

ASIAN MANAGEMENT INSIGHTS



Hello, JARVIS

AI-enabled interactive
agents will reshape
our workforce

Developing Singapore as a Smart Nation

An interview with
Mrs Josephine Teo,
Singapore's Minister for
Communications and Information,
and Minister-in-charge of Smart
Nation and Cybersecurity

Superminds at Work

The future of
human-AI
collaboration

Navigating Sustainable Futures

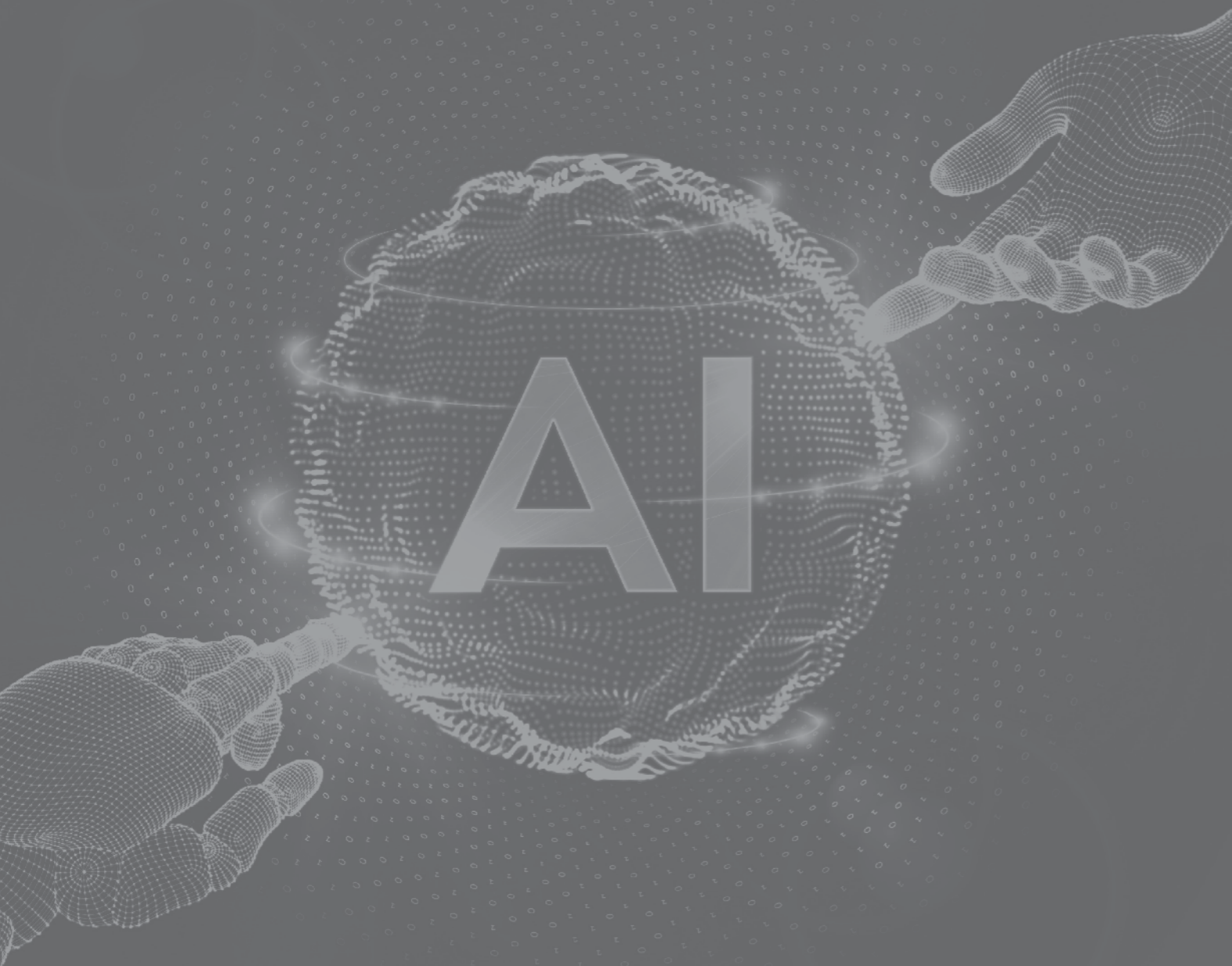
A leadership
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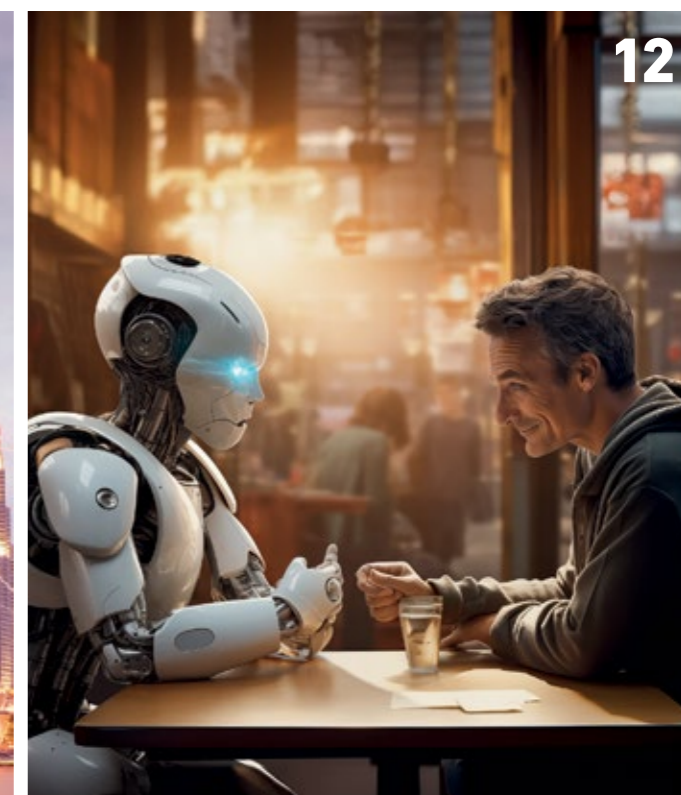
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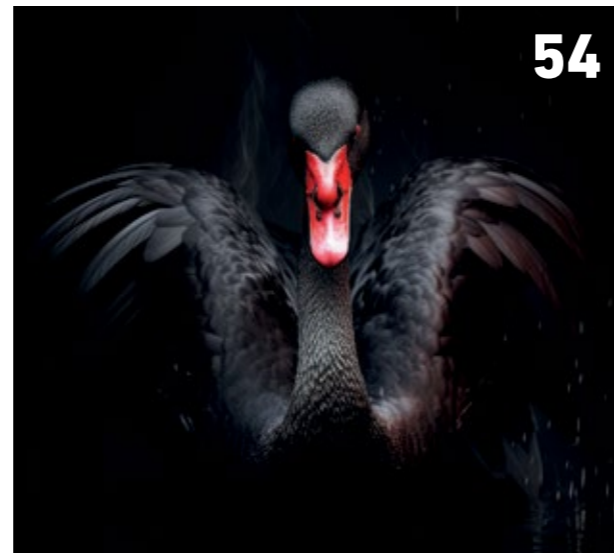
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FROM THE EDITOR

AI may be the future of work, but *caveat emptor*

Artificial Intelligence (AI) could well become the phrase *du jour* for 2024. For one, ChatGPT, the Generative AI (GenAI) software created by OpenAI, has become arguably the best-known AI-driven app. Microsoft founder Bill Gates observes that ChatGPT “will change our world”, while Google co-founder Larry Page describes AI as “the ultimate version of Google” that “would understand exactly what you wanted, and it would give you the right thing”.

Such profound change provokes inevitable concerns of AI replacing humans at the workplace, or even humanity itself, with the late Stephen Hawking once expressing concerns that AI “could be the worst event in the history of our civilisation”. Nonetheless, AI-enabled technologies such as the Internet of Things (IoT) and digital home assistants are increasingly embedded into our daily lives, generating ever more data and competing for broadband bandwidth with the ubiquitous mobile phone.

With all that in mind, Singapore will invest up to S\$100 million to improve the nation’s broadband infrastructure over the next two years. Mrs Josephine Teo, Singapore’s Minister for Communications and Information, and Minister-in-charge of Smart Nation and Cybersecurity, tells us how the country’s 10-year-old Smart Nation initiative aims to put the island at the forefront of the AI wave while guarding against security risks and negative social impact. While being open to global talent is key to developing cutting-edge technical capabilities, governments must create a safe online environment to build the trust necessary for a technology-enabled society, she adds.

That positive combination of human intellect and technology is the essence of what Thomas W. Malone calls ‘Collective Intelligence’. In the debut of Asian Management Insight’s Pulse Point section, Malone articulates how Collective Intelligence can help build ‘Superminds’, which are “groups of individuals acting together in ways that seem intelligent”. Despite all the hype about technology, human values must and will remain central to mankind, he says.

Fans of the Marvel Cinematic Universe might imagine a Supermind to be something like the character JARVIS (Just A Rather Very Intelligent System). Archan Misra examines recent advances in ‘cognitive augmentation’, ranging from software that understands human gestures to holographic devices that relay real-time information. Misra believes successful AI-human co-working could become a reality in less than 10 years, especially with an intuitive human-machine interface. Like JARVIS.

Even before all that happens, AI has already seen plenty of action in the real world. Shoeb Kagda comments on how the rise of GenAI models is revolutionising traditional sectors such as agriculture, healthcare, and education in developing nations across Asia. He gives an example of how Indonesia plans to use AI and drones to monitor rice fields and increase rice production. All that depends on building the requisite data and digital infrastructure, which is a pressing need not just in the country but the region at large.

Still on the topic of AI, Lau Hoong Chuin and his collaborators developed a data-driven AI supply chain optimisation model that helped predict COVID-19 lockdowns and realise millions of dollars in savings, while Steven M. Miller, David Gomulya, and Mahima Rao-Kachroo chart out Singapore-based start-up EyRIS’ journey to

commercialise SELENA+, an AI algorithm for eye disease detection. Whereas the former showcases a triumph of software design and data usage, the latter details the lessons learnt in overcoming commercial obstacles and navigating regulatory frameworks.

Continuing on the topic of healthcare, Lim Tow Keang believes business executives can make better decisions by taking reference from how clinicians arrive at a diagnosis and treatment plan. Doctors and business executives can both benefit from generating hypotheses to account for observed phenomena and adjusting their course of action depending on any given situation. The best solutions though integrate scientific evidence with personal experiences.

Many situations allow for the methodical integration of experience and data into what are effectively heuristics or simple rules learnt repeatedly. Jochen Reb, Shenghua Luan, and Gerd Gigerenzer point to the value of simple rules matching the requirements of any given situation. Smart heuristics, they claim, can be useful for decision-makers operating under time pressure or in times of crisis.

Addressing the climate change and global warming crisis is what last November’s United Nations Climate Change Conference in Dubai, otherwise known as COP28, was all about. Franziska Zimmermann shares her thoughts on the crucial role of decisive leadership in transitioning away from fossil fuels and keeping global temperatures in check. While increased accountability provides hope of success to that end, she points to engaging the youth of today as one avenue of sustaining an environmentally-conscious business landscape for the future.

Technology is not the only mechanism for transformation. Neeta Lachmandas-Sakellariou argues that a service mindset that enhances the customer experience can make all the difference. By viewing service delivery as a profit-making tool, organisations adopting the customer’s perspective can enhance their relationship with their customers by delivering a superior level of service. At the core of it all: Leaders must set the tone and cultivate the company culture to support this.

We round out this issue with AI once again, but of a less glamorous nature: chatbots. Tamas Makany and Felicia Goh dive through how Singapore SMEs (small and medium enterprises) use chatbots and the way customers perceive them. They conclude that chatbots are business tools, not entertainment sources, and successful chatbot implementation is all about balancing AI and the human touch.

Talking to an advanced form of AI like you would to a human being, and it delivers exactly what you need? Sounds like JARVIS.

On a celebratory note, as we mark a decade in publication, we extend our heartfelt gratitude to our readers for their unwavering support. Here’s to the next 10 years of delivering enriching content, and continuing to inspire and engage our audience!



DR HAVOVI JOSHI
Editor-in-Chief
Asian Management Insights
havovijoshi@smu.edu.sg

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Developing Singapore as a Smart Nation



Creating trust in digital services is key to building a tech-enabled society. Mrs Josephine Teo, Singapore's Minister for Communications and Information, and Minister-in-charge of Smart Nation and Cybersecurity, speaks about leading the country's Smart Nation drive.

Come November 2024, Singapore's Smart Nation initiative will celebrate its 10th anniversary. Could you reflect on its key achievements and challenges in managing an ever-growing demand for seamless and effective digital government services?

I am not a science-fiction fan but what Arthur C. Clarke, the author of *2001: A Space Odyssey*, said strikes me as profound: "Any sufficiently advanced technology is indistinguishable from magic."

In many ways, this has to be our ambition for the Smart Nation strategy. It means using technology so well that you are delighted by the experience, without even knowing what technology is used, and how.

That is how we feel when we land at Changi International Airport. We clear immigration and get our bags quickly. In no time at all, we are hugging our family or friends at the arrival hall. We do not know what technologies they used to get these things done, and frankly we do not *want* to know as long as they work.

More often than not, technology also frustrates us. Your favourite *char kway teow*¹ is ready but the bank app on your smartphone is not working so you cannot pay for it. Or the company's information technology (IT) system is so backward it makes you tear your hair out.

Nowadays, technology can frighten us too, such as not knowing if we have accidentally downloaded some malicious app that will cause us to lose our life savings. Or we are troubled by the nastiness and lies we see online.

So the Smart Nation effort, apart from trying to promote all the wonderful technological innovations, must also deal with the not-so-great things.

When I am asked by fellow policy-makers outside Singapore, I tell them we have four pillars in our Smart Nation initiative—a vibrant digital economy, a stable digital society, a progressive digital government, and comprehensive digital security. They love that we are so clear, but I always tell

them, "Look, we're still only at the starting line. There is a ton of stuff we want to do and no ready playbook. So, let's learn as quickly as we can, together."

With Singapore releasing its latest National AI Strategy (NAIS) 2.0 at the end of 2023, how would it help close or improve some of the gaps that you have identified prior?

We released NAIS 2.0 as one of the key planks of the Smart Nation effort. It lays out our thinking to unlock even more opportunities from Artificial Intelligence (AI) for our people and businesses, and better manage the risks and disruptive effects of the technology amid recent advances, especially in Generative AI (GenAI), which is a subset of AI that can create novel and realistic content, such as images, text, and audio. Under NAIS 2.0, we continue to make holistic investments in our people and the computing infrastructure supporting AI innovation.

For people, we adopt a segmented approach to talent attraction and development, welcoming top-tier talent (Creators) and their teams to work with and from Singapore, and tripling the number of scientists and engineers (Practitioners) in Singapore working on data and machine learning to 15,000. Creators are engaged in novel and cutting-edge AI activities and can have an outsized impact in fostering a culture of experimentation and excellence in AI, while practitioners are the backbone of AI deployment at scale. For computing infrastructure, we are committed to working with industry partners to ensure that we have sufficient high-performance computers available in Singapore, to meet our growing research and industry demands, and support high-value AI activities.

One of the things we learnt over the course of implementing the first iteration of our Smart Nation strategy in 2019 was to take a systems approach. This means we need to bring partners and individuals from industry, research,

and civil society together to contribute to our resources, capabilities, and infrastructure for AI development and deployment. We have also updated our approach to being a super-catalyst. This means promoting meaningful AI activities in industry, government, and research.

