out that export is mostly decided by large enterprises. When the country encourages export, it is actually important to reward and subsidize these large enterprises. So, will future trade restrictions' targets turn from specific goods to specific companies? What do you predict for the future patterns of trade disputes?

Oleg Itskhoki: Many existing trade policies, and in particular trade wars, target individual large foreign companies in line with the predictions of a granular model of trade – as such policies can induce the largest terms of trade shift in favor of the country for a given loss of consumer surplus from due to trade restrictions. Nonetheless, the reverse case for subsi-

dizing largest exporters it a lot less clear. The issue is that it has enhanced the monopoly power that will be exercised in particular in the domestic market and hurt domestic consumers. Open economy allows to shift part of the burden of monopoly power to foreign consumers, yet this might not be enough to guarantee domestic welfare gains. The question of benefits associated with policies that subsidize national champion firms remains open.

International trade is perhaps an area where the countries of the world have received the greatest benefit from cooperation, which relies crucially on sustaining the norms of fair international competition and orderly conflict resolution using the mechanisms of the World Trade Organization. Trade wars are highly disruptive to these norms and increase the risk of deterioration of the global trade system. Thus, it is crucial for large countries, in particular the United States, Europe, China, and Japan, to cooperate in this area and to come to a set of jointly supported and enforced norms and rules. Since WTO does not have enforcement mechanisms, it is the reputation of these large players that sustains such norms for all member countries. Global economic prosperity in the coming decades will depend a lot on the ability of these large countries to come to an agreement regarding the rules and restore principles of cooperation in the area of international trade and investment. Failure to do so will result in a global economic slowdown which would affect every region in the world.

Q: We are very impressed by your paper "Sanctions and the Exchange Rate". It is an important paper that combines geopolitics with exchange rates. Restricting a country's imports tends to appreciate its exchange rate, while restricting a country's exports or freezing foreign assets tends to depreciate it. What do you think of Russia's ongoing resetting of its currency to peg the Ruble to oil and gold? Do you think that geopolitics will have an increasing influence on exchange rates in the future?

Oleg Itskhoki: Sanctions since Russia's invasion of Ukraine combined with the Bank of Russia's policy of financial repression of foreign currency savings have resulted in a remarkable appreciation of the ruble. Currently, the goal of the central bank is to avoid any further appreciation of the ruble which puts excessive stress on fiscal balance – where the majority of revenues come from foreign-currency commodity exports, while expenditure is fixed in rubles. Over the previous years, the ruble was stabilized using FX interventions with its long-run value correlated with world oil prices, an arrangement typical for many “commodity currencies.” The future of the ruble depends a lot on the balance of exports and imports, which will likely be both restricted as long as the occupation of Ukraine continues, as well as on the strain on the fiscal balance of the government, which needs to increasingly support domestic incomes and employment, and would put increasing pressure on the central bank to monetize future fiscal deficits without access to international financial markets.

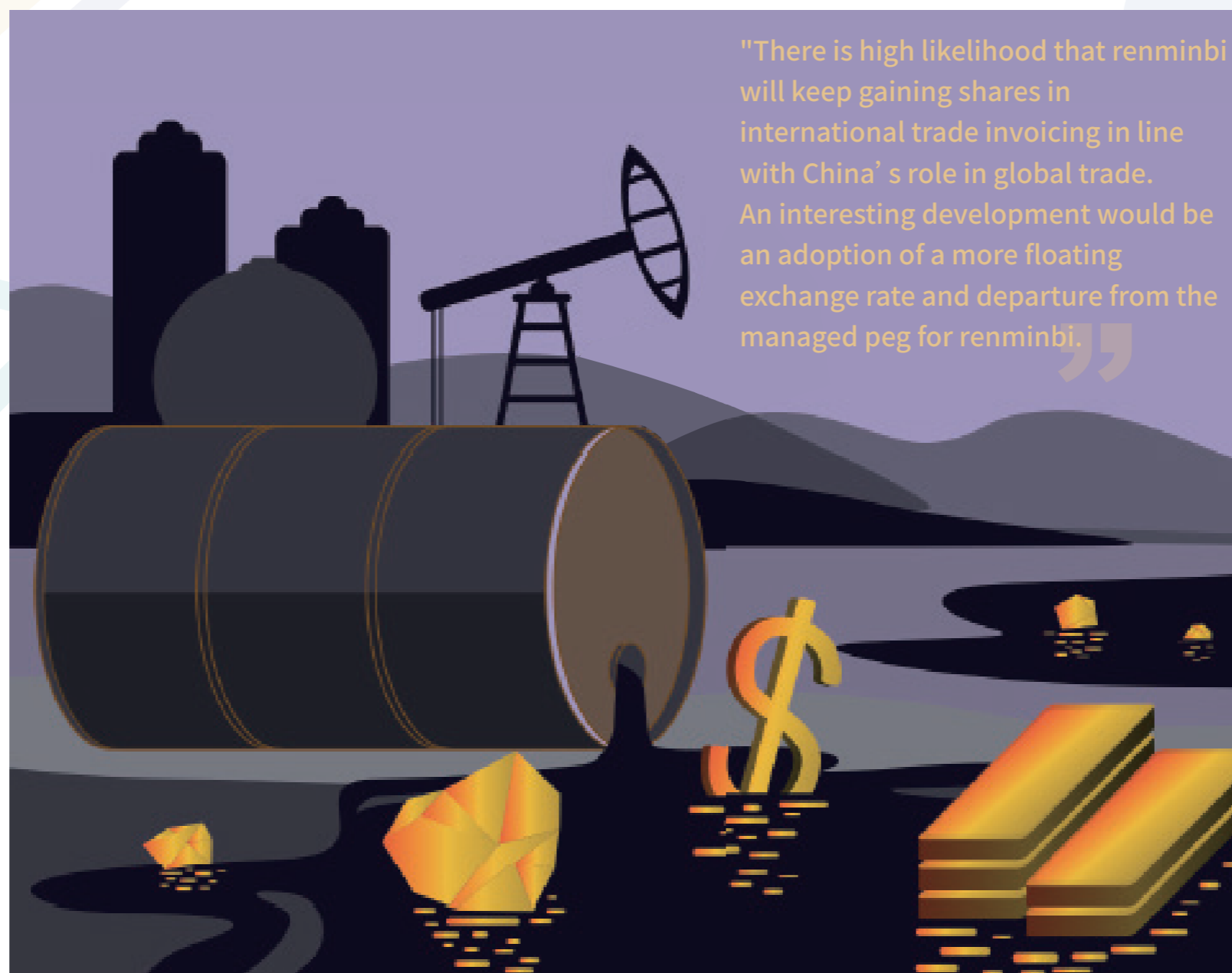
Sanctions must be a measure of last resort in response to gross violation of international norms, in particular annexation of foreign territories using military force. One can hope that a new international equilibrium would emerge where clear rules of cooperative international engagement are spelled out between liberal and authoritarian countries. Such a cooperative equilibrium is beneficial for all parties involved relative to an equilibrium of fragmentation and deglobalization, and thus I think it is not unlikely. In any case, exchange rate is unlikely to be the main variable affected by geopolitics, it is rather the overall levels of international trade and investment that depend on the choice between international cooperation and fragmentation.