In industry, we want to not only grow Singapore's overall bench strength of leading AI industry developers and deployers, but also drive sophisticated AI value creation and usage in key sectors. We will therefore attract and anchor new AI Centres of Excellence (CoEs) in Singapore-based companies, and explore establishing industry-wide AI innovation platforms in key areas like advanced manufacturing, as well as financial and biomedical services, where Singapore is operating at the leading edge.

In government, we want AI to meaningfully power even more public services, and will double down on driving public sector adoption of AI in our 'Smart Nation Priorities': Healthcare, Education & Manpower, Trust & Safety, and Public Service Delivery. In research, we will sharpen our focus to support the widespread, trusted deployment of AI across society, by investing in Responsible AI, Resource-Efficient AI, and Reasoning AI.

We will also increase the support for our workforce and enterprises under NAIS 2.0. Our citizens and enterprises must have access to the latest tools, and the confidence that they can succeed in an increasingly AI-enabled world in which AI will benefit not just a few players, but all segments of society.

We recognise the uneven impact of AI on the nature of work across different industries, and will invest significantly in adult education and training, including sector-specific AI training programmes, to reskill and upskill our workers. We will also address the low AI adoption rate among our enterprises (currently at four percent) through more public-private partnerships and innovation acceleration programmes that lower the barriers to AI experimentation.

Take, for example, our AI Trailblazers initiative with Google Cloud, which linked up its AI toolsets and best-in-class support services with over 80 businesses and government agencies across Singapore. Not only did we manage to spark more experimentation, generating novel use cases within 100 days, but we also gave many business owners the confidence to invest further resources once they saw the business value of AI. One such business owner is Doctor Anywhere, a telemedicine service that developed a GenAI tool that helps recommend specialists based on a patient's preferences and books the appointment once the patient selects a specialist. This tool can be accessed 24/7, whenever

the patient needs it, and has already resulted in improved operational efficiency by 30 percent. Considering the overall value and impact of AI Trailblazers, we estimated that we have accumulated more than S\$10 million annually in terms of time savings and efficiency gains.

Notwithstanding such opportunities, we remain mindful of AI's risks and the many ways that AI can be misused, from deepfakes, to scams, cyber-attacks, and the spread of misinformation. There are also moral and ethical issues around delegating certain instances of decision-making to machines. We will continue to find a pragmatic balance between innovation and safeguards, while considering the interests of users and technology providers.

There is no silver bullet to overcoming the disruptions AI poses. We will encounter more obstacles and 'gaps' when maximising the opportunities generated by AI while managing the evolving problems they pose. We will have to work through these issues with our partners from industry, research, civil society, and other governments.

What has Singapore done and what more does it plan to do to protect the nation and its citizens from the excesses and shortcomings of AI and other emerging technologies?

As we set out to unlock the transformative potential of AI, we are also mindful of the risks and challenges that AI may pose, such as ethical dilemmas, social implications, and security threats. We have taken a pragmatic approach to AI governance and ethics, which is to put up guardrails against systemic risks, while allowing innovation to thrive.

Singapore has been a pioneer and leader in this area, both regionally and globally. We were the first in Asia to develop and launch a Model AI Governance Framework in 2019, which provides practical guidance for organisations to implement ethical and accountable AI practices. The framework is based on two core principles: decisions made by AI should be explainable, transparent, and fair; and AI systems should be human-centric. Since then, we have updated and enhanced the framework, considering the feedback and experiences from various stakeholders, including industry players, academia, and civil society.

Building on this framework, we are currently developing a new framework for GenAI. It has significant transformative potential but comes with new and unique risks, such as the creation of deepfakes and synthetic media, which can undermine trust and cause harm. This new framework covers nine dimensions, such as content provision, security, and

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accountability, to support a comprehensive and trusted AI ecosystem. Right now, we are seeking international feedback on the framework, and it is expected to be finalised by mid-2024.

Speaking of deepfakes, the use of it for malicious means is a concern for all societies. We must examine how legislation can be put in place to regulate it, but in exactly what shape or form it will take, we will have to see. In the meantime, we are already working with industry partners to strengthen our capabilities to deal with such threats. For example, the Centre for Advanced Technologies in Online Safety (CATOS), which will be launched in the first half of this year, aims to enhance industry collaboration and knowledge exchanges in deepfake detection.

To complement our efforts to build a safe and inclusive digital society, we have introduced public education programmes on digital media and information literacy. For example, the National Library Board's (NLB) signature S.U.R.E. (Source. Understand. Research. Evaluate.) programme, launched in 2013, offers a wide variety of resources and programmes, including free courses, talks, tours, and workshops, that support everyone of all ages to learn information literacy skills. The resources in Singapore's official languages—English, Chinese, Malay, and Tamil—cover topics ranging from fighting online scams, to GenAI tools, Information Literacy, Digital Safety and Digital Wellness, and the dangers of misinformation.

Amid today's contested and fragmented international AI landscape, and the difficulty for a small country like Singapore to solve complex challenges of AI on our own, we must plug ourselves even more deeply into global networks, deepening research and technical collaborations to support innovation across borders. We do this through partnerships with the UK's new AI Safety Institute, and supporting multilateral, multi-stakeholder platforms such as ASEAN (the Association of Southeast Asian Nations), the Forum of Small States, the United Nations, and the World Economic Forum. No one should be left out of the global conversation on AI.

Beyond AI, what other aspects of the Smart Nation initiative can we expect to be further enhanced or improved upon in moving Singapore towards becoming a more technology-enabled society?

A big focus for us is trust and safety. Today, 85 percent of Singaporeans say that overall, technology has benefitted them. Their confidence in going online safely determines whether they choose to participate in or withdraw from the opportunities that technology and digital innovations can bring. So we are sharpening how we govern and manage the digital domain to facilitate safe, secure, and enriched digital participation.

In recent times, people have become much warier due to issues such as scams. We have observed how scammers are increasingly exploiting online platforms and new technologies, including the use of malware, to carry out their crimes.

Strengthening our partnership with various major digital platforms is one key way we are combatting this. For instance, to contain the impact of scams, we are exploring the possibility of co-locating staff from online platforms at the Anti-Scam Command (ASCom). This will help to enhance coordination amongst key parties to respond to scams more quickly. Today, bank staff are already co-located with the police at ASCom to facilitate the swift freezing of scam-tainted accounts, and tracing of scammed monies.

In January 2024, we operationalised the Online Criminal Harms Act (OCHA). This legislation enables us to take a more proactive approach to countering scams occurring on online platforms. For a start, OCHA will allow the Government to issue directions to online platforms to prevent Singapore users from coming into contact with scam accounts and content. With OCHA, directions can be issued proactively once scam activities are detected, without having to wait for victims to first fall prey.

To sustain our containment efforts, we must also work to prevent scams from occurring in the first place. Hence, as part of OCHA, we will also be introducing a framework later this year to further strengthen our partnership with online platforms to counter scams. Under this framework, the

Government can issue Code(s) of Practice requiring designated providers of online services to put in place systems, processes, and measures to proactively disrupt scams affecting people in Singapore. These include user verification measures to tackle e-commerce scams.

Beyond OCHA, we are also working closely with the banks, particularly to prevent scammers from gaining unauthorised access to victims' accounts. This includes ensuring that the banks' malware detection software remains effective against new malware strains, and that users are increasingly provided with more secure authentication methods.

That said, a vigilant public remains a key form of defence, as scammers will continually evolve their modus operandi. We will continue to educate the public and provide tools for individuals to protect themselves from scams.

The resilience and security of digital infrastructure and services is another important aspect that we are strongly focusing on. With more of Singapore's economic and social activities being digitalised, disruptions and outages in digital infrastructure and services can have far-reaching impact. The Government recognises the need to ensure that the digital infrastructure and services that we depend on are reliable, resilient, and secure. This will help our citizens and businesses move forward with confidence. As such, we have set up a multi-agency task force to look at this issue, to consider how we can strengthen not only the government's own digital infrastructure and services, but also other foundational infrastructure that our citizens rely on, such as cloud and data centres.

Through my mentors, I learnt to build teams, instead of trying to do it all; focus our energies on what matters most; and rally the people around us to move towards a common goal.

The 'Forward SG' report² talks about “using digital means to help seniors stay connected, thereby empowering them to access key services and communicate with loved ones via various channels”. What would you say to those who are nervous about life with AI and living in a Smart Nation? How would you encourage them to be open to these technologies?

As you rightly mentioned, one of the key themes of the report is the use of digital means to help seniors stay connected, thereby empowering them to access key services and communicate with their loved ones via various channels. This is part of our broader vision to build a Smart Nation where we use technology to improve the lives and livelihoods of our people, and enhance our competitiveness and sustainability as a country.

I understand that some seniors may feel nervous or apprehensive about life with AI and living in a Smart Nation. They may worry about being left behind by the fast pace of technological change, or that we as a society lose the human touch. They may also have concerns about the security and privacy of their personal data, or the reliability and safety of digital systems and devices. These are valid and natural concerns, and we are committed to addressing them and supporting our seniors in their digital journey. Let me share with you some of the ways that we are doing so.

We are making digital services more user-friendly and inclusive. We adopt a human-centric and empathetic approach to designing and delivering digital services so that they are easy to use, thereby increasing accessibility for groups such as seniors. We have also provided various channels and platforms for our seniors to access digital services, such as the seven ServiceSG Centres located islandwide. These ServiceSG Centres can help the public to access close to 600 Government services and schemes. In 2023, about 400,000 transactions were completed at ServiceSG Centres, with one in four citizens receiving help on more than one service within the same visit.

Next, we are equipping our seniors to get up to speed in the digital domain. Established in June 2020, Digital Ambassadors from the SG Digital Office (SDO) provide personalised guidance to help seniors pick up basic digital skills. Currently SDO has 37 community hubs islandwide, along with over 200 mobile pop-up counters in workplaces, healthcare institutions, and community spaces. Beyond the Digital Ambassadors, some tech-savvy seniors also volunteer as Silver Infocomm Wellness Ambassadors to support their peers in embracing technology.

To better support our efforts to improve digital literacy among citizens, the Infocomm Media Development Authority (IMDA) has recently launched the Digital Skills for Life (DSL) framework in January 2024. DSL covers five competencies such as setting up and using smart devices; exploring information, communicating, and transacting online; as well as being safe, smart, and kind online. Based on the practical digital skills needed for daily living, there are also DSL guidebooks and online videos in the four official languages for seniors who may want to learn at their own pace, in their own time.

These are some of the ways that we are helping our seniors overcome their concerns and embrace living in a Smart Nation. We believe that by doing so, we can enable our seniors to stay connected, engaged, and empowered in the digital age.

As a leader, what have you found to be the most significant challenges and learnings in driving Singapore's Smart Nation journey? What advice would you give to young women (and men) aspiring to leadership roles in technology and government?

As working women, we often wear many hats. Through my mentors, I learnt to build teams, instead of trying to do it all; focus our energies on what matters most; and rally the people around us to move towards a common goal.

I also had great bosses who supported me on a very personal level. For example, in the months following the birth of my twins, my former boss Lee Yi Shyan, an ex-Member of Parliament (MP), gave me permission to work from home, long before telecommuting became a formalised policy and telecommunications infrastructure was mature. Throughout my working life, bosses like former MP Lim Swee Say and former senior civil servant Philip Yeo made room to accommodate my personal passions and circumstances.

One of my favourite quotes is: “Don't climb the ladder only to find that it is leaning against the wrong wall.” I hope that even as we work towards our aspirations, we pace ourselves, take a step back every now and then, and not forget our priorities in life.

I also learnt about the intrinsic worth of every person, and what it takes to bring this out from reading 'The Rabbi's Gift'³ by M. Scott Peck. This is a short story that I highly recommend and one that has been useful in shaping the way I think of myself as a leader. [Read more](#)

Mrs Josephine Teo

is Singapore's Minister for Communications and Information, and Minister-in-charge of Smart Nation and Cybersecurity

Endnotes

- ¹ *Char kway teow* is a stir-fried flat rice noodle dish commonly eaten in Singapore.
- ² The report, which drew on inputs from Singaporeans from all walks of life, outlines how the Singapore government will work with citizens to refresh the country's social compact for the road ahead.
- ³ M. Scott Peck, 'The Rabbi's Gift' in "The Different Drum: Community Making and Peace", Simon and Schuster, 2010.

Hello, JARVIS



How AI-enabled interactive agents will reshape our workforce of today and tomorrow.

by Archan Misra

The era of human and Artificial Intelligence (AI) co-working has arrived. While we may still be in the early days of such co-working, it is time for organisations to invest in such capabilities and plan for how they will progressively become more pervasive in our lives. The market value for such AI-driven innovation is expected to grow at a dramatic rate of 36.5 percent CAGR (Compounded Annual Growth Rate) in less than a decade to reach US\$88 billion by 2032.¹ The recent breakthroughs in AI, such as generative AI (also known as GenAI), are creating dramatic new capabilities for machine-based reasoning and interaction that go well beyond the reading and production of text which has captured the popular imagination.

In this article, I discuss how the ongoing advances in technology will provide what I describe as 'cognitive augmentation' of human activities. Embedding advances—in capabilities such as physical environment sense-making and natural two-way dialogue—into software agents deployed on a variety of personal and Internet-of-Things (IoT) devices will help us avail of such cognitive augmentation via more natural conversational interactions. In time, we may all have such personal JARVIS-es², agents which have been designed for specific tasks and environments, thus transforming us into Iron Men and Women!

This JARVIS-like capability enables AI agents to behave more like a partner (such as a helper or co-worker) who can ably support routine activities in various contexts. They are no longer just chatbots, but are able to do a lot more. I will illustrate such possibilities with a couple of current use cases and some that may be realised in the not-too-distant-future. In the last section of my article, I will discuss some key considerations that technology leaders need to keep in mind over the next few years to harness this promise of embedding interactive agents as a natural partner to humans.

THE CURRENT STATE OF TECHNOLOGY

*Imagine that you want to plan a trip... An agent will know what time of year you'll be travelling and, based on its knowledge about whether you always try a new destination or like to return to the same place repeatedly, it will be able to suggest locations. When asked, it will recommend things to do based on your interests and propensity for adventure, and it will book reservations at the types of restaurants you would enjoy.*³

The excerpt above comes from Bill Gates. He is among many prominent industry luminaries who have argued that agents embedded with such AI-driven reasoning and proactive interventional capabilities will drive dramatic, disruptive changes in how we use and interact with technology in our daily life. In parallel, mobile, wearable, and IoT devices are increasingly being equipped with more sophisticated (and cheaper) sensors that can make sense of the device's physical environment (such as the distance, dimensions, and colour of surrounding objects). For example, the Apple iPhone from the 12 Pro models onwards and Microsoft's HoloLens augmented reality (AR) holographic device already come with sensors that can map out their physical surroundings in real time and 3D (three-dimensional [form]).

With these twin advances in sensors and AI, it is understandable that we anticipate the emergence of newer forms of 'situated agents'—that is, agents that run continuously in the background, and keep themselves updated about the state of the surrounding spatial environment without being instructed to do so. Such agents can effortlessly comprehend and respond to, and eventually even *anticipate*, instructions or queries that require the combination of both the sensing capabilities of smart devices and the reasoning capabilities of AI models. In other words, these agents are able to respond to queries that require a deep and sophisticated spatial and semantic understanding of both the physical environment (perceived through multiple sensing modes) and the digital knowledge embedded in cyberspace.

Knowing how to relate what we see in our physical spaces (such as checking the price of a pair of jogging shoes displayed in a sportswear store) to what we know from the Internet (comparing prices of the same item on several online shopping platforms) may seem to be easy tasks for humans, but it is non-trivial from a computing point of view. As an illustration, current AI virtual assistants such as Amazon's Alexa and Apple's Siri are purely voice-based, *virtual* agents, i.e., they read and respond only to voice commands and process only online information. As a result, using speech to ask Siri to play the most popular song today is child's play because it can easily retrieve

such information from the Internet. However, when you ask Alexa to play the most popular song by the artist featured on the cover of the *Rolling Stone* magazine that sits on your coffee table, the virtual assistant is stymied as it does not know *where*, and to *what*, you are pointing at.

Such virtual assistants are currently neither equipped with visual perception to scan our physical environment nor can they capture our pointing gestures. These agents do not have what the computing fraternity calls 'situated awareness'—the ability to make sense of our physical surroundings. But with the right sensory inputs and software (including AI models, such as Vision-Language Models or VLMs that interpret text and image data), we can now introduce situated awareness capabilities to the likes of Alexa and Siri. In fact, several technological advances in AI research today are about improving the ability of devices to make sense of these situated cues, especially visual and gestural ones, such as that of pointing to an object. Computer scientists refer to this ability of AI models to align visual and language cues as 'visual grounding'.⁴

However, there is one catch. Many such AI models, including OpenAI's now-famous GPT-4, require network or Internet access as a lot of the actual heavyweight AI computation is done remotely, on a GPU (Graphic Processing Unit)-rich server farm. For natural interaction with situated agents, we however desire to have most, if not all, of this intensive work done on what we call 'pervasive devices', whether they are mobile phones, smartglasses, or even robots. In other words, the processing and response generation should be done 'locally'. This is because the moment you need to run

Building optimised systems that enable situated awareness locally and swiftly is extremely demanding and requires significant research breakthroughs.

anything on the cloud, you invariably lose interactivity because it will take time to complete. This 'latency' or the time lag between a request and its response⁵ is highly perceptible to us, even in hundreds of milliseconds, as it is just how we humans rapidly perceive and respond to our environment. Such response speed may also be critical if we need to count on such processing to be the basis for time-sensitive actions, like when we instruct the agent controlling our electric bicycle to "swerve around that slick spill on the sidewalk".

Building optimised systems that enable situated awareness locally and swiftly is extremely demanding and requires significant research breakthroughs. There are two main challenges to overcome. First, some of the sensors that are responsible for reading the visual (e.g., differentiating colours) and spatial cues (e.g., depth and distance of objects from the sensors) are extremely power-hungry. For example, the power that a LIDAR (light detection and ranging) sensor consumes is nearly 800 times that of a microphone sensor, thus making it less suitable for continuous background sensing that may be necessary under some operational contexts. Second, newer AI models (including GPT-4 or another OpenAI tool, DALL-E 3) are computationally too complex⁶ and large for devices such as smartphones or smartglasses to handle.

RESEARCH ADVANCES AND CHALLENGES

The research that my collaborators and I have been working on helps to address some of these challenges,⁷ such as developing 'lightweight' AI models that perform the bulk of the more complex processing locally on the pervasive device. For example, we have developed newer and optimised AI models, amenable to

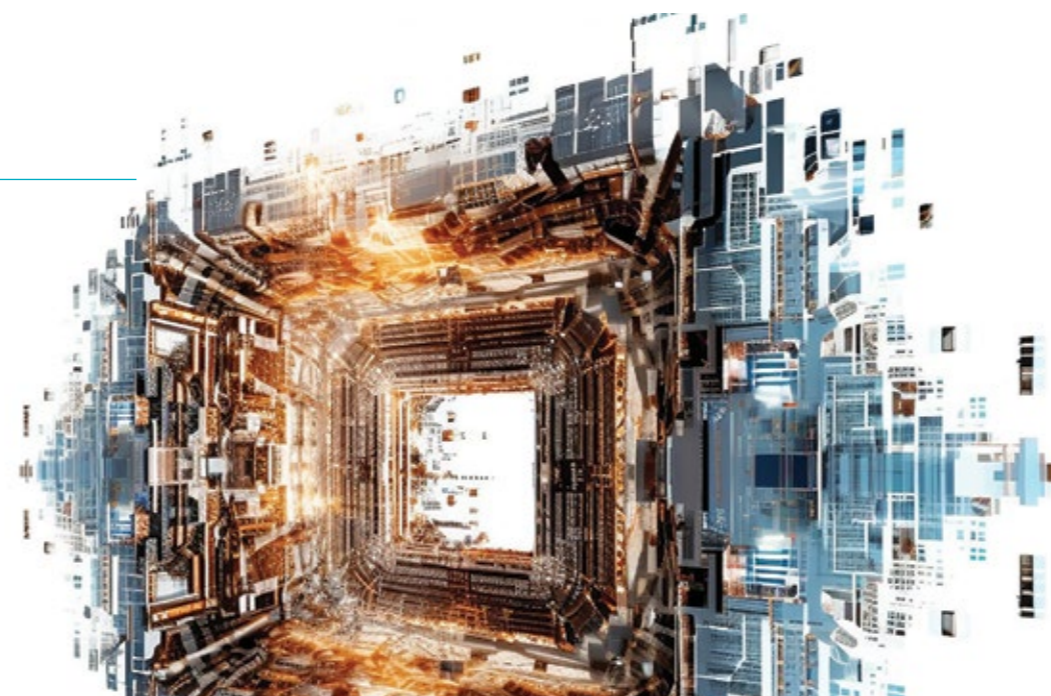
local execution, that are not only able to interpret verbal commands and visual cues, but also factor in human gestures such as pointing. Such an advance allows the AI to become more efficient at following visual, voice, and gestural cues from the sensors with more precise prompts (or what we call 'resolving questions') to zoom in on the object of interest, say to focus on *Rolling Stone* when there are perhaps multiple magazines on the coffee table from the previous example.⁸ Notably, these models are able to deal with the fact that the act of pointing itself is imprecise, with our pointing error higher when referring to more distant objects.

Second, we have also developed techniques that automatically skip over or approximate some of the complex stages the AI model has to complete,⁹ especially for visual reasoning, when the verbal instructions suggest that it may be prudent to do so. As an intuitive example, a query like "what is the price of the object next to the laptop?" implicitly provides the hint that the visual processing can be restricted principally to finding 'medium-scale' objects such as the laptop instead of 'smaller-scale' objects (e.g., pens) or 'larger-scale' objects (e.g., cabinets).

There are, of course, still many additional challenges to overcome. Among them, agents need to perform more efficient 'video grounding'—i.e., the ability to 'interpret' a video segment rather than a single image. This will help an agent deconstruct the motion semantics needed to answer questions such as "where can I find the bag that is being carried by the lady who just walked into aisle 4?". That said, rapid advances in such combined vision-language AI reasoning capabilities suggest that interactive situated agents may begin to find their groove as quickly as in the next three years.

HUMAN-AI AGENT COLLABORATION SCENARIOS

As we work at resolving these challenges, the ways in which humans and AI agents are able to work together can only be limited by our imagination. I describe an assortment of scenarios below to demonstrate their potential. These different forms of collaborative task executions can be structured around two dimensions: the expert-novice relationship, and the physical form in which such interactive agents will be embodied.



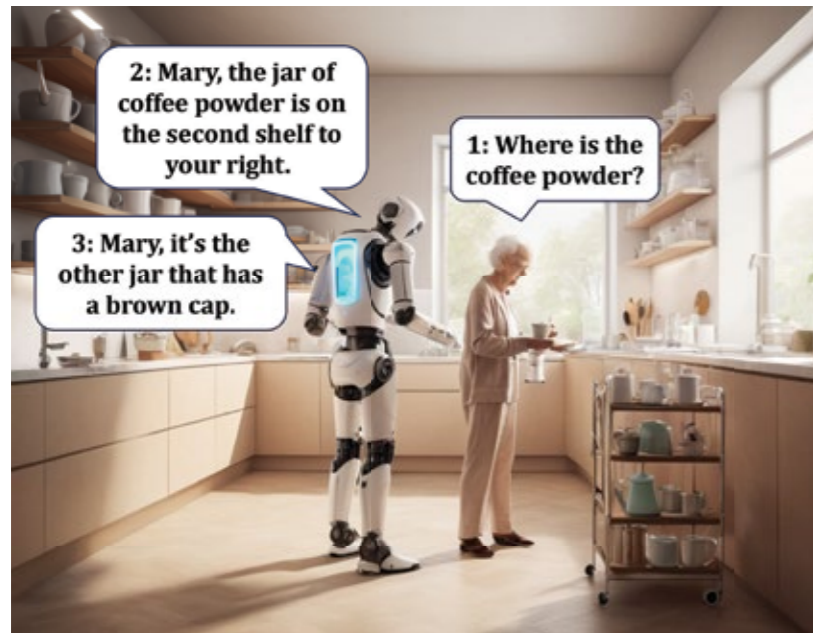


FIGURE 1

Note: Image was generated using Fooocus from the main prompt “elderly in a kitchen assisted by a robot”. It is based on the Stable Diffusion model, Juggernaut XL Version 6.

Agents as experts versus novices

In many scenarios, the interactive agent serves as the assistant and is tasked with comprehending instructions provided by an ‘expert’ human. Conversely, in the AI agent as personal helper scenario below, the agent is the ‘expert’ interpreting the combination of visual, verbal, and gestural inputs to make sense of an individual’s query and provide cognitive assistance.

AI agent as personal helper

Imagine there is an elderly woman, Mary, who has dementia and is experiencing cognitive impairment (refer to Figure 1). She would like to make a cup of coffee in the kitchen. Unsure of her surroundings, she asks, “Where is the coffee powder?” Her robotic assistant, which comes equipped with microphones and cameras, as well as suitable AI-based perception models, would be able to make sense of her request. “Mary, the jar of coffee powder is on the second shelf to your right,” it says. When Mary picks the wrong jar, it would be able to proactively correct her with helpful attribute clues such as “Mary, it’s the other jar that has a brown cap”. Later, the robot may even advise her on how much water to pour into the kettle, among other tasks. The robot, with the right sensors and AI model, is able to provide cognitive augmentation to support Mary with her daily routines. Central to this scenario is the service robot’s ability to support such cognitive augmentation via natural interactive, bi-directional conversations, both comprehending an individual’s queries and instructions, and generating situated responses.

Embodiment of an agent

The agent itself can be embedded in various devices such as smartglasses and AR headsets worn by a worker. Alternatively, the agent can be embedded in an external embodied form, such as the robot in the personal helper scenario, or the tyre change scenario described below. This capability is especially timely as we are just beginning to transition from expensive industrial robots being used for repetitive mechanical tasks to ones that perform more common ‘household’ tasks, such as Abluo¹⁰, the new restroom cleaning robot in Singapore, and Optimus, Tesla’s newly announced laundry-folding robot¹¹. However, such robots still operate under tightly-defined constraints and lack the integration with the interactive agents mentioned here that will allow them to exhibit greater flexibility by incorporating explicit human instructions.

AI agent-enhanced robotic tyre change

One potential use case, which integrates such agent-based interactive support with robotic manipulation, and where the human serves as the expert, may involve maintenance and aircraft repairs at an airport (refer to Figure 2). Aircraft tyres are subject to significant stress and may need to be changed after about every 120 landings, often while the aircraft is being prepared for the next flight at an airport gate. The current process of a three-person engineering crew changing and replacing one aircraft tyre (out of 14 for a typical Boeing 777), weighing as much as 250kg, may now need only one individual and one or more robots. Eventually, a robot could nimbly

dismount and re-install a tyre once it is equipped with the right array of sensors, software (including the AI models), and mechanical actuators.

The engineer could then serve as an overall supervisor of the tyre change operation, and an agent embedded in the robotic platform could comprehend the instructions from the engineer and adjust its position to carry out specific operations, such as rotating the wheel or tightening certain bolts. It is important to note that this scenario serves as an example of labour *augmentation* rather than replacement—the use of robots capable of understanding human instructions serves to ramp up the operational tempo and scale of airport operations, and relieves humans from physically arduous tasks, rather than eliminating them.

WHAT ALL THIS MEANS FOR SENIOR TECHNOLOGY EXECUTIVES

While technological advances often happen faster than we can predict, their integration into real-world business processes and operations is often much more complex and thus slower. To take advantage of this emerging world of situated agents, industry professionals and senior technology executives need to be cognisant of several key principles.

Data, data, data

Every work environment in which such advanced technology platforms are situated is complex and differentiated, and proper agent functioning requires appropriately tailoring and

optimising the underlying AI models. As a result, collecting the right training data from the operational environment is critical for the AI models to work effectively. For example, while both ostensibly fall into the category of ‘field worker assistance’, offshore workers on marine platforms will likely face operating conditions and equipment that are quite distinct from those encountered by workers dispatched to repair utility equipment in a city.

It is thus important for senior technology executives to start planning now and provision their workforce to proactively begin collecting such ‘situated data’. Workers could be equipped with body-worn cameras or smartglasses, even if such devices are presently unable to support such bi-directional situated interaction. Having this corpus of real-world, field data will be a critical asset in the rapid deployment of such interactive agents once the technologies mature. For the case of real-time guidance to field workers performing maintenance and repairs of industrial equipment, such data from experts will provide a baseline and thus help identify anomalies or mistakes that non-expert technicians may make during task execution.

Prioritising use cases

While such interactive agents can usher in powerful new forms of human-machine collaborative working, it is important to recognise that agents will develop only incrementally. To justify initial investments on such situated agents, senior executives need to carefully analyse their



FIGURE 2

Note: Image was generated using Fooocus from the main prompt “worker doing aircraft wheel change operation”. It is based on the Stable Diffusion model, Juggernaut XL Version 6.

operations, and identify the key processes and operations that are likely to demonstrate early benefits. I believe that initial gains will come from processes that exhibit the following three characteristics.



1. Controlled, uncluttered physical environments

AI models capable of fusing verbal and visual cues presently perform well under relatively 'benign' operating conditions, including relatively little visual clutter and well-lit operating conditions. Accordingly, initial uses of such agents are likely to be more effective in relatively well-organised spaces, such as a kitchen, rather than very complex environments such as an industrial construction site.



2. Infrequent and slow robotic manipulation

While seamless comprehension of human commands can enhance a robot's efficacy in many environments, physical robots currently perform manipulation tasks much more slowly than humans (partly out of safety constraints). Accordingly, successful interactive human-robot co-working is likely to be initially confined to low-volume, physically complex, and somewhat latency-tolerant tasks (such as the tyre change scenario mentioned above) as opposed to high-volume, high-frequency, and time-critical tasks (such as rapidly sorting and packing luggage onto an aircraft).



3. Sensing data is generated by infrastructural sensors

While several examples of situated agents cite the use of AR smartglasses, such devices are often still too bulky and uncomfortable for continuous use, especially in challenging field environments like the hot and humid conditions on an airport tarmac or a marine platform. Accordingly, initial deployments of situated agents may utilise third-party equipment—i.e., sensing capabilities that are embedded in non-wearable devices, such as smartphones and robots.

Digitalisation

For the successful integration of such agent technologies for human-machine co-working, it is important to view such human-machine teams not as atomic units, but as elements of a broader transformation of enterprise business processes and workflows. Many existing workflows and organisational structures (e.g., reporting hierarchies) are designed for human-only teams and may need to be reimagined for a future where teams consist of humans, AI-powered agents, and machines. A field worker on a marine platform may require the streaming of audio-visual assistance from a remote human expert, but in due course, the assistance may be provided by one of many AI assistive agents, each customised to tackle a specific scenario. Moreover, exception handling, for cases that cannot be handled by an AI agent, may also require routing to a selective group of experts, each of whom specialises in handling specific tasks and challenges, and involves additional employees in newly created roles to perform continuous outcome monitoring and auditing to proactively identify gaps in agent capabilities.