Q: In your paper “Dominant Currency Paradigm: A Review,” you described the characteristics of world's currencies. We are curious whether the US dollar will suffer the same fate as the pound sterling? During the 1930s, although Britain's economy was no longer the stron-

gest, pound sterling remained the world's currency, and it was eventually replaced by the US dollar. In your opinion, is there any possibility that any currency will replace the US dollar in the future? Or will there be new weighted currencies, such as gold + SDRS?

Oleg Itskhoki: The role of the US dollar has been enhanced in the last 30 years by trade and financial globalization, and in particular by the emergence of China as a global pillar of production and international trade, as Chinese growth strategy was based on deeper integration into the world trade and financial

systems that rely on the use of the dollar. Going forward, it is possible that world trade would become more fragmented or even without fragmentation there would be multiple leading trade currencies. For example, the Euro has already emerged as a dominant regional currency for international trade. International financial markets, however, are more likely to persistently rely on the dollar, at least in the foreseeable future, as it requires depth of the all-around financial development that is currently lacking for any alternative currency.



"There is high likelihood that renminbi will keep gaining shares in international trade invoicing in line with China's role in global trade. An interesting development would be an adoption of a more floating exchange rate and departure from the managed peg for renminbi."

Q: In the current era, the order of economies, trade shares as well as geopolitics will change. How do you view the status of RMB?

Oleg Itskhoki: Renminbi will without doubt have an increasing role in world trade and finance, provided continued economic growth of the Chinese economy. There is high likelihood that renminbi will keep gaining shares in international trade invoicing in line with China's role in global trade. An interesting development would be an adoption of a more floating exchange rate and departure from the managed peg for renminbi. This would likely trigger adjustment in the pricing strategies of firms involved in international trade, leading some of them to switch to pricing in renminbi. It is harder to foresee the increased role of renminbi as international funding currency for multinational firms in the immediate future, yet renminbi will likely become increasingly important in sovereign debt markets for developing countries that receive financing from China.

Q: Many congratulations to you on winning the Clark Award. What do you think is most important about economics for the world? Can economics make a seemingly bad world better?

Oleg Itskhoki: This is true without a doubt. Economic exchange and cooperation is the main engine that brings people of the world together even when they hold conflicting political and social beliefs. Nobody has explained this better than Milton Friedman in this brief lecture: <https://www.youtube.com/watch?v=67tHtpac5ws&t=47s>. There is no stronger force in the world than economic cooperation that can so seamlessly unite vastly different populations across the world. This provides hope for global peace and prosperity in the 21st century.

* This article was initially published in PKU Financial Review.

Thomas J. Sargent: Sources of Artificial Intelligence

Abstract

This essay describes a partial eyewitness account of how artificial intelligence and machine learning were invented. I name names and ideas.

1. Introduction

This essay is about human and artificial intelligence and learning. I take artificial to mean ‘nonhuman’. Before describing artificial intelligence and machine learning, I’ll state my understanding of what natural or human intelligence is by describing salient classes of activities that a combination of innate and learned skills enable intelligent people to perform: recognizing patterns and making

choices. Other aspects of intelligence are awareness of time and space, and also sympathy and empathy with other people. Successive generations of parents pass on to their children tools and perspectives that their parents taught them, as well as new ideas that they have learned. After describing how Galileo and Darwin combined their innate talents with their text-book knowledge to create scientific breakthroughs, I’ll tell how modern researchers have designed computer programs that can recognize patterns and make choices.¹

While I hope that my description of the machine-learning “forest” is clear, I do mention many “trees,” i.e., a variety of concepts and technicalities that might be new to a general reader. For readers curious to learn more about a perplexing “tree,” I recommend checking a good online search engine or some of the items in the references at the end of this essay.



Professor Thomas J. Sargent

“While I hope that my description of the machine-learning “forest” is clear, I do mention many “trees,” i.e., a variety of concepts and technicalities that might be new to a general reader. For readers curious to learn more about a perplexing “tree,” I recommend checking a good online search engine or some of the items in the references at the end of this essay.”

2. Human Intelligence

I start with messages from chapter 13 of *The Blank Slate* by cognitive psychologist Steven Pinker. Chapter 13 of Pinker (2003) is titled “Out of Our Depths.” Read it if you are a high school student or college freshman or anyone else who wants to think about the purpose of education. Steven Pinker provides advice about what to study in high school and college and why, advice based on his understanding of our cognitive disabilities as human beings. He begins by describing

some things evolution has hard-wired us to do well and some other things that we have to learn to do.

Things that we aren’t hard-wired to do well weren’t important during most of our 100,000 years of human history and pre-history. But modern life has elevated the importance of some things we just aren’t hard-wired for. Pinker identifies four such subjects.



Physics

Theories of weight, time, space, motion, energy, heat, and light.



Biology

Theories of life, birth, and death.



Statistics

Methods for describing uncertainty and for recognizing and interpreting relative frequencies.



Economics

Descriptions of work, production, distribution, prices, and quantities.

Making wise private and public decisions in modern life requires understanding these four fields.

But these are subjects for which our “intuitions” often fail us. For working purposes, just define “intuition” as how we think about situations that evolution constructed us to understand quickly. Maybe “common sense” is a synonym for intuition, things that we think we understand instinctively. Steven Pinker describes how our hard-wired theories in these four fields can lead us astray unless they are improved by education.

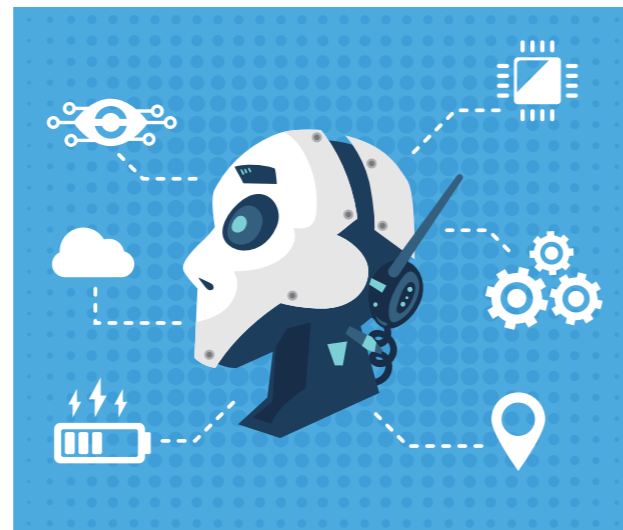
Pinker provides fascinating examples from all of these areas. Thus, our common sense and intuition don't help us understand modern physics. The general theory of relativity and quantum mechanics make no sense according to Richard Feynman and other distinguished physicists. Pinker tells how we evolved to make some statistical calculations that helped us when we were hunters and gatherers. These involved probabilities of events that occurred frequently relative to the incidence of important risks that we have to evaluate today. We are not naturally well-equipped to deal with probabilities of events that occur very infrequently. That has been costly in terms of public policy decisions that involve balancing costs and benefits from accepting low probability risks. Pinker describes how evolution gave our ancestors a set of economic theories about production and exchange that do not equip us to understand the division of labor, distribution, markets, middlemen, intermediaries, stabilizing speculation, and profits. Actually, we innately misunderstand these things, with too often tragic consequences that have occurred during recurrent expropriations and pogroms against middlemen and traders, speculators, and liquidity providers, people who were often members of ethnic minorities.

These cognitive deficiencies set the stage for Pinker's chapter 13 recommendations for redesigning curricula. Pinker describes education as a technology for compensating for our innate cognitive limits and for capitalizing on our innate abilities to learn. He calls for significant changes in academic curricula to align them better with what will help us enjoy life and make good decisions today: biology, statistics, and economics. He acknowledges that teaching more of these subjects means teaching less of others.

2.1 AI and our innate cognitive limits

Another lesson that we can learn from chapter 13 is how we want "artificial intelligence" to supplement and surpass our innate natural human intelligence.

A paradox lurks here because the principal technical tools that have been and are being used to create artificial intelligence and machine learning are drawn from physics, biology, statistics, and economics, the same areas in which we are innately limited. Thus, the very fields that we are not naturally equipped to be good at are being used to create artificial intelligence and machine learning. Early pioneers and practitioners of machine learning and AI compensated for their natural cognitive deficiencies by thoroughly learning and then imaginatively using the best analytical techniques available to them.



“A paradox lurks here because the principal technical tools that have been and are being used to create artificial intelligence and machine learning are drawn from physics, biology, statistics, and economics, the same areas in which we are innately limited. Thus, the very fields that we are not naturally equipped to be good at are being used to create artificial intelligence and machine learning.”

3. Two Pioneers of Machine learning

3.1 Galileo



Galileo Galilei

Italian physicist,
mathematician,
astronomer, and philosopher

Because he believed that the earth revolved around the sun, the great early 17th century Italian mathematician, scientist, physicist, astronomer Galileo Galilei (1564-1642) was eventually arrested by the Inquisition. Many years before he was arrested, Galileo did something that I regard as illustrating the essence of the “machine learning” approach. Galileo (1) designed and conducted experiments to collect data; (2) stared at his data and tried to spot patterns; (3) reduced the dimension of the data by fitting a function; and (4) interpreted that function as a general law of nature. Galileo's strategy offers a beautiful example, maybe the first, for what machine learning and artificial intelligence are all about.

I am of course writing about Galileo's “inclined plane” experiments and the data processing and data reduction that he performed on his data. Galileo wanted to discover the natural laws that govern the dynamics of falling bodies. Perhaps you are thinking:

“That's easy, just apply Newton's laws of gravity.” But not so fast: Newton wasn't born yet. The most widely accepted prevailing theory was the one that Aristotle had pronounced 2000 years before: heavier bodies fall faster than lighter ones.