Reskilling and retraining

While putting in place the right digital infrastructure is critical, we cannot ignore the other equally, if not more, important element of the equation—humans. For industrial operations, senior technology executives need to be serious about training and reskilling managers, in addition to the rank-and-file workers. As a small but significant example, in spite of undoubted advances, the tyre-changing robot may be able to reliably comprehend only a tightly constrained set of instructional phrases and may fail to recognise abbreviations or colloquialisms. To reap the benefits of such technologies, it is hence important to ensure that humans are trained to suitably and consciously frame, as well as constrain, their queries and instructions. In addition, investing in and deploying sufficient training tools, in the form of simulators that provide immersive training, may be important to transition a workforce that may be sceptical of the efficacy of such agents.

CONCLUSION

I have shared why AI-powered situated conversational agents are attractive, and articulated how ongoing advances in AI and IoT/sensing technologies are likely to translate my vision into practice over the next few years. However, there are limits to the contexts under which AI-human co-working can be realistically implemented within the next five to seven years. For example, when a task requires precision, speed,

and flexibility, such as a complex surgery, humans would still have to be the ones to execute the task. Even so, we envision a future when AI agents are going to be embedded in pervasive devices like wearable smartglasses and service robots, such that these AI models can utilise inputs from multiple embedded sensors to provide situated and immersive comprehension of human instructions or augmentation of human perception capabilities.

Several researchers, including myself, are working to translate this vision into reality. One of the identified strategic research pillars at Singapore Management University has been labelled "Human AI Synergy" (HAIS)—it encompasses not just the sort of situated agent capabilities described here, but also a broader set of initiatives that seeks to reimagine the human-machine interface beyond current practices involving pure voice and touch-based interactions via screens. We are developing mechanisms to support conversational interfaces that help provide visually-impaired people with situational awareness of their surrounding environment, or allow natural verbal instruction-based programming of objects and their behaviour in virtual immersive environments. In addition, as part of an MIT (Massachusetts Institute of Technology)-led, NRF (Singapore National Research Foundation)-funded programme titled "Mens, Manus and Machina: How AI Empowers People, Institutions and the City in Singapore" (or M3S for short), I am working to develop the foundational AI/AR capabilities, and prototype situated agents, to support AI-augmented execution of industrial repair and maintenance tasks, as well as enhance the interactivity of online learning platforms.

So, if we indulge in a bit of imagination and science fiction, we might end up with something not unlike JARVIS.¹⁰

Dr Archan Misra

is Vice Provost (Research), Lee Kong Chian Professor of Computer Science, and Co-Director of the A*STAR-SMU Joint Lab in Social and Human-Centred Computing at Singapore Management University

Endnotes

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- JARVIS refers to a fictional character in the Marvel comics. Short for "Just A Rather Very Intelligent System", it is an AI personal assistant to Tony Stark who is also Iron Man in the comic series.
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- Some AI models may be required to run as many as a billion variables or parameters. In a nutshell, a parameter is a factor that the model needs to compute a response. Examples of factors are distance in the horizontal plane (i.e., the x-axis), a specific primary colour (e.g., red), and temperature.
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Superminds at Work:

The Promise of Human-AI Collaboration

Shaping a collaborative future.

Massachusetts Institute of Technology (MIT) Center for Collective Intelligence Director Professor Thomas W. Malone's scholarship offers deep insights into the promise afforded by the synergies between human intelligence and technology. According to Professor Malone, the boundaries between human intellect and technological prowess are becoming increasingly blurred, but this may not be a bad thing for humankind. In *Asian Management Insights'* inaugural Pulse Point interview, we get to learn more about the concept of 'collective intelligence', which explores how a partnership between humans and Artificial Intelligence (AI) can be catalysed to make ground-breaking advancements in addressing the wicked problems of our time. At the heart of his arguments is the idea of 'superminds'—entities comprising individuals and computers—that can work together in intelligent ways to make this human-computer partnership possible. Professor Malone also introduces the use of the 'Supermind Design' methodology as a systemic approach to designing such collective intelligence systems.

What do you think of the current debate about the risk of AI displacing or even replacing human intelligence? How do you address this persistent perception that AI and humans cannot work well together? How do these concerns relate to your idea of 'superminds'?

I think we need to spend much less time thinking about people *or* computers, and much more time thinking about people *and* computers. Similarly, *less* time ought to be expended on thinking about how many jobs computers are going to take away from people and *more* time could be devoted to thinking about what people and computers can do together that was never possible before. In other words, we need to ask ourselves: How can people and computers be connected, so that—together—they act more intelligently than any person, group, or computer has ever done before? One way people often talk about this is to say we should 'put humans in the loop'. But I think it's better to start with the human groups that have done almost everything we humans have ever accomplished, and then add computers to those groups. In other words, we need to move from putting *humans in the loop* to putting *computers in the group*.

Using AI and other technologies, these computers can do the things they do better than people—like arithmetic and certain kinds of pattern recognition—and people can do the rest. Perhaps even more importantly, computers can also be used to provide *hyperconnectivity*, i.e., connecting people to other people—and often to computers—at a much larger scale and in rich new ways that were never possible before. Think, for instance, how Internet-based platforms like Wikipedia, Google, and Facebook allow vast numbers of people to create and share information all over the world in a multitude of ways that were never possible when similar kinds of information had to be shared by moving papers around the planet!

A good way to understand this concept is to think about what I call ‘*superminds*’, which I define as *groups of individuals acting together in ways that seem intelligent*.¹ By this broad definition, superminds are all around us, all the time: companies, governments, labour markets, scientific communities, the editors of Wikipedia, and even the global economy. All these examples are groups of people (and often computers) acting together in ways that—at least sometimes—seem intelligent. These superminds can take on various organisational forms for collective decision-making and problem-solving, such as hierarchies (e.g., firms), democracies (e.g., governments and clubs), markets, and communities (e.g., scientific communities and neighbourhoods).

Often, computers can make these superminds smarter. Think of ChatGPT for instance. The system’s AI algorithms can conduct intelligent conversations about an amazing range of topics. But this wouldn’t have been remotely possible without the vast amount of human-created content on the Internet that was used to train ChatGPT.

Of course, it’s also possible for computers to make superminds more stupid, like when fake news influences voters in a democracy. But I think if we use them wisely, computers can help us create much more intelligent human-computer superminds in business, government, local communities, and many other parts of society. And the concept of superminds gives us an evocative new way of viewing AI, not as a *rival* to human intelligence, but as an increasingly valuable *partner* in all the different kinds of groups that make up our human societies.

How does the supermind concept relate to the ‘collective intelligence’ idea you had also proposed?

In my mind, saying something is a “supermind” is just shorthand for “collectively intelligent system”. And the phrase “collective intelligence” also suggests that we might be able to measure the intelligence of superminds the way we measure the intelligence of individual humans. In fact, my colleagues and I did exactly that. We created an ‘IQ (Intelligence Quotient) test’ for groups using the same statistical techniques that psychologists use to create such tests for individuals. We found that, just as for individuals, there is a single statistical factor for groups that predicts how well a group will perform on a wide range of tasks. We called this factor ‘collective intelligence’. To our surprise, we also found that the collective intelligence of a group was only weakly correlated with the average individual intelligence of the group members. And it was significantly influenced by three other factors: the average social perceptiveness of the group members, the extent to

which the group’s conversations were not dominated by a few members, and the percentage of women in the group.² And the last factor was mostly accounted for statistically by the first factor. In other words, it was well-known before we conducted our research that women on average score higher than men on this measure of social perceptiveness, and this may well explain why groups with more women did better. In addition, we found that social perceptiveness was a significant predictor of collective intelligence not only in face-to-face groups but also in online groups, and not only in laboratory groups but also in classrooms and online games. In short, to create collectively intelligent superminds, we don’t just need smart people, we also need people who are good at working with other people.

Given the sensitive nature of the human-computer relationship, how do you create such AI systems?

One way of thinking about this is to consider the five cognitive processes that are needed by any intelligent system, whether it is a person, computer, or group. Before taking any action, you need to *decide* first what action to take. In order to do that, you usually need to *create* a few options. You can also usually *decide and create* something better if you can sense the world around you and remember the past. And if you’re really smart, you can *learn* to do all these things better over time. In my book *Superminds*, I give examples of how computers can help human groups do all these things more intelligently.

For groups, perhaps the most important cognitive process is decision-making, and in the book, I describe five basic ways groups can make decisions. In Hierarchies, group decisions are made by delegating them to individuals in the group, and technology makes this possible in very new ways. For instance, in Google, all the operational decisions taken to generate the results for a user’s search query are made by computer algorithms, and the key role of humans is to manage, train, and maintain these algorithms. In Democracies, group decisions are made by voting, and computers make new kinds of democratic decision-making possible. For example, in ‘liquid democracies’, humans can vote directly on any issue they want to, but for issues they don’t want to pay attention to, they can delegate the action of voting to human proxies or to computers.

In Markets, group decisions are just the combination of many buyer-seller agreements. For instance, computers have long been able to carry out automatic trading in financial markets that also include humans, and computers can now do online retailing with very little human intervention. In

The concept of superminds gives us an evocative new way of viewing AI, not as a *rival* to human intelligence, but as an increasingly valuable *partner* in all the different kinds of groups that make up our human societies.

Communities, group decisions are made by a kind of informal consensus based on group norms, and online communities like Wikipedia show how groups of people and bots can jointly edit the same documents with very good results. But social media filtering algorithms illustrate an unfortunate possibility that can arise from the interaction among communities for online discussions and markets for online advertising. In many cases, these filtering algorithms are designed to optimise advertising revenues, not the experience of their users, and this often leads to undesirable social consequences, such as people becoming addicted to their news feeds.

For the first four types of superminds, there is some degree of cooperation among the group members. But there is also a fifth kind of supermind, which I call Ecosystems. Here, the group decisions are made by the law of the jungle—people with the most power get what they want—and the survival of the fittest. Just as individuals often compete for power in a group, superminds also often compete with one another for power. For example, countries compete with one another in economic markets, cultural spheres, and military wars. Within a given society, too, there are often conflicts for power among corporations, governments, voters, and communities. And there are many ways that computers can change the balance of power among these different types of superminds—some are probably good (like the rapid spread of innovations in society), and some are probably bad (like using killer robots in wars).

I believe this is a powerful framework for thinking about a lot of what goes on in the world, since almost all the human groups we know of belong to one of these five categories. In most situations, several of these types of superminds (sometimes all of them) are in play at the same time. This is also a helpful way to analyse and come up with ideas for how computers,

especially AI, can help make superminds smarter. For instance, collective intelligence can be incorporated into corporate strategic planning by using crowdsourcing, prediction markets, and data analytics to get a wider range of stakeholders involved in the planning process.

Can you give us some examples of how to design such systems?

To help design such collective intelligence systems, my colleagues and I have developed a methodology called ‘Supermind Design’.³ The methodology fosters innovative thinking about how to design groups for solving specific problems. It does this by systematically asking questions about factors such as different types of group decision-making and technology uses. The methodology has been used in organisations such as Takeda Pharmaceuticals and Deloitte Consulting, and trialled in Singapore by the National Robotics Programme.

We call these systematic questions ‘moves’, and the first set of moves is also used as part of many other creativity techniques. It comprises *Zoom In* to focus on the parts and types of a problem, *Zoom Out* to concentrate on the bigger picture of which the problem is a part or type, and *Analogise* to look for analogies to the problem.



The second set of moves is focused specifically on designing superminds, that is, groups of people and, often, computers. Those moves include *Groupify*: What are the different kinds of groups (hierarchies, democracies, etc.) that could help solve a problem? The next move is *Cognify*: How can the different cognitive processes be used in solving a problem? And the third is *Technify*: How can different kinds of technologies be used to help solve a problem?

We have also recently developed an AI tool called Supermind Ideator to help people design superminds. For example, if you want to come up with innovative ideas about how to reorganise the structure of a company or use a new AI capability, you could use the Supermind Ideator tool to help you. What the Ideator tool essentially does is applying the Supermind Design moves automatically. It is built on top of OpenAI's GPT-3.5 and GPT-4, and uses generative AI techniques to provide people with ideas that can inspire them to think of things they would never have thought of before.

We are currently using Supermind Design and Supermind Ideator in our work with Singapore's Changi Airport. For example, we're exploring opportunities for improvement in the aeroplane turnaround process, which is what happens between the time the plane arrives at the gate and the time it pushes back to go to the runway. There are many processes that happen then—passengers getting off the aircraft while others prepare to board it, refuelling, as well as unloading and loading of baggage, food, etc.—and these have to happen fast. Hence, we want to use our approach of analysing processes to try to develop more innovative processes that can be more efficient and flexible.

We also want to look at security screening and think about what can be done to improve the process. AI can do some part of it, with humans doing the rest, so there are a lot of interesting possibilities.

While it is, of course, important to design technology, we believe that the successful use of AI technologies will also depend on being able to devise the processes in which those technologies are embedded. And we think it's possible to develop a body of scientific knowledge about process design that can be very useful for doing this.

The advent of superminds sounds promising, but what could be some of the perils? How would the role of humans change in such partnerships?

I've already talked about some of the potential risks of human-computer superminds, like fake news, addictive social media algorithms, and killer robots. And I don't think it is guaranteed that using computer technology will make things better. But, in general, I'm optimistic about the long-term potential of the ways we use computers. I believe there are huge opportunities for very good things we can do with these technologies.

One important perspective to emphasise is that no matter how much computers can accomplish, we will probably still want humans to play the role of setting goals for computers and using human values to judge the results. In other words, people will often be managers of computers and not just of other people.

In the future, as the world becomes more and more interconnected and AI software becomes more capable, thinking of people and computers as parts of a cohesive global supermind will prove invaluable. And perhaps our future as a species will hinge on how effectively we can harness this global collective intelligence, to make choices that are not only smart, but also wise.^{1,2,3}

Dr Thomas W. Malone

is the Patrick J. McGovern Professor of Management,
and Director of the MIT Center for Collective Intelligence
at the MIT Sloan School of Management

Endnotes

- 1 See Thomas W. Malone, "Superminds: The Surprising Power of People and Computers Thinking Together", Little Brown, 2018.
- 2 The study was conducted by Professor Anita Williams Woolley of Carnegie-Mellon, Professor Christopher F. Chabris of Geisinger Health System, Professors Alexander Pentland and Thomas W. Malone of MIT, and Assistant Professor Nada Hashmi of Babson College. For details, refer to "What Makes Teams Smart", MIT Sloan Management Review, October 4, 2010.
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NAVIGATING SUSTAINABLE FUTURES



A leadership imperative.

By Franziska Zimmermann

In 2023, global headlines alluded to corporates and financial institutions turning their focus away from climate and ESG (Environmental, Social, and Governance); some even suggested that sustainability was only a fad that was due to end. But as we enter 2024, it is becoming clear that these narratives were headline-grabbing at best. While corporate action may have garnered less public attention, this is mainly because a number of companies have been intentionally regulating their climate communications¹ to minimise reputational and litigation risks, often due to the lack of clarity and changing regulations. The fact is, beneath the surface, many corporate leaders remain acutely concerned about the current and future threats of climate change, ecosystem degradation, and social instability. And they are (and must be) ready to act.