Galileo wanted to study Aristotle's theory empirically. Why not just drop balls of different weights and measure how fast they fall? Galileo couldn't do that because balls of all weights fell much faster than existing clocks could accurately measure. Therefore, Galileo decided to construct smooth inclined planes of different angles, and to adjust the angle so that falling balls slowed down enough so that he could measure their rates of travel along the plane with the clocks he had. For a plane of length l and height h , the ratio $\frac{h}{l}$ determines the angle of the plane. Galileo dropped a ball and carefully measured the distance d along the plane that the ball traveled as a function of the time t elapsed after the ball had been dropped. He made a table with two columns in which he recorded t_i and d_i , $i = 1, \dots, n$ for his n measurement times for each experiment. For a given experiment, he then plotted d_i against t_i . He conducted experiments for a variety of balls of different weights with different settings of l and h (i.e., different angles for the inclined plane). He then stared at his graphs. He noticed a striking thing: for all of the graphs, the distance traveled was proportional to the square of the elapsed time, independently of weight of the ball and independently of the angle of the plane. He inferred a formula:

$$d = \tilde{g} \frac{h}{l} t^2$$

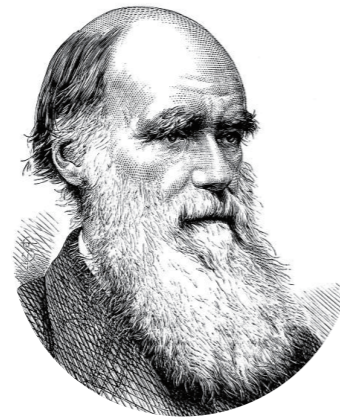
Notice that, remarkably, the weight of the ball is not in the function on the right side. So the rate at which

a ball falls is apparently independent of its weight. Thus, by fitting a function to data from his experiments, Galileo simultaneously accomplished data dimension reduction and generalization. He discovered a law of nature that was an important input into Isaac Newton's thinking 50 years later.

Galileo's inclined plane experiments have all of the elements of modern machine learning and artificial intelligence. He started out not knowing how the world works and not having a good theory. What he did was entirely atheoretical. So he conducted a set of experiments and collected tables of numbers, one table for each experiment, indexed by the weight of a ball as well as by the length l and height h of his inclined plane. From his tables of many numbers he deduced (i.e., "fit") a function that turns out to be determined by only one new number, the "parameter" g .²

I don't fully understand what inspired Galileo to design his experiments, collect those measurements, and reduce the dimensionality of his measurements by fitting a function. I do know the tools that Galileo possessed and the tools that could have helped him but that he didn't possess. In particular, he didn't know differential and integral calculus – only decades later would those tools be invented by Fermat, Newton, and Leibniz. But Galileo did know geometry and algebra very well. He was thoroughly conversant with Euclid and Archimedes. Without those tools, pure inspiration and his skepticism about Aristotle's theory would not have been enough.³

3.2 Charles Darwin



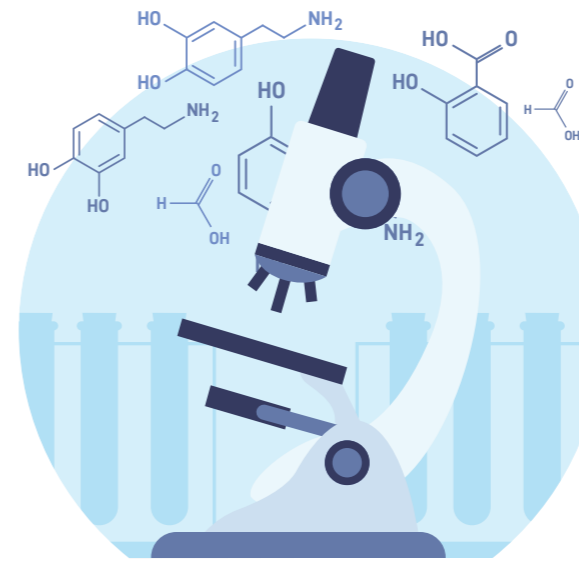
Charles Robert Darwin

British naturalist, biologist, founder of the theory of evolution

This next story is about the role that an economic theory played in helping Charles Darwin (1809-1882) complete his theory of "evolution of species by natural selection". The following 1899 statement by Simon N. Patton cited by Hayek (2011, Appendix B) summarizes my message: "... just as Adam Smith was the last of the moralists and the first of the economists, so Darwin was the last of the economists and the first of the biologists."

Darwin used raw empiricism and dimension reduction to construct his theory. He didn't know what a gene was. He didn't know what DNA was. What he did "know" was a huge data set, collected from his breeding pigeons, and observing animals and plants in nature. From his pigeon data alone he could deduce two of his three fundamental principles:

- 1 Natural variation.
- 2 Statistical inheritance of new variations.



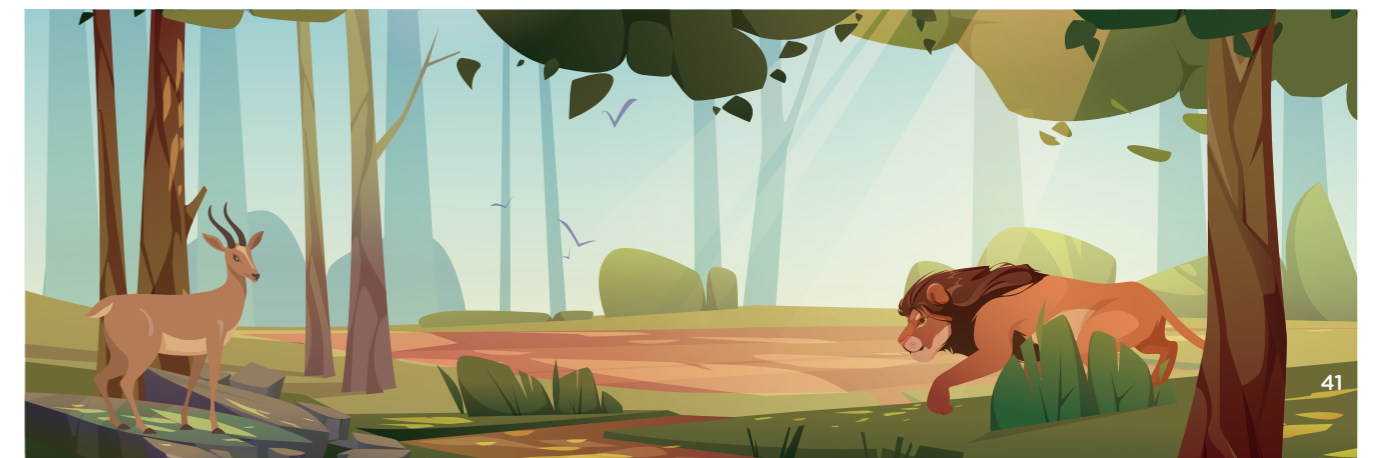
As a pigeon breeder, Darwin used these two principles to select desirable traits and then rely on statistical inheritance to produce new varieties of pigeons. Baby pigeons acquire some characteristics from their parents. "Selection by Charles Darwin," not natural selection guided his breeding of pigeons. For a long time Darwin lacked a source for selection in nature. Then he read a book by Thomas Malthus (2007) entitled *An Essay on the Principle of Population as It Affects the Future Improvement of Society*. Malthus wrote about a struggle that was set off by the propensity of people to reproduce at faster rates than food sources. This situation created a struggle for existence that aligned surviving populations with available food. This part of Malthus' s argument presented Darwin with the missing piece: natural selection that emerges from a struggle for existence. More babies were born than food sources could feed. The introduction to Darwin (1859) credited Malthus with the third pillar of his theory:

3 Selection via Competition – the struggle for existence.

Some distinguished game theorists and economists now routinely use evolution as a source of economic and social dynamics. Maybe some of them think that they got this idea from Darwin. But Darwin actually got an essential piece of his theory from economists. Thus, Hayek (2011, Appendix A) notes that Darwin's study of Adam Smith in 1838 provided him with a key component of his theory of biological evolution and natural selection. Hayek (2011) also documents that theories of cultural evolution were widely accepted by economists and sociologists long before 1800.

Darwin's research strategy stands as a wonderful example of reducing a huge data set to extract a low-dimensional model based on three principles that can be applied generally. Data collection, data reduction via three principles, and then generalization: what an extraordinary package!

Like Galileo, Darwin did not start from a blank slate. He was well read not just in biology and geology but also in economics. His deep understanding of existing work in these fields empowered him to step beyond what had been known and understood. He was a "macro" person in the sense that he had no "micro-foundations" for the first two pillars of his theory – variation and inheritance of some of new traits. He was vague about how much time would be required for his three pillars to produce the paleontological and biological evidence at hand.⁴



4. Artificial intelligence

So far we have been talking about human intelligence and inspiration. Let's now turn to artificial intelligence or machine learning. What is it?

By artificial intelligence I mean computer programs that are designed to perform some of the “intelligent” things that some humans do. Big parts of “machine learning” deploy calculus and statistics to accomplish pattern recognition. Designers of the computer chips and programs that do machine learning and AI copy Galileo's approach to measuring speeds of falling bodies with his inclined plane experiments. Thus, think of a function as a collection of “if-then” statements. Think of the “if” part being the abscissa x in a function and think of the “then” part as the y ordinate. Using a computer to recognize patterns involves (1) partitioning data into x and y parts, (2) guessing a functional form for f , and then (3) using statistics to infer f from data on x and y . The discipline called “statistics” provides tools for inferring or “fitting” the function f .

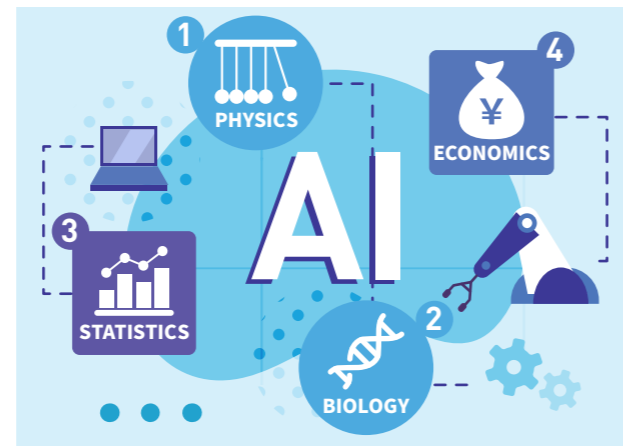
Here's a simple example. Suppose that at a given location on the earth, each day of the year you record the length of “daytime” from sunrise to sunset. Record the day of the year as an integer running from 1 to 365 on the x axis. Record time from sunrise to sunset on the y axis. Make a table with x and y as the two columns. This table has 365 times 2 equals 730 numbers. Now plot them and stare. Guess that a function $y = \cos(\alpha + \beta x)$ might summarize the data well. Use calculus to find values of the two parameters α, β that make the function fit well in the sense that they minimize:

$$\sum_{i=1}^{365} (y_i - \cos(\alpha + \beta i))^2$$

You'll find that this function fits well (though not perfectly). By summarizing the data (also known as performing “data compression” or “data reduction”) in this way, we have “generalized” by discovering a rule of thumb (a function) that we can use to predict lengths of days for days i a 365 outside of our sample.

5. Tools for AI

Machine learning and artificial intelligence import their essential methods from the following fields:⁵



Let's take these up one by one.