In this article, I will highlight how climate change continues to occupy mindshare and ranks high on corporate leaders' agenda, and how organisations can facilitate and lead the way to help everyone navigate this crisis. Specifically, I will discuss pressing issues concerning decarbonisation and net zero emissions, and draw our attention to the promise of emerging technologies and involvement of the youth in our journey to address climate change.

CLIMATE CHANGE AND OTHER ENVIRONMENTAL RISKS REMAIN TOP OF MIND

Building on the findings of the World Economic Forum (WEF)'s latest Global Risks Perception Survey (GRPS)², the 2024 edition of the WEF *Global Risks Report*³ drew attention to environmental risks approaching their tipping points, and those that were close (refer to Figure 1).⁴ Two out of three GRPS respondents chose extreme weather events as the number one risk to trigger "a material crisis on a global scale" this year.⁵ In fact, what is more eye-opening is that environmental risks (highlighted in green) occupy four out of the top five spots over the 10-year horizon.

GLOBAL RISKS RANKED BY SEVERITY OVER 2-YEAR AND 10-YEAR HORIZONS



FIGURE 1

Source: Adapted from Figure C in WEF, "Global Risks Report 2024", January 10, 2024.

The first Global Stocktake (GST) under the Paris Agreement was a detailed stocktake of global action on climate change so far, trawling through some 1,600 documents from diverse sources and building on consultations among stakeholders.



Interestingly, different stakeholders had divergent views on the urgency of these risks, such as ecosystem collapse, biodiversity loss, and critical change to Earth systems. These risks are ranked more highly over a two-year time frame by younger respondents, as compared to their more senior counterparts. That dichotomy is mirrored by respondents in the private sector vis-à-vis those in civil society and government, with the former paying more attention to risks over the longer 10-year term, while the latter group prioritised these risks over shorter time frames.

The difference in assessment, and perhaps worldview, implies a lack of alignment amongst decision-makers. This heightens the risk of missing key moments of intervention, which would result in long-term changes to planetary systems. It is therefore critical that corporate leadership, while taking a long-term perspective, acts with the necessary urgency today.

ACTION ON CLIMATE REMAINS HIGH ON CORPORATE AGENDA

Against this backdrop, it was encouraging to see the level of engagement of businesses at the Conference of the Parties (COP28), also known as the United Nations (UN) Climate

Change Conference, held in Dubai in late 2023. The conference drew over 80,000 delegates representing almost every country, and included more than 160 heads of state and 700 CEOs, making it the largest such assembly to date. For the first time, COP28 also included the Business & Philanthropy Climate Forum, which brought together some 1,200 private-sector and philanthropic leaders to drive climate action.

Major announcements from the summit marked the growing shift across sectors and an increasing focus on collaborating across organisational boundaries. Initiatives that were symbolic of the breadth and pace of change were, for example, the launch of the Industrial Transition Accelerator for Heavy-Emitting Industries that focused on catalysing decarbonisation across heavy-emitting sectors, including energy, industry, and transportation; and the acceleration of the delivery of Paris Agreement-aligned targets⁶. Following a similar initiative in industry, the First Movers Coalition for Food was launched. It represents a global coalition of companies leveraging their combined purchasing power for sustainably-produced farming products to speed up the adoption of sustainable farming, innovations, and transitional funding.

Temasek, a global investment company headquartered in Singapore, also took part in several initiatives. For instance, to address climate finance gaps in Asia, Temasek partnered Allied Climate Partners, the Monetary Authority of Singapore (MAS), and the International Finance Corporation to establish a green investments partnership to mobilise capital, and increase the bankability of green and sustainable projects in Asia.

NAVIGATING NEW REALTIES REQUIRES DECISIVE LEADERSHIP

COP28 was also the time for the first Global Stocktake (GST) under the Paris Agreement. The GST assesses humankind's progress on cutting down greenhouse gas (GHG) emissions, building resilience to climate impacts, and securing finance and support to address the climate crisis. It represented the most detailed stocktake of global action on climate change so far, trawling through some 1,600 documents from diverse sources and building on consultations not just with governments and scientists, but also varied stakeholder groups including farmers, indigenous people, businesses, civil society, cities, and others.

The key findings of the first GST, released in a Synthesis Report⁷ in September 2023, made clear two things: the goals of the Paris Agreement were a long way to being met, and the window of opportunity to do so was getting smaller by the

day. Without decisive action before the next GST in 2028, the unpleasant prospect of global temperatures repeatedly soaring by 1.5°C or more could soon be reality. But the report also laid out a course of action that governments should follow to combat the climate crisis. It pinpointed key areas where immediate action must be taken and provided a roadmap for the systems transformations needed to dramatically reduce emissions, build resilience, and safeguard our future.

As corporate leaders are looking to navigate the possible climate futures, there are a few areas emerging from COP28 and the subsequent conversations at the WEF Annual Meeting 2024 that are worth taking note of. The key highlights are listed below.

Getting ready for a post-fossil fuel world

Following tense final negotiations at the close of COP28, a historic agreement to 'transition away' from fossil fuels made headlines around the world. Leaders also committed to tripling renewables by 2030, doubling energy-efficiency improvement rates and establishing new standards to unlock global trade in hydrogen. These key agreements provide critical directional guidance.

It is paramount for corporate leaders to understand the implications of the evolving climate policies, actively monitor and adapt to new regulations, and strategically align their organisations with the directional momentum created through these international agreements. Many organisations may delegate the task to their legal and regulatory teams to ensure compliance with any new requirements. While this is a sound approach to remain abreast with the evolving practices, corporate leaders also need to adopt a mindset beyond compliance, take a longer-term perspective and set the tone for strategic sustainability initiatives and business transformation.

The urgency of climate action requires corporate leaders to embrace proactive climate leadership and reposition businesses for success in tomorrow's world. Initiatives such as the WEF First Movers Coalition that seek to decarbonise heavy-emitting sectors make it clear that companies not standing at the forefront of climate action may find it increasingly difficult to remain relevant as suppliers and partners in global value chains.

Speed up mitigation while preparing for adaptation

The 2024 Global Risks Report also drew attention to another unpleasant and inescapable scenario: Earth will likely reach the point-of-no-return by the early 2030s or earlier,

when another 1.5°C of global warming has been tagged on to the thermometer. Potentially irreversible and self-perpetuating changes to some planetary systems will take place at this point, unleashing ‘non-linear’ impacts that many economies will be largely unprepared for. Several related socioenvironmental risks could be triggered, which could in turn accelerate the climate crisis through the release of carbon emissions and amplifying related impacts, threatening climate-vulnerable populations. The collective ability of societies to adapt could be overwhelmed, considering the sheer scale of potential impacts and infrastructure investment requirements, leaving some communities and countries unable to absorb both the acute and chronic effects of rapid climate change.

Similarly, many large companies around the world may still have a blind spot when it comes to climate adaptation. This gap in building resilience to hazards from climate change, such as from extreme weather events to increasingly frequent and severe stretches of hot and dry spells, is emerging as one of the crucial risks affecting the global economy.⁸

Adaptation is and must be a critical component of climate action—both at the country and business level. Climate hazards can have profound impacts on supply chains and business operations, for example, in locations which face life-threatening heat and humidity spikes in the coming years. Singapore’s Third National Climate Change Study (V3), which was released in January 2024, provides the required high-resolution climate change projections for Singapore and the wider Southeast Asian region by dynamically downscaling the coarse resolution of global climate model simulations.⁹ This new data set can be readily used for adaptation planning.

Building resilience across regions, sectors, and value chains requires collective action. COP28 saw significant agreements on nature, health, food, and water systems, and further negotiations on adaptation are expected to be a focus at COP29 in Baku, Azerbaijan.

Drive business innovation and transformation from the top

It is estimated that half of the reductions required for net-zero emissions by 2050 must be delivered by technologies not yet available at scale, such as carbon capture and storage technologies, hydrogen to produce low-emission steel, and sustainable aviation fuel. This technological gap provides opportunities for businesses in such industries to innovate, lead sector transformation, and thereby capture value. It also provides opportunities for new forms of collaboration among

the different players in a value chain to collectively accelerate the development and adoption of climate solutions, drive cost reductions, and secure favourable policy environments.

Having a clear view of the pathways towards decarbonisation and a compelling plan to transition the business is increasingly vital for any company operating in a high-emission sector. Considering the potential for stranded asset risk, investors, including Temasek, are increasingly seeing the climate transition readiness of companies as an important investment consideration. This was underscored by the breadth of activities that took place at COP28, including transition plan-related events hosted by MAS, the UN Secretary-General, the City of London, and more. Similar momentum can be observed in the European Union (EU), UK, US, Japan, Singapore, Australia, and many other countries.

Taking a strategic view on how to develop and drive decarbonisation through the business and dealing with risks and opportunities are crucial roles corporate leaders must play. In the last decade, deployment of various climate technologies has accelerated significantly, often outpacing expectations—for example, solar and wind power now account for more than 10 percent of electricity generation and over 80 percent of new electricity-generating capacity.¹⁰ But greater acceleration is needed, both for renewables and for a range of other climate technologies. Each critical technology must grow at more than 20 percent per year over the coming decade to achieve commercial viability and technological readiness.¹¹

By fostering a culture of continuous improvement and investment in sustainable technologies, corporate leaders can position their organisations as innovators and front runners in the race to net-zero and in the competition to build and scale the next generation of green businesses.

Get ready for increased levels of accountability and scrutiny

One year ago, the UN Secretary-General’s High-Level Expert Group on the Net-Zero Emissions Commitments of Non-State Entities (HLEG) set out 10 practical recommendations to “bring integrity, transparency, and accountability to ensure that net-zero pledges are fully aligned with limiting global temperature rise to 1.5°C above pre-industrial levels by establishing clear standards and criteria”.¹² These recommendations serve as a tool to hold non-state actors accountable to their net-zero pledges, as detailed transition pathways set out by the International Energy Agency (IEA) and UN Intergovernmental Panel on Climate Change (IPCC) function as roadmaps and instruction manuals.

Climate hazards can have profound impacts on supply chains and business operations, for example, in locations which face life-threatening heat and humidity spikes in the coming years.



Consumers, investors, and regulators are actively seeking effective ways to hold companies accountable for their GHG emissions. This heightened focus is fuelled by the alarming disparity between current emission reduction efforts and ambitious net-zero targets set in recent years. This is one of the reasons why regulators and standard-setters globally have stepped up their activity.

Most notable is the work of the International Sustainability Standards Board (ISSB). Nearly 400 organisations from 64 jurisdictions have committed to its standards for climate-related reporting ahead of COP28, thanks, in no small part, to the common language for sustainability information that enables comparable and consistent sustainability disclosures across global capital markets. This groundswell of support from non-governmental organisations (NGOs), companies, investors, stock exchanges, accountants, multilaterals, academia, data analytics providers, corporate advisors, and others comes as ISSB puts its standards into action. In Singapore, the Sustainability Reporting Advisory Committee (SRAC) proposes to mandate listed issuers to report climate-related disclosures in line with the requirements of the ISSB climate disclosure standards starting from financial year 2025 (FY2025). Large non-listed companies with annual revenue of at least S\$1 billion will follow suit in FY2027.¹³

Transparency about environmental impact, climate-related risks, and sustainability initiatives is crucial. Corporate leaders bear the responsibility for establishing robust disclosures and they should drive the adoption of best practices, including those outlined by ISSB. Beyond providing climate-related financial information to capital markets, corporate leaders should lead in adopting a stakeholder-centric approach. Transparent communication and active engagement with diverse stakeholders are essential for gaining support, fostering collaboration, ensuring the success of sustainability initiatives and, ultimately, for retaining a business’ social licence to operate.

This is particularly relevant given that in today’s age of digital platforms and tools, including Artificial Intelligence, there is no place to hide. Various stakeholder groups are working to curate, connect, and analyse relevant data sets. At COP28, a new swathe of tools was launched to further scrutinise corporate actions. One example is the Net-Zero Data Public Utility, an open repository backed by the UN, ISSB, and IEA. Its database of consistent company-level GHG emissions facilitates analysis and comparison of company climate data, which is invaluable for interested parties: investors, regulators, analysts, NGOs, and the media. Another example is Climate TRACE, a satellite-based inventory of GHG emissions sources and locations.

There is no net zero without nature

Action on climate alone is insufficient without also addressing nature. COP28 dedicated an entire day to nature, and, for the first time, another day to food and agriculture. The message that nature-based solutions (NbS) are critical to climate action has well and truly experienced a breakthrough. Take Living Carbon for example. It is a biotechnology company that Temasek has invested in that enhances CO₂ absorption and storage in trees through photosynthesis enhancement and the shortening of tree-growing cycles.

However, it is equally true that NbS as an approach is not a silver bullet that can excuse delayed action on decarbonisation. In fact, for NbS to deliver their full potential, they must be deployed alongside decisive action on climate mitigation, including the transition to low-emission energy sources. These two must go hand in hand. Because the science is clear that, in many instances, the warming climate has negative impacts on nature’s ability to serve as a carbon sink.

The most recent *State of Finance for Nature* report by the UN Environment Programme (UNEP) and partners found that in 2022, investments in NbS came to about US\$200 billion, but finance flows to nature-harming activities were

more than 30 times larger.¹⁴ This exposes a significant disparity between the volumes of finance to NbS and nature-negative finance flows.

Carbon markets can play a vital role in driving down GHG emissions and spurring climate ambition, but only when it is done right. An effective and trusted carbon market will help accelerate decarbonisation by providing a mechanism to fund decarbonisation technologies and NbS, while a credible ecosystem and market will be critical to enhance transparency and confidence. While COP28 may not have landed on an outcome on carbon markets, important signals were sent to re-confirm the commitment and re-establish trust in the voluntary carbon markets. Temasek-owned investment firm GenZero, for instance, has released its inaugural white paper to address common misconceptions around carbon markets and highlight ways to drive climate mitigation at scale.¹⁵ The paper explored the state of the carbon markets today, along with obstacles from both the demand and supply sides. GenZero also offered eight recommendations to “unleash the full potential of carbon markets”, including refining carbon credit taxonomies and incentivising corporate participation.

Harnessing the next generation: digital technologies and youth

Digital technologies are altering the way climate change is addressed, be it emissions reduction, greening transport networks, or mitigating impacts with early warning systems. The WEF estimates that such technologies could eliminate GHG emissions by some 20 percent by 2050 in three of the high-emitting sectors: mobility, materials, and energy.¹⁶

The increased demand for data from various stakeholders—including regulators, value chain partners and investors—provides clear use cases for a focus on the implementation and acceleration of the digital transformation of businesses, also when it comes to sustainability performance. And the good news is that any sustainability-related efficiency typically translates into improved financial performance.

Climate change already affects, and is poised to alter, the lives of various generations. The latest *IPCC Sixth Assessment Report* carried a striking visualisation that shows the observed and possible projected global temperature trends, and how they would impact different generations born in 1950, 1980, and 2020 (refer to Figure 2). It underscores the responsibility

that people currently have to correct the course of GHG emissions in the decades and centuries ahead. It also brings home the need for a robust dialogue among generations, be they grandparents, parents, or children.

In a study published by medical journal *The Lancet Planetary Health*, nearly 70 percent of the 10,000 16-25-year-olds surveyed in 10 countries reported being extremely or very worried about climate change.¹⁷ This number was even higher on average in developing countries in the Global South that are expected to be most vulnerable to climate change-related destruction. Yet, rather than seeing young people as only victims of climate change, they can instead be regarded as agents of change, entrepreneurs, and innovators. Be it through education, science or technology, we are encouraged to see many young people globally ramping up efforts to address the climate crisis.

Progressive corporate leaders should find ways to regularly consult and engage with future generations, seek their views, and harness their energy and potential, to help fuel the innovation pipeline or shape the future direction of the corporate world. The need to include next-generation leaders was recognised in the official COP28 negotiated text. The role of the Presidency Youth Climate Champion (YCC) was instituted within the United Nations Framework Convention on Climate Change (UNFCCC) process, enhancing the meaningful participation and representation of youth in future COPs. A total of 110 young people from around the world, including a delegation from Singapore, were empowered to drive climate action and participate in the COP negotiations as part of the COP28 Youth Climate Delegate Program, the largest initiative to date to expand youth participation in the COP process.

CONCLUSION

COP28 emphasised that the role and active involvement of corporate leadership are pivotal in steering organisations towards sustainable futures. By considering the above takeaways, corporate leaders can proactively lead their organisations in navigating the complexities of climate action, and fostering a resilient, socially responsible, and environmentally-conscious business environment. **AM**

Franziska Zimmermann

is Director, Sustainability and Climate Change Strategy at global investment company Temasek

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THE EXTENT TO WHICH CURRENT AND FUTURE GENERATIONS WILL EXPERIENCE A HOTTER AND DIFFERENT WORLD DEPENDS ON CHOICES NOW AND IN THE NEAR TERM

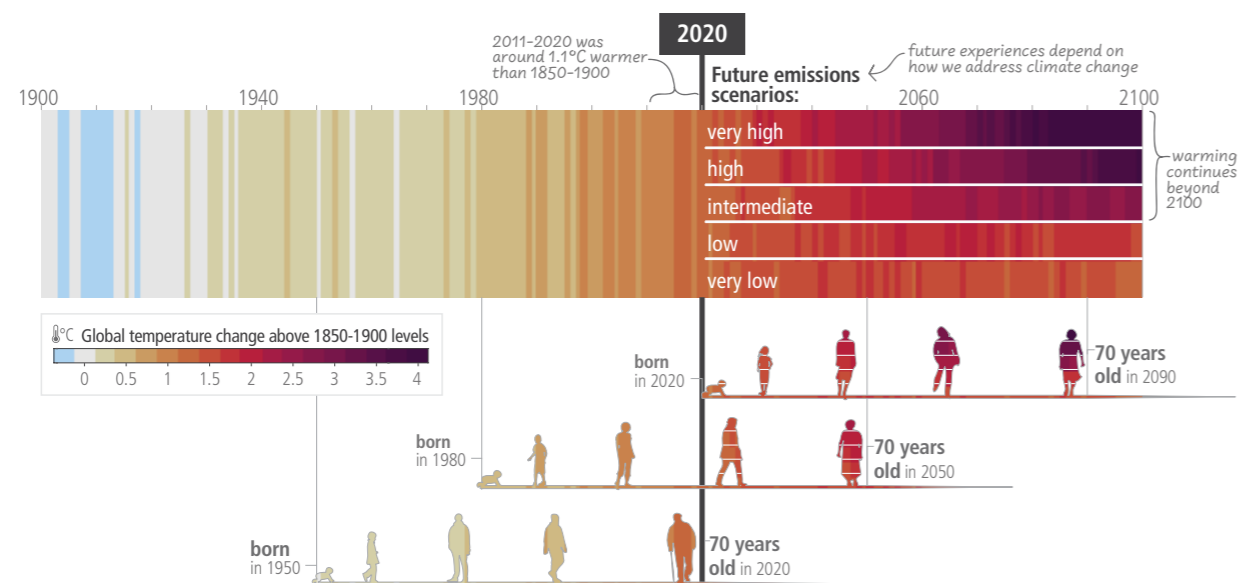


FIGURE 2

Source: Figure SPM.1 (c) from Hoesung Lee and José Romero (eds.), ‘IPCC, 2023: Summary for Policymakers’, in “Climate Change 2023: Synthesis Report”, Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland. Reproduced with permission from IPCC.



Smart Heuristics for Smart Management

How leaders can make effective decisions in a VUCA world.

by Jochen Reb, Shenghua Luan,
and Gerd Gigerenzer

On January 2, 2024, Japan Airlines flight JL516 arrived at Tokyo's Haneda Airport with 379 people on board. Shortly after the plane touched the tarmac, it collided with a Japanese Coast Guard plane that was to deliver emergency supplies to Ishikawa Prefecture's Noto Peninsula, which had been hit by a magnitude 7.6 earthquake the day before. The Coast Guard plane had entered the runway, leading to the tragic accident in which five of its six crew died.¹ Amazingly, all 379 people on board the burning JL516 exited the plane to safety within 18 minutes of landing, in what British newspaper *The Guardian* called the "Miracle at Haneda".²

Video footage showed the explosion when the two planes collided, and how JL516, which was engulfed in flames, continued moving forward before slowly coming to a stop. Seeing these images, it is hard to believe that all the people on board, both passengers and crew—with the pilot leaving last—escaped this seeming 'death trap' with only a few passengers sustaining injuries. Experts noted that improvements in, and the increased use of, fire-resistant materials played a big part in each and every one of the passengers surviving the crash. Yet, a lot of commentators also emphasised the role of human decision-making. Indeed, both crew and passengers have been praised for their actions.

It seems that the crew combined excellent execution of learnt rules for emergencies with quick, adaptive decision-making in the unexpected and unfolding crisis. Both are examples of *smart heuristics*, that is, simple rules that match the requirements of a situation. Learnt heuristics are simple rules that the crew of Japan Airlines—an airline with a stellar safety record over the past decades—had practised repeatedly. These heuristics tend to consist of simple if-then rules such as: *If an emergency situation arises, ask passengers to remain calmly seated and await further*

instructions. This heuristic helps prevent panic and clogging of the aisles. Adaptive decision-making was exemplified in the use of only three of the eight emergency exits because the others were ablaze. Here, the simple rule was to only open exits that are safe, even if that meant there would be fewer doors available for evacuation. The underlying principle is quality over quantity: a safe exit, even if slower, is better than an unsafe exit. Passengers also followed several smart heuristics, the most important perhaps being that they left behind their hand luggage to facilitate a speedier exit.

Smart heuristics—whether learnt, practised, and consciously executed, or more intuitively applied on the spot—are key to successful decision-making under pressure and in crises. Yet, their applicability is much broader, as we argue in our new book, *Smart Management* (forthcoming from MIT Press). In this article, we want to share some of our key ideas.

SMART HEURISTICS FOR A VUCA WORLD

The term ‘heuristic’ is of Greek origin and can be translated as “serving to find out or discover”. In science and art, heuristics are indispensable tools for discovery. New ideas and theories typically do not come out of analysis but from intuition and heuristics. As the famous mathematician George Pólya argued, mathematics, the most abstract of the sciences, requires both analytical and heuristic strategies: heuristics are used to arrive at theses and potential proofs, while analysis helps to prove or verify a thesis.³ Neither one is superior to the other. At their best, they work together beautifully and effectively complement each other.

Unfortunately, many leaders are not aware of the value of heuristics. This is in no small part due to education systems favouring analytical approaches. Business school courses on management, leadership, and finance, for example, teach expected utility maximisation as *the* way to make rational decisions. However, they fail to point out sufficiently that this supposed ‘gold standard’ is only possible in what one of the fathers of decision theory, Leonard Savage, called “a small world”. To maximise expected utility, a manager would have to be able to foresee *all* possible consequences of *all* options and evaluate these accurately on the single scale of utility (whatever that means). According to this narrative, “more is better”: more options, more information, and more analysis enable better decisions. Heuristics, in contrast, have been falsely associated with pernicious biases that supposedly lead to worse decisions than expected utility maximisation. But given it is not conceivable to evaluate or even know all possible options, their consequences, and the respective probabilities

of them occurring, utility optimisation and maximisation are simply impossible.

The reality is that any decision-making strategy can lead to bad decisions if it is not appropriate for the task at hand. This is the principle of *ecological rationality*, which is derived from Herbert Simon’s theory of bounded rationality. Its essence is that rationality is not a property of the decision-making process itself. Instead, rationality is the result of a match between the organisation’s decision-making strategy and the task environment. When a heuristic matches its task, it becomes a *smart heuristic*. In the case of JL516, the heuristic *quality over quantity* does exactly that by matching the task of a quick evacuation to a situation that is VUCA—volatile, uncertain, complex, and ambiguous. Effective leaders have a portfolio of decision-making strategies that they can draw on, making it an *adaptive toolbox of heuristics*. They developed this toolbox through years of experience and learning. From this box, they take out the appropriate heuristic tool for the task at hand. In contrast, utility maximisation is like the proverbial hammer to which every problem looks like a nail.

Consider SoftBank founder Masayoshi Son and what we call the *time machine heuristic*. Under the ‘Strategy’ section of SoftBank’s 2000 Annual Report is a description of the “time machine management” strategy, which “fosters[s] the global incubation of superior business models found through its venture capital operations in the United States.”⁴ Technology-based business models such as e-commerce, social media, and ride-sharing services often spread across the globe in stages. They are typically invented and first go to market in the US. If they prove successful there, they are introduced to other developed economies such as the European Union (EU), Japan, and Korea. Subsequently, they are further rolled out to markets like China, India, Indonesia, and others.

Smart heuristics—whether learnt, practised, and consciously executed, or more intuitively applied on the spot—are key to successful decision-making under pressure and in crises.

This heuristic relies on imitation, a key human strategy for learning, survival, and effectiveness. Son used it as a tool to make strategic business decisions, with Yahoo! Japan imitating the model of Yahoo! in the US—to great success—of a web portal that directs traffic, and provides information and services in areas such as news, finance, and shopping. SoftBank’s hugely successful stake in Chinese e-commerce giant Alibaba—modelled after Amazon—is another example of the effectiveness of what could be described as a time(-space) machine strategy.

THE MANY BENEFITS OF SMART HEURISTICS

A key environmental characteristic favouring heuristics is uncertainty. In a VUCA world, instead of devising five-year plans that aim to utilise resources optimally in an uncertain future, smart heuristics provide crucial strategic flexibility and speed. In this way, heuristics make companies more robust against the unpredictability of a fast-changing environment.

In general, we argue that smart heuristics have several important benefits. The first is speed, as they allow for quick decision-making. Smart heuristics are also frugal, requiring limited amounts of information and processing. Moreover, despite being fast and frugal, they can be as, or more, accurate than slower and more complex strategies. And finally, they are transparent. Smart heuristics can be effectively communicated, taught, and learnt, and their transparency can also address fairness and discrimination concerns.



Smart heuristics are fast

Consider speed. Experts often rely on a strategy called *fluency heuristic*, which boils down to choosing the first option that comes to mind.⁵

By doing so, instead of exhaustively considering all possible options, decision-makers can act quickly and avoid analysis-paralysis. Importantly, for this heuristic to be smart, expertise is required. For example, when expert handball players were shown game situations on video and asked which play they would make next, the first option that came to their minds tended to be considerably better than the second, third, or subsequent options which often deteriorated progressively in quality. Thus, a deliberative search produced inferior options instead.

This illustrates an important principle for smart heuristics: Less can be more. Less data, less search, and less processing can lead to better decisions being made amid uncertainty. You may think that perhaps this heuristic is only helpful in situations of time pressure such as the aeroplane emergency

described at the start of this article, or for firefighters. That is not so, but instead it is more useful generally for experts. For example, expert golfers made more accurate putts when they had only up to three seconds rather than an unlimited period of time. It is also not limited to sports. One study found that senior executives deciding on which projects to invest in made equally good decisions using heuristics as when using slower analytical methods.⁶ And firms making faster strategic decisions often are more profitable and grow more quickly.⁷

Unfortunately, many companies have a defensive decision-making culture, where making decisions slowly is used to signal carefulness and quality. However, just because a decision is made slowly does not mean it is good. In fact, fluency heuristic research shows that when managers replace their intuitive decisions with the results of subsequent analyses, the consequences may be worse. Even when managers eventually go with their first option, much time and effort would have been wasted producing analyses, presentations, and reports only to justify a decision that had been reached on the basis of intuition. A negative-error culture makes matters worse, instilling a fear of making decisions that cannot be justified by large amounts of data and detailed analyses.

Smart heuristics are frugal

Less can be more, especially in an uncertain environment. The frugality of heuristics exemplifies this principle. Consider the task of predicting the rate of flu-related visits to the doctor for the coming week. To develop a big data algorithm called Google Flu Trends (GFT), Google engineers analysed about 50 million search terms and tested hundreds of millions of prediction models, constantly refining the model.⁸ However, when the swine flu arrived out of season in March 2009 and peaked in October of the same year, GFT failed to forecast the outbreak accurately.⁹ It consistently underestimated the spread of the flu, having “learnt” from the data collected in the years before that infection numbers tended to be high in winter and low in summer, so it was slow to adjust to the unexpected swine flu outbreak.

Instead, the *recency heuristic*, a very frugal heuristic that uses only a single data point, fared better at predicting the rate of doctor visits for the coming week. It uses the following strategy: *Predict that next week’s rate of flu-related doctor visits will be the same as the most recent rate*. Because it relies solely on the most recent data point, the recency heuristic quickly adapts to unexpected events. The recency heuristic predicted flu outbreaks more accurately and consistently for



the eight years that GFT was tested, and it also outperformed all revisions of the big data algorithm.¹⁰ A key reason for this is that frugal heuristics tend to be more robust in the sense that they are less likely to overfit their model to noise in the data.

Similar results have been observed in a business context. One good example is the *hiatus heuristic*, which can be described thus: *If a customer has not made a purchase within x months, the customer should be classified as inactive*. Studies on 24 companies showed that this heuristic predicted future purchases better than much more complex algorithms, including machine-learning techniques, such as random forest.¹¹



Smart heuristics are transparent

Societies and organisations are increasingly becoming aware of the downsides and sometimes outright dangers of black-box algorithms that spit out predictions and decisions without anyone—not even the algorithms' creators—knowing how they arrived at their outputs. These decision-making strategies are not transparent. There are good reasons to value transparency in decision-making rules. Transparent rules are more easily communicated, memorised, taught, learnt, and understood with less chance for misunderstanding.