5.1 Physics

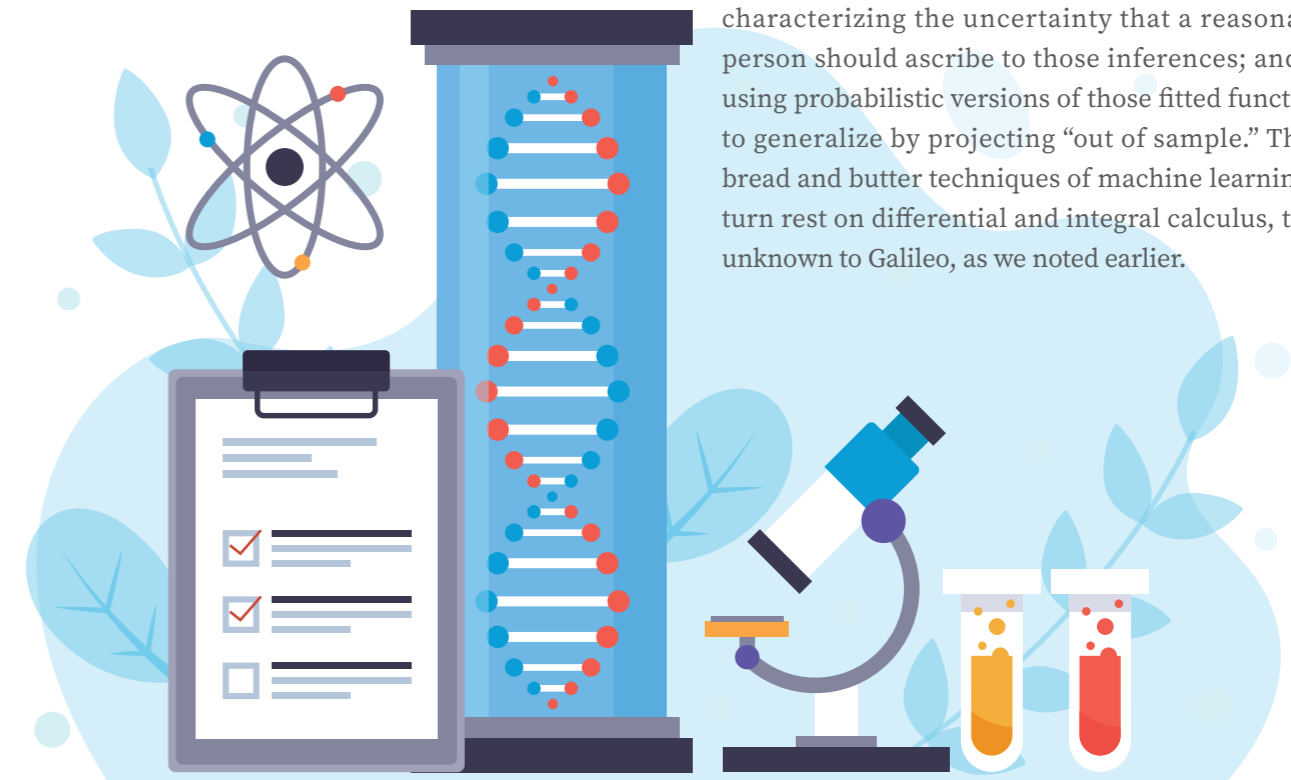
Eighteenth and nineteenth century work by Euler, Lagrange, and Hamilton extended and perfected ways to use calculus to optimize integrals of functions of quantities over time. That set in place essential building blocks for a twenty-first century Hamiltonian Monte Carlo simulation technique that is now powering sophisticated Bayesian estimation and machine learning techniques. Nineteenth century work by Clausius, Boltzmann, and Gibbs created concepts for describing thermodynamics statistically. They defined a second law of thermodynamics in terms of entropy, an expected value of a likelihood ratio, i.e., the ratio of one probability distribution to another. One of those probability distributions was a flat uniform distribution that statistically represented complete disorder, the other a distribution that represented “order” in a precise statistical way. In the late twentieth century and early twenty first, entropy provided a way for many machine learning algorithms to

measure discrepancies between a fitted model's probability distribution and an empirical distribution traced out by data. In ways that would pave the way to producing further tools for artificial intelligence and machine learning, Paul Samuelson (1947) and his colleagues imported these and other techniques from mathematical physics into economics.

5.2 Mathematical Biology

Biology is about patterns of reproduction and variation of species across time and space. Patterns can be detected at “macro” and “micro” levels, depending on the unit of analysis – either an individual person or animal, or smaller units like DNA, RNA, or the molecules composing them. Mathematical theories of biology (e.g., Feldman (2014) and Felsenstein (1989)) formalize these things by constructing dynamic systems in the form of stochastic difference or differential equations. At the micro-level, key ideas involve encoding DNA as a binary string upon which an analyst can perform mathematical operations of mutation and sexual reproduction via cutting and recombining.

For example, see Holland (1987).



5.3 Statistics

Modern mathematical statistics deploys two possible meanings of “probability”:⁶



A frequentist interpretation that a probability is a relative frequency to be anticipated after observing a very long sample of independently and identically distributed random variables.



A Bayesian interpretation that a probability is a subjective expression of uncertainty about an unknown hidden “state” or “parameter.”

Modern statistics deploys an arsenal of tools for (1) specifying sets of functions that are characterized by vectors of parameters, or sometimes by a hierarchy of vectors of parameters; (2) inferring or “estimating” those parameters from observations; (3) characterizing the uncertainty that a reasonable person should ascribe to those inferences; and (4) using probabilistic versions of those fitted functions to generalize by projecting “out of sample.” These bread and butter techniques of machine learning in turn rest on differential and integral calculus, tools unknown to Galileo, as we noted earlier.







5.4 Economics

Economics is about how collections of individuals choose purposefully to utilize and to allocate sets of scarce resources. Modern economic theory is multi-person decision theory within coherent environments. The abstract artificial people inside a coherent economic model are “rational” in the sense that all of them solve constrained optimization problems that take into the account their common correct understandings of their environment.⁷ Two leading classes of such multi-person decision theories are⁸:

• Game theory

• General equilibrium theory

Components and forces in these theories include

-  Constraints
-  Uncertainties
-  Prices
-  Ledgers for exchange networks
-  Competition
-  Decentralizations and parallel optimizations

In these models, one agent’s decision rules form part of the constraint set of other agents’ choice problems. Such constraints arise via a model’s “equilibrium conditions.” A solution of an agent’s constrained optimization problem produces a personal value that contains useful information for allocating resources.

These economic models describe “parallel processing” and decentralized decision making. An arrangement called an equilibrium serves to reconcile diverse selfish decisions with each other and with limits on physical resources. Within both of these dominant frameworks, precise notions of an equilibrium prevail. Defining an equilibrium is one

thing. Computing one is another. Thus, prominent economic theorists for years have wrestled with curses of dimensionality as they sought fail-safe methods to compute a competitive equilibrium allocation and price system. Landmark contributions to that enterprise were Arrow and Hurwicz (1958), Arrow et al. (1959), Arrow (1971), and Nikaido and Uzawa (1960) as well as Scarf (1967), and Scarf et al. (2008). These algorithms deploy accounting schemes that keep track of individual and social values and gaps between quantities of goods and activities that people want and quantities that the social arrangement provides.

Work on computing an equilibrium eventually discovered an intimate connection between computing an equilibrium and convergence to an equilibrium by a collection of boundedly rational agents. Bray and Kreps (1987) and Marcet and Sargent (1989) present important distinctions between “learning within an equilibrium” and “learning about an equilibrium”. Marcet and Sargent (1989) and Sargent et al. (1993) study convergence to a rational expectations equilibrium by using the mathematics of stochastic approximation (e.g., see Gladyshev (1965)). So far as I know, initial work on stochastic approximation began with the quest of Hotelling (1941) and Friedman and Savage (1947) to construct a statistical sampling method to find the maximum of an unknown function that could nevertheless be accurately evaluated at a given abscissa.⁹

Related work by Shubik (2004) and Bak et al. (1999) formulated games that could be used to think about equilibrating processes facilitated by the presence of price setters (Inside a general equilibrium model, there are only price-takers, no price-setters.) Shubik’s work exploited his expertise about a topic with important lessons for machine learning and AI, a topic that lives in the interstices between the general equilibrium theory and game theory:



In the spirit of Shubik (2004), a good way to think about monetary theory is to notice that its aim is to provide a theory about how an equilibrium price vector could be set by the agents who actually live inside a general equilibrium model. The classic general equilibrium model of Arrow and Debreu tells properties of an equilibrium price vector, but is silent about who sets that price vector and how.

Instead, deus ex machina outside the model mysteriously announces a price vector that simultaneously clears all markets. An equilibrium price vector assures that every agent’s budget constraint is satisfied. In a general equilibrium model, trade is multi-lateral and budget constraints are reconciled in a single centralized account. Monetary theory is instead about a decentralized system populated by people who meet only occasionally in a sequence of bilateral meetings and exchange goods and services by using “media of exchange.” Media of exchange can be durable metals (gold or silver), tokens (pennies or paper “dollars” or “pounds”), circulating evidences of indebtedness, or entries in a ledger of a bank or clearing house or central bank. Ostroy and Starr (1974), Ostroy and Starr (1990), and most recently Townsend (2020) describe work in this tradition that leads directly to a theory for crypto currencies.

I offer a few more words about how studying games has contributed to machine learning. For decades, applied economists have constructed algorithms to compute an equilibrium of a game. Key tools that underlie these calculations include backward induction (dynamic programming) and tree search. Because the dimension of possible states to be investigated grows exponentially, reducing the number of situations to be investigated is essential to making headway on approximating equilibria. Here the minimax algorithm and the alpha-beta pruning tree search algorithm are mainstays.

See Knuth and Moore (1975) and <https://www.youtube.com/watch?v=STjW3eH0Cik> for descriptions of alpha-beta tree search and watch for an accounting system and a “survival of the fittest” idea. A related line of research studied whether a collection of players who naively optimize against histograms of their opponents past actions converges to a Nash equilibrium. For examples, see Monderer and Shapley (1996), Hofbauer and Sandholm (2002), Foster and Young (1998), and Fudenberg et al. (1998). When convergence prevails, such “fictitious play” algorithms provide a way to compute an equilibrium (see Lambert Iii et al. (2005)).



5.5 John Holland's circa 1985 Vision for AI



John Henry Holland

American scientist,
pioneer of complexity theory and nonlinear science,
father of genetic algorithm

The renowned computer scientist John Holland¹⁰ was a pioneer. He combined ideas from all of the technical fields we have mentioned to construct computer models of decision makers living in environments in which they have no choice but to “learn by doing” in the sense of Arrow (1971). See Holland (1987, 1992) for descriptions of Holland’s approach and Marimon et al. (1990) for an application to a multi-person economic environment. A substantial piece of Holland’s approach was a global search algorithm that he called a “genetic algorithm”. It searched “rugged landscapes” by representing arguments of functions by strings that could be randomly matched into pairs of strings, cut, and recombined. This was Holland’s mechanical way of representing “sexual reproduction.” Such a “genetic algorithm” comprised part of what he called a “classifier” system. Holland’s classifier system consists of (1) a sequence of if-then statements, some of which must compete with each other for the right to decide on-line (i.e., in real time); (2) a way to encode if-then statements as binary strings that can be subjected to random muta-

tion, cutting, and recombining; (3) an accounting system that assigns rewards and costs to individual if-then statements; (4) procedures for destroying and creating new if-then statements that include random mutations and sexual reproduction based on DNA cutting and recombining; and (5) a competitive struggle that promotes survival of fit decision rules. Systems of Holland classifiers have been shown to learn how to be patient in dynamic settings, a subtle outcome summarized by Ramon Marimon’s phrase “patience requires experience” in a world of Holland’s artificially intelligent agents. Holland classifiers succeeded in computing a “stable” Nash equilibrium for a dynamic economic model that the model’s authors had not recognized a priori, although they could verify the “guess” that the Holland classifier handed to them. See Marimon et al. (1990).