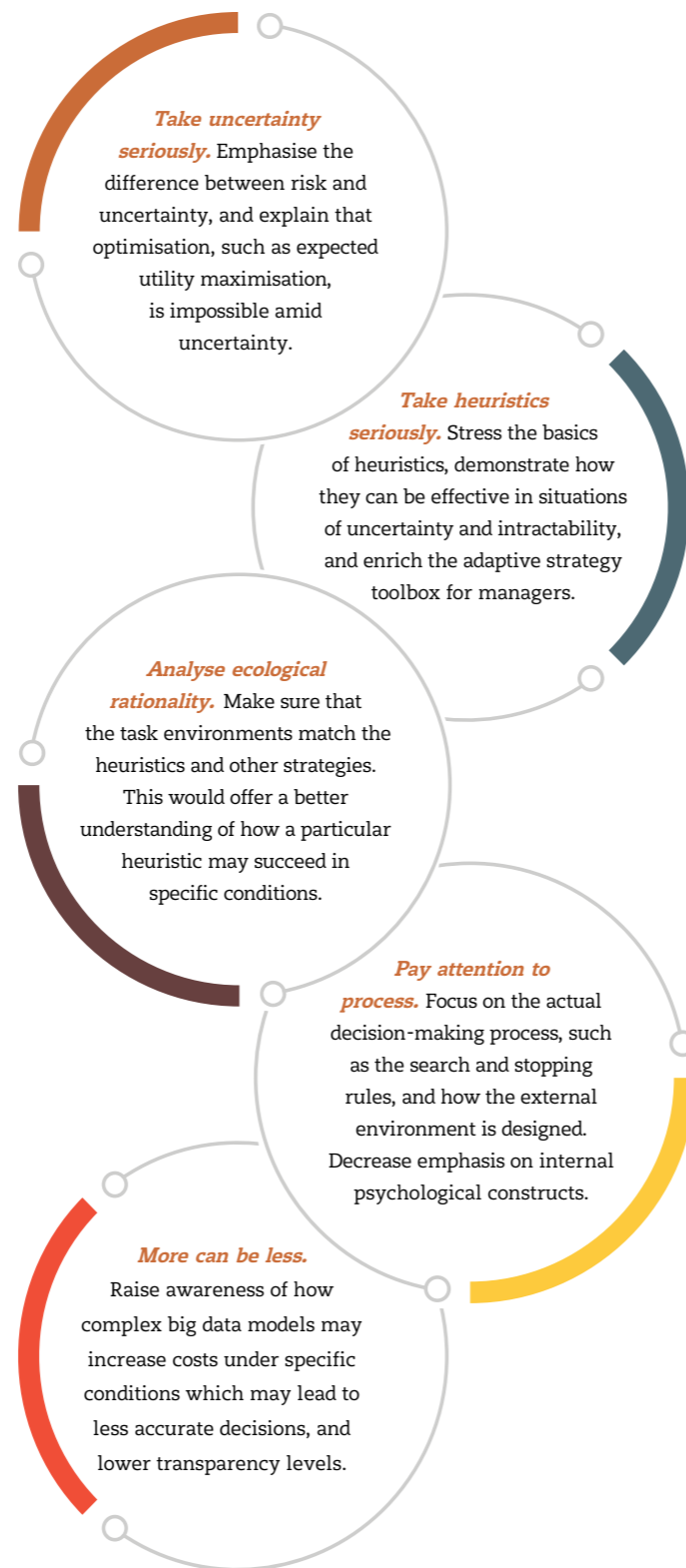
The hiatus heuristic is transparent—a manager can easily understand, communicate, and apply it. In contrast, a complex machine learning technique is not understood by the managers using it. Proponents of big data Artificial Intelligence (AI) algorithms sometimes claim that a lack of transparency is a minor 'evil' that organisations and societies have to accept for the superior accuracy of these black-box algorithms. But as we have seen from the results of pitting the recency heuristic against GFT, accuracy does not have to come at the cost of transparency. It is also easier to identify where a decision-making strategy has gone wrong or if it discriminates against, for example, minority groups, something of increasing concern for AI algorithms, when there is transparency.¹²

TAKING HEURISTICS SERIOUSLY

Unfortunately, few schools currently teach the science and art of heuristic decision-making. Instead, heuristics have been linked to systematic decision-making errors. What is needed is a paradigm shift in how schools and organisations approach heuristics. This shift should produce an approach that does not discourage managers from using heuristics (something they do anyway!), but rather one that guides them in developing their adaptive toolbox of decision strategies and the ability to select the appropriate heuristic for the task at hand.

The general approach we recommend to organisations, leaders, and business schools is: *Don't avoid heuristics—learn how to use them*.

This can be broken down into the following five principles.¹³



By following these five principles, leaders and their organisations can create what we call a smart decision-making culture. In this culture, organisations embrace the following: they operate mostly in large worlds of irreducible uncertainty, rather than small worlds of calculable risk; errors are unavoidable and can be a source of learning; and less is often better in situations of uncertainty.¹⁴

Dr Jochen Reb

is Professor of Organisational Behaviour & Human Resources, and Director, Mindfulness Initiative @ SMU at Singapore Management University

Dr Shenghua Luan

is the principal investigator of the Risk And Uncertainty Management (RAUM) laboratory at the Institute of Psychology, Chinese Academy of Sciences (CAS)

Dr Gerd Gigerenzer

is Vice-President of the European Research Council (ERC) for the Social Sciences and Humanities; Director of the Harding Center for Risk Literacy at the Faculty of Health Sciences Brandenburg (University of Potsdam); and Emeritus Director, Center for Adaptive Behavior and Cognition, Max Planck Institute for Human Development

This article is based on our upcoming book, "Smart Management: How Heuristics Help Leaders Make Good Decisions in an Uncertain World" by Jochen Reb, Shenghua Luan, and Gerd Gigerenzer, forthcoming from MIT Press.

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Focus on your customers to catapult your company to success. However, leaders must drive a culture change to make it happen.

by Neeta Lachmandas-Sakellariou

During its heyday in the 1990s, Borders bookstore stocked an average of 140,000 titles in each of its 500-plus superstores in the US, and another 40 stores in Europe, Asia, and Australia. The associated high costs of real estate and inventory management ate into its profit margins, but Borders believed its wide selection represented the essential value that would keep customers coming back for more. With over US\$3 billion in sales and more than 30,000 employees in 2001, it was hard to dispute the company's business strategy then.

Just 10 years later in 2011, Borders filed for bankruptcy. Its selection of titles had become dwarfed by the ready availability of almost any book on the Internet, on which Amazon had become the dominant bookseller, thanks in part to Borders's decision to outsource its online sales to Jeff Bezos's company. Mark Evans, a strategy and analytics executive working then at Borders, cited a customer survey that the bookstore chain did to understand its plummeting numbers, "Customers didn't notice our larger assortment of books. They didn't care."¹

Borders's misunderstanding of its e-commerce and online strategies has become a case in point of companies failing to recognise and adapt to a changing macro environment. What is perhaps more important is its failure to identify what represented 'value' to the customer. Instead of being wowed by its impressive-before-the-Internet 140,000 titles, customers simply wanted to have the book they desired delivered to them as quickly as possible. Customers were also beginning to buy e-books, which required a different infrastructure from the one that underpinned traditional brick-and-mortar operations. In other words, Amazon understood what value meant to the Internet-era customer, while Borders no longer did.

The success of Amazon, along with digital service providers such as Spotify, Netflix, and various private-hire ride-hailing apps, represents a fundamental shift: value has migrated from mere product or service provision to customer centricity and the service experience. These companies have a service-centric business model that begins with the perspective of the customer and translates into solving whatever problems the customer might have to deliver what is desired.

Organisations must decide how service initiatives can be funded by determining if customers are willing to pay a premium for better service, or if operational savings can fund service excellence initiatives.

In this article, I argue that by putting the customer at the core, organisations can embark on a process of service transformation that would spark organisational and systemic changes, and make them relevant and valuable to their customers. Beyond innovation in technology and service processes, service transformation requires the understanding that ‘service’ is the key component in a complete remake of organisational culture. Above all, it requires a shift in leadership mentality to put service excellence at the heart of everything the company does.

IN SERVICE OF THE CUSTOMER EXPERIENCE

Most people associate the services industry with organisations such as hotels, and food and beverage (F&B) outlets, and perhaps individuals such as personal fitness trainers and hairdressers. Indeed, these entities do not directly create a physical product that customers can hold in their hands in the same way Toyota might be seen as ‘assembling’ a car, or how Nike ‘manufactures’ sneakers for instance, or indeed any high street retailer that sells a variety of physical products.

But how would you classify Apple, a company that makes not only phones and computers but also fashions the services that run on its products? What about Lego, whose ostensible products are its much-loved plastic bricks, but which often ranks among the top few in rankings of companies according to the quality of their customer service?²

The fact is, all companies, whether they are business-to-business (B2B) or business-to-consumer (B2C), provide a service. The trend of servitisation has blurred the line between ‘product’ and ‘service’, and customers care little except for the experience of dealing with the company. For example, people who hail a ride on Uber or Lyft or similar apps hardly care that they are not in a taxi; instead, they prioritise efficiency and convenience. Travellers who choose Airbnb are looking for a different experience from staying in hotels—one where they get to holiday like the locals and experience the authenticity of a city. And, sadly for Borders, book lovers just wanted a convenient experience of getting whatever books they fancied delivered to their doorstep.

But while the customer experience is key to service transformation, it is often not as simple as it may appear on the surface. The service delivery chain is many a time a complex one made up of multiple parties. Online retailers often receive complaints of third-party logistics partners delivering parcels without recipients signing for them or leaving packages outside customers’ gates, risking damage to products. Online content providers could be hit by a server outage or cybersecurity threat, denying users the 24/7 access that they have come to expect. Or in the rising trend of connected retail, refusing an exchange at your physical outlet to a customer who bought an item from your website is a sure way to lose business, possibly forever.

Now imagine a scenario in which all the above problems never existed—no more missing or damaged parcels, service outages reduced to the point of being negligible, and a 100-percent no-questions-asked return/exchange policy. This might involve training and/or incentivising third-party partners to ensure safe delivery, spending on back-up servers and cybersecurity safeguards, and investing in back-end infrastructure and storefront personnel training to ensure a pleasant and connected retail experience respectively. If executed properly, these measures would likely create a positive customer experience and bring more business, not only from the customers in question but also those sharing their experiences on their social network.

But all that requires commitment to customer experience and financial investment. I once heard a conference speaker say, “Think of service as a profit tool rather than a loss leader,” which speaks to the unfortunate misperception that service is a drain on the bottom line, rather than a key driver for growing the business. Leaders who are committed to service excellence must think of service as a profit tool. However, it would be unsustainable to invest in improving the customer experience with no regard to the bottom line. Organisations must therefore decide how service initiatives can be funded by determining if customers are willing to pay a premium for better service, or if operational savings can fund service excellence initiatives.

Many small and medium enterprises (SMEs) also operate based on the business owners’ intuition and make decisions based on blind faith in their own assumptions. While intuition about what matters to customers is fine, it should be supplemented with a hypothesis that will test its assumptions using evidence.

DESIGNING THE SYSTEM FOR COLLABORATION

The importance of leaders who understand, and are committed to, service excellence cannot be overstated. ‘Service’ is often perceived as customer service or restricted to customer-facing functions within an organisation. Some of that thinking stems from Industrial Age constructs of ‘departments’ and ‘silos’ that still make up many organisations: Department A does one part in the production line and passes the product to Department B, which does further work before passing it to Department C to distribute it, and so on.

Industrial Age thinking also comes with command-and-control leadership, which is at odds with the increasingly complex world that is beyond the purported wisdom of any single individual. If one single person gets to decide how customer experience is delivered, there would be a lack of diversity in inputs when trying to forecast how a product or service might be received.

This way of organisational structuring makes collaboration difficult. Incentives are individualised whereby rewards are based on meeting individual departmental key performance indicators (KPIs). To embed a mindset of service

excellence into the entire organisation, leaders must figure out how to enable people to collaborate while bearing in mind one another’s responsibilities, all with the common goal of offering service excellence instead of meeting any individualised KPI.

Business leaders could learn from the Singapore Civil Service, which is designed to facilitate staff movement among the various ministries that are in charge of distinct functions. This personnel policy of rotation or secondment helps build an appreciation of what other ministries do and the problems they face.

One might point to the public sector’s lack of profit imperative which facilitates the policy of secondment, but that would be missing the point. Teams in the civil service consist of humans just like those in the private sector. It is the architecting of the system and leadership commitment that make this happen.

TRIPLE E TRANSFORMATION

To help leaders navigate the process of service transformation in their organisations, I propose adopting the Triple E Transformation Framework (refer to Figure 1) which entails three phases: Explore, Engage, and Expand.

This model serves as a guide to help businesses as they think through the process of service transformation. It attempts to spark basic thought starters and interjection points before big investments in capital are made. It is not meant to be prescriptive or linear.

THE TRIPLE E TRANSFORMATION FRAMEWORK

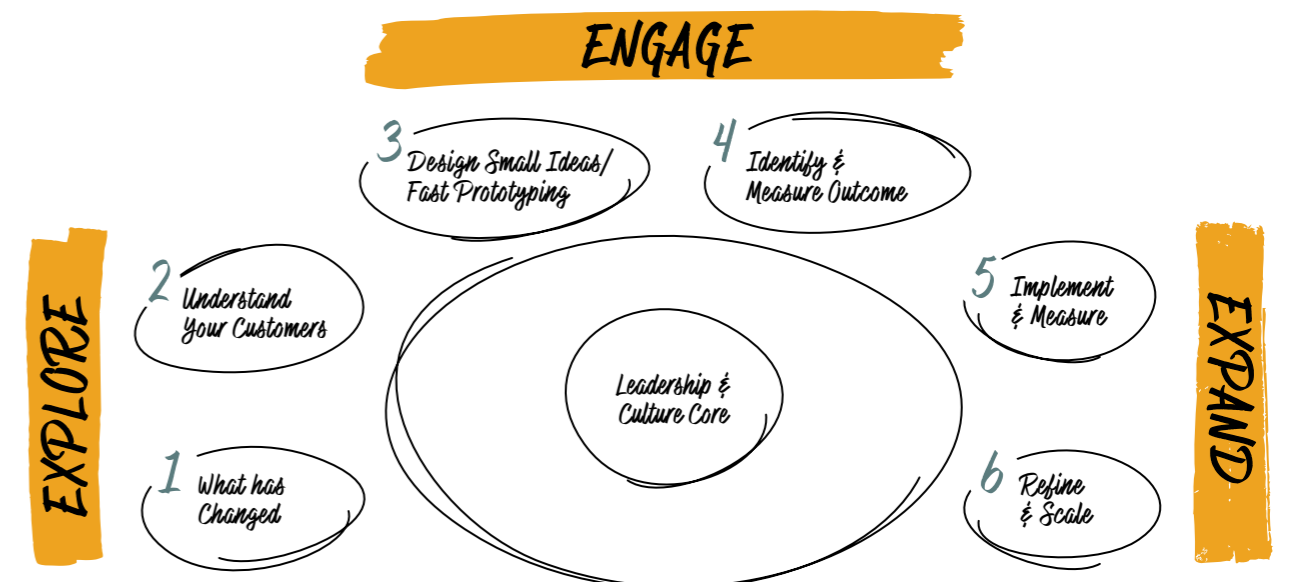
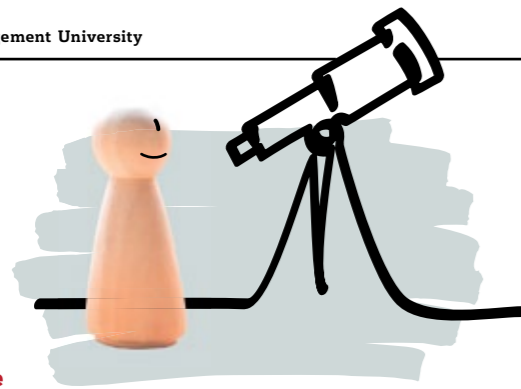


FIGURE 1

Source: Neeta Lachmandas-Sakellariou, “Stay Relevant to Stay Profitable”, World Scientific Publishing, 2023.



Explore

This phase is about assessing where your business is, and how the business environment and your customers have changed. Many business owners or decision-makers often jump into projects without making this assessment, which is akin to embarking on a journey without identifying the starting point. When you can better identify how your customers and their desires have changed, you will be better able to design products or services that meet their needs.

Atelier Carrie K. is a good example of how a thoughtful service transformation process can power a successful SME business to greater heights. Launched in 2009, Carrie K. has grown into a global brand offering silver costume jewellery with a playful touch. The Singapore-founded company's products can be found in several cities around the world, and is carried by stores like Bloomingdale's and worn by celebrities such as Mila Kunis and Angelababy.³

Carolyn Kan, founder of Carrie K., did a deep dive in 2019 to understand how she could improve the brand's service experience. She realised that sales from her costume jewellery business had hit a ceiling and felt that she needed to re-think their strategy for the next phase of growth. During the review process, Carolyn and her team asked themselves a fundamental question: How could they move the business of selling jewellery from being 'wants-based' to 'needs-based'? Where in the journey of her customers was there a need for jewellery?

Following in-depth discussions with her clients, at a time when the pandemic forced people to think about the meaning of life, relationships, and family, Carolyn discovered that there was a hunger for jewellery that could tell a meaningful story for both the giver and the wearer. This was especially salient during important occasions such as weddings and graduation ceremonies.

Carolyn also realised that her customers, many of whom are Asians, are proud of their heritage and see it as an important anchor in their lives. However, Asian jewellery designs are often traditional and old-fashioned, and are thus bereft of modern appeal. Therefore the challenge for Carrie K. was to create a line of jewellery that is timeless at heart yet has the versatility to change with evolving times and trends.

The result was a line of jewellery that could be deconstructed. Such jewellery could be added on to look substantial for an important event like a Chinese wedding tea ceremony. It could also be deconstructed and simplified for daily wear.

Engage

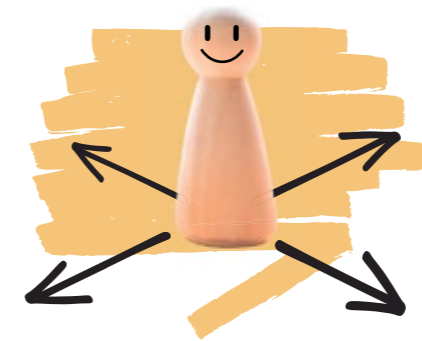
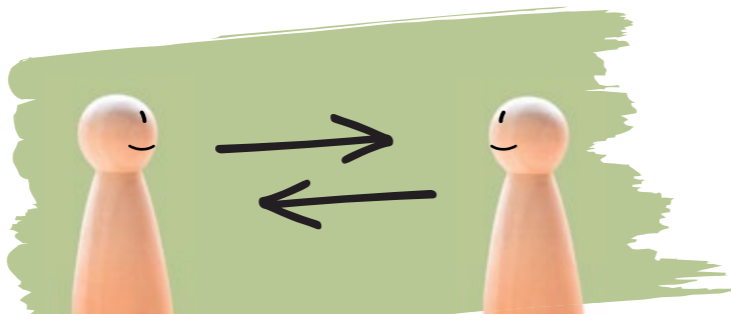
The Engage phase is about trialling ideas generated from the Explore phase to see what works. Organisations could put together a team or build a minimum viable prototype (MVP) to test out an idea or hypothesis. By putting in place a system of measurable outcomes or initial success parameters, ideas can be iterated and assessed for success.

Carolyn thus followed up on the Explore phase and created a few pieces to test her ideas and engage with clients. The objective was to understand what types of traditional gemstones were most popular and meaningful, the kind of emotions the jewellery needed to evoke, and which modern-traditional blends made the most sense.

The response was positive and encouraging, and Carolyn was getting referrals from customers whose friends were getting married or approaching important milestones in their lives. This gave the team at Carrie K. the confidence that they were on the right track in redefining the service and customer experience.

Another important component of this change was also understanding the journey of a potential customer. Carolyn and her team started to understand that prospective customers often had a more enduring relationship with them before making a purchase. In fact, she found that some customers had been engaging with the brand for over a year before they actually made a purchase. Hence the process of building trust and understanding between the Carrie K. team and these customers was as important as the actual sale.

As a result of this, Carrie K. started offering ancillary services such as workshops on gemstones and jewellery fashion trends. The team was also trained to give advice on selecting jewellery, instead of simply pushing customers to close a purchase. The focus has thus shifted to educating and providing advice.



Expand

The final phase is launching a new product or service. By this stage, there should be some degree of confidence based on the Explore and Engage phases that the product or service has the capability of meeting a set of needs and can be scaled up. During this phase, what consumers see might not be the final product but the 'beta test' trial options. Companies will gather feedback first and see which version was better received before scaling up for the final release.

The new Carrie K. line was subsequently re-launched. All stocks of the previous Carrie K. jewellery were recalled globally. The focus was now on creating modern heirloom fine jewellery with a twist by giving traditional gemstones and materials, such as jade and pearl, modern meaningful designs. Investment in Computer-Aided Design (CAD) and three-dimensional (3D) prototyping facilities enabled Carrie K. to produce more innovative and versatile pieces which could be used in various ways. The resulting deconstructed designs give the wearer the ability to add and take away different elements in each piece of jewellery, allowing creativity in putting them together.

In the process, Carolyn and her team put in a series of measurements to quantify and track the progress that they were making. These included metrics for customer satisfaction, personal engagement with clients, as well as marketing channels and engagement effectiveness.

LEADERSHIP AND CULTURE LIE AT THE CORE

Why are some service transformations successful while others are fraught with obstacles and problems? Sitting at the core of an organisation's ability to change is the leadership team's effectiveness in fostering a culture where change is not seen as something to be feared and resisted. This is often harder than imagined. Most of us are hardwired to see our roles through certain lenses and perform our tasks in a certain way. It is therefore imperative that the leadership team build a culture where employees feel safe and even empowered to transform their work.

Carolyn understood quickly that successful service transformation required a culture change in the organisation. That started with Carolyn changing her management style and

creating a safe environment where there was open sharing without judgement, and a more consultative environment in which management was, in her words, "much more vulnerable". To enable the change to take root, new opportunities to reinforce and share the culture were created. This included an onboarding programme for new staff, the creation of team coaching workshops, and the provision of managers with training to give and receive constructive feedback.

On the whole, the transformation has been successful for the company. Whilst the change is still fresh and the business had to contend with the COVID-19 pandemic which severely impacted the retail business, revenue has gone up. Most importantly, the transformation has given Carolyn and her team a fresh understanding of the purpose and meaning of their work.

CONCLUSION

The last 20 years have brought about enormous changes in the way we consume products, much of it driven by changing technology and evolving customer habits. Business leaders often complain that customers are excessively demanding, but the truth is customers just want to be treated like they are valued. Not enough businesses make customers feel that they appreciate their business. By focusing on the customer experience, co-creating the service experience with them, and adopting the customer's perspective, businesses can set in motion a change in culture. That has the potential to transform an organisation into one that not only rides on the wave of Internet-wrought changes and business model innovations, but also continues to be relevant to its customers.

And when in doubt about taking the customer's perspective, remember this quote from Harvard Business School's Professor Emeritus Theodore Levitt, "People don't buy a quarter-inch drill. They want a quarter-inch hole!"¹

Neeta Lachmandas-Sakellariou

is the Founder of ConsciousService, a training and consulting company focused on building service excellence in organisations. She was formerly the Executive Director of the Institute of Service Excellence at Singapore Management University and the Assistant Chief Executive of the Singapore Tourism Board. She is also the author of the book, *Stay Relevant to Stay Profitable*, published by World Scientific Publishing.

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EyRIS: From the Lab to the Market

Singapore's trailblazer AI algorithm for detecting diabetes-related eye diseases.

by **Steven M. Miller, David Gomulya, and Mahima Rao-Kachroo**

Can you imagine getting the results of your eye disease screening within minutes rather than days? This capability is what EyRIS, a Singapore-based start-up that uses the AI (Artificial Intelligence)-driven Singapore Eye LEsion Analyzer (SELENA+) algorithm to screen for diabetes-related eye diseases, set out to productise and commercialise.

SELENA+ was designed to screen for diabetic retinopathy¹, glaucoma and age-related macular degeneration (AMD).² The AI algorithm had proven that it could detect the early onset or presence of such eye diseases with speed and accuracy. The ready availability of such eye disease screening, and hence disease detection, would reduce the extent of vision degradation or loss related to these three eye diseases across populations in various countries or regions.

Jointly developed by the Singapore National Eye Centre (SNEC), Singapore Eye Research Institute (SERI), and the National University of Singapore (NUS) School of Computing, the SELENA+ algorithm leveraged a deep learning (DL) system. This approach used multiple layers of neural networks to probabilistically learn and identify complex patterns and relationships in data to analyse retinal images and detect eye diseases. Like other DL systems, the more high-quality retinal image data SELENA+ was trained on, the more it learned to improve its ability to accurately detect the eye diseases it was screening for.

In early 2018, the company EyRIS was incorporated in Singapore by a founding team of eight members to transition SELENA+ from a research and development (R&D) project to a commercial product that could be marketed and used in Singapore, as well as internationally. Seven of these co-founders were from the SELENA+ research team, which included ophthalmology researcher and clinician Dr Wong Tien Yin, the lead principal investigator for SELENA+, three other healthcare professionals from SNEC and SERI, and three computer science researchers from the NUS School of Computing. The eighth member was Lai Teik Kin, a health technology entrepreneur who became the founding CEO of EyRIS.

This article details the two-decade journey that led to the development of SELENA+, the establishment of EyRIS, and how the company addressed some of the many challenges it encountered as it launched and strove to develop a base of customers and draw in revenue.

THE GROWING USE OF AI SUPPORT TOOLS IN SINGAPORE HEALTHCARE

In recent years, the Singapore government had decided to leverage DL-based AI systems to improve healthcare delivery across the public healthcare system. Singapore's ageing population already had a high prevalence of chronic diseases, including diabetes. This substantially increased the load on public healthcare facilities. To better manage the increased load, government agencies looked toward the impressive predictive capabilities of DL-based AI systems, which were viewed as a strategic tool that could make certain diagnostic health screenings more accessible and cost-effective. Together with the Integrated Health Information Systems (IHIS)³, Singapore's national health technology agency, the government initiated the use of DL-based AI systems in multiple healthcare applications.⁴ One such initiative under Singapore's Ministry of Health (MOH) involved multiple healthcare research and clinical institutions using image-based algorithms to analyse retinal images to screen for eye diseases often associated with diabetes.

DIABETES-RELATED EYE DISEASES IN SINGAPORE

Diabetes has been a growing health concern for the Singapore government. It was estimated that one in three Singaporeans was at risk of developing the disease.⁵ When studies showed that diabetic retinopathy-related vision loss could be prevented with early detection, MOH launched a national-level diabetic retinopathy screening programme as part of its broader nationwide 'War on Diabetes' in the late 1990s. The eye-disease part of this diabetes treatment strategy involved annual screenings for diabetic patients to catch the onset of diabetes-related eye diseases.

Eye screenings were conducted by family physicians who had basic training in diabetic retinopathy grading. Results often took two to four weeks to be returned to the patient, and had a high number (sometimes as high as 38 percent) of false positives, as the physicians tended to err on the side of caution.⁶

Singapore Integrated Diabetic Retinopathy Programme

To address the issues of long turnaround times for diagnostic reports, variability in interpretations across physicians, and false positives, MOH together with several healthcare public sector units started a pilot version of the Singapore Integrated Diabetic Retinopathy Programme (SiDRP) in 2010, expanded it, and officially launched the effort in 2012. Through special infrastructure created to support SiDRP, retinal images were

transmitted to a centralised facility via a tele-ophthalmology network. All of these images were reviewed by both a trained Level I human 'grader' (assessor) and an expert Level II human assessor. This ensured a more standardised and controlled process of evaluation by trained human image assessors. This new process eventually led to many advantages. Turnaround time improved significantly from two to four weeks originally to one business day, and often within an hour. The costs of eye screenings also substantially decreased.

SELENA+ AND THE JAMA PUBLICATION

In the early 2000s, Dr Wong and two NUS computer science professors, Dr Wynne Hsu and Dr Lee Mong Li, worked together to develop software algorithms to analyse retinal images for common eye diseases. In 2014, ophthalmology researcher and clinician Dr Daniel Ting, who had also been investigating the use of AI-based software algorithms to analyse eye images as part of his ongoing PhD work, joined the effort. The expanded team created a next-generation, deep-learning-based retinal image analysis system called SELENA+.

To train SELENA+, the team utilised the retinal images which had been collected, labelled for the three eye diseases, and then graded during SiDRP's initial years. As the SiDRP effort continued from 2012, multiple healthcare clusters⁷ and IHIS worked together to improve the procedures and standardise the workflows associated with the eye screenings. The SELENA+ R&D team used not only high-quality Singapore-based SiDRP data sets, but also several other international data sets that included other ethnicities beyond those in the Singapore sample, to train, test, and evaluate the system. This combination of using the newest generation of DL methods and high-quality data sets led to the success of SELENA+.

The SELENA+ R&D team submitted their findings to the *Journal of the American Medical Association (JAMA)*, a prominent, high-impact medical research publication. Much to their elation, after a lengthy review process, their results were published in December 2017. The *JAMA* publication was a feather in their cap, as it showcased both the robustness of their results and the rigour of their approach. It validated the software and gave the team a higher standing in the international medical science community, as well as in Singapore's domestic R&D funding community. The team also noticed that applying for R&D grants to refine and more extensively test SELENA+ became easier as the publication helped with securing buy-in from MOH. It also further set the stage for moving ahead to follow on commercialisation and regulatory approval efforts.



Eye screenings were conducted by family physicians who had basic training in diabetic retinopathy grading. Results often took two to four weeks to be returned to the patient, and had a high number of false positives, as the physicians tended to err on the side of caution.

not only a wider audience including private sector healthcare providers in Singapore within SiDRP, but also internationally. SELENA+ seemed like a good solution to meet eye disease screening needs for countries with underserved population segments and overburdened medical staff.

In 2016, Lai Teik Kin, a healthtech and IT entrepreneur with business interests in Singapore and the region, was appointed as a business mentor by SNEC. The SELENA+ research team required commercialisation help and Lai was looking for new business prospects.

Based on discussions with the relevant Singapore authorities, the SELENA+ members became aware that marketing their software had to be done by an independent start-up entity. This was because commercial products could not be marketed by a government healthcare institution, or by a government-sponsored university like NUS. Furthermore, a separate commercial entity was required to apply for regulatory approval. Without such approval, SELENA+ could not be used on an operational basis to support the SiDRP effort, nor could it be commercialised. But first, they needed a CEO for the start-up.

Lai threw his hat into the ring and submitted a business plan for evaluation. He became the founding CEO, and the start-up entity was named EyRIS. In February 2018, the company was officially incorporated as a private limited company in Singapore, partly owned by Lai's healthtech and software technology company novaHEALTH Pte Ltd. EyRIS became the official licence holder for SELENA+ in September 2018 after working out the intellectual property licensing terms with SERI and NUS.

R&D testing of SELENA+ in SiDRP

Given the R&D progress that had been made with SELENA+ as demonstrated by the *JAMA* publication, the natural next step was to use the system within SiDRP. As SELENA+ was still an R&D effort under evaluation, human graders were required to do first- and second-level image evaluations. SELENA+'s results were generated and checked against the human assessors' results.

SELENA+ was tested within SiDRP during 2018 and 2019. This created extra work for the human evaluators and supervisory staff at the centralised image assessment facility. Not only did they have to complete their existing workload of analysing regular evaluations, but they also had to compare their evaluations to those generated by SELENA+ and note if the human-versus-AI algorithm results agreed or disagreed. However, this was the safe and assured way to pilot-test SELENA+'s capabilities in a situation that was very similar to under real-world operating conditions. Towards the end of 2019, this one-year testing effort concluded with an overall positive assessment of SELENA+'s capabilities and performance.

EyRIS

In parallel, while SELENA+ was