5.6 AI today

In a remarkable achievement, DeepMind’s computer program called AlphaGo succeeded in mastering the game of Go so well that it defeated champion human players of Go. See Wang et al. (2016). The approach that the creators of AlphaGo deployed reminds me of cooking delicious food – add a touch of this to a handful of that, taste, and add something else Among the ingredients combined to cook up AlphaGo were ideas gathered from dynamic programming; Thompson sampling (see Thompson (1933)) and stochastic approximation (see Hotelling (1941) and Friedman and Savage (1947)); alpha-beta tree search (see Knuth and Moore (1975)); Q-learning (see Watkins and Dayan (1992)); and Monte Carlo tree search (see Browne et al. (2012)). A rule of thumb

choice for tuning a parameter that trades off “exploration” for “exploitation” is important (as it also is in Fudenberg and Kreps (1993) and Fudenberg and Kreps (1995)).

Other recent advances in machine learning also import heavily from economics and statistics.

Thus, computational optimal transport (e.g., Peyr’e et al. (2019)) uses a linear program of Dantzig, Kantorovich, and Koopmans to measure discrepancies between a theoretical probability and an empirical measure. It then uses that measure to construct a computationally efficient way to match data to a theory. An economist Hotelling (1930) used Riemannian geometry to represent parameterized families of statistical models. That idea inaugurated computational information geometry, an approach systematized by Amari (2016).



6. Sources of Creativity: Imitation and Innovation

I described how Galileo and Darwin discovered new laws of nature by somehow combining mastery of findings and methods of their predecessors with unprecedented flashes of insight. Respect for precedent, and their ability to venture beyond, characterized the work of both geniuses. Many subsequent geniuses used the same general approach. A source of other examples is electricity and magnetism and the sequence of discoveries by Franklin, Davy, Faraday, Maxwell, Michaelson and Morley, and then Einstein. Each of them began not from a Blank Slate (not coincidentally the title of Pinker (2003)) but from their deep understanding and respect for their predecessors. Each saw something that their predecessors hadn't, often because they deployed improved ways of observing or reasoning. Thus, by unleashing mathematics that Faraday did not know, Maxwell organized a breathtaking unification, generalization, and reduction of the laws governing electro-magnetic dynamics into twelve equations that Heaviside would soon reduce to four equations. Those four equations set the stage for Einstein's special theory of relativity.¹¹

Seemingly unrelated, purely theoretical work in mathematics preceded and then coincided with those discoveries about electro-magnetism. Descartes invented a coordinate system that enabled him to convert geometry into algebra and to write down functions. Fifty years later Newton and Leibniz used Cartesian coordinates to invent differential and integral calculus. In the first half of the nineteenth century, Gauss and his student Riemann refined geometries for curved spaces and parallel lines that meet. Ricci added a sharp notion of curvature.

Einstein brought together these two independently motivated and seemingly "unrelated" lines of work, the first about practical physical phenomena, the second about some purely abstract mathematics. Struggling to extend his special theory

of relativity, Einstein learned how to use Riemannian geometry and Ricci curvature in order to construct a coherent general theory of relativity.¹²

Scientific advances illustrate an interaction between "imitation" and "innovation" that is featured in modern theories of economic growth (for example, see Benhabib et al. (2014) and Benhabib et al. (2020)). For those pioneers in electro-magnetism, relativity, and mathematics, the "imitation" phase was copying the techniques of their predecessors and teachers; the "innovation" phase was somehow stepping beyond because they had learned and understood more than their teachers.

7. Concluding Remark

My survey of ideas from physics, biology, statistics, and economics confirms my claim that the subjects in which Pinker (2003) tells us we are all innately cognitively challenged are the ones that are being deployed to create artificial intelligence and machine learning. This is just one more reason to study these subjects in school and after school too. I think that their intrinsic beauty is another.

June 3, 2022

Notes:

[1] Hayek (2011, Appendix A) discusses other possible interpretations of natural and artificial.

[2] Fast forward to today and watch how scientists use machine learning and AI. You'll see smart people collecting masses of data and fitting functions. For some wonderful examples, please see de Silva et al. (2020) and Brunton and Kutz (2022).

[3] To find his three laws of planetary motion that were buried in Tycho Brahe's (1546-1601) tables of time-stamped measurements of the positions of the known planets, Johannes Kepler (1571-1630) used a method similar to Galileo's. Li et al. (2021) follow in Kepler's footsteps by using machine learning techniques to extract one of Kepler's laws from Brahe's data. See Weinberg (2015) for spell-binding accounts of the scientific methods of Kepler and Galileo. masses of data and fitting functions. For some wonderful examples, please see de Silva et al. (2020) and Brunton and Kutz (2022).

[4] Darwin's work was not immediately accepted by leading scientists. For example, on the basis of the then prevailing estimates of the age of the earth, Lord Kelvin would soon say that the earth was simply much too young for Darwin's theory to work.

[5] Thus, it was not a coincidence that an important inventor of modern computing and AI, John von Neumann, studied and substantially contributed to all four of these fields. See Bhat-tacharya (2022) for a wonderful account of von Neumann's work and life.

[6] This site explores these two possible senses of probability with the assistance of some Python code: https://python.quantecon.org/prob_meaning.html.

[7] When economists speak of "rational expectations" they are referring to an assumed "common correct understanding of an environment". The phrase "rational expectations" modifies "model", not "people".

[8] See Kreps (1997) for an account of common features and shortcomings of these two classes of models, as well as some thoughtful opinions and conjectures about new directions that seem to me to have forecasted subsequent incursions of AI into economics.

[9] The work of Hotelling and Friedman and Savage ultimately led to the "Bayesian optimization" machine learning technique. For example, see Snoek et al. (2012).

[10] Please see https://en.wikipedia.org/wiki/John_Henry_Holland, <https://www.nytimes.com/2015/08/20/science/john-henry-holland-computerized-evolution-dies-at-86.html>.

[11] A photo of Maxwell hung on Einstein's office wall.

[12] See Farmelo (2019, ch. 3) for an account of these events.





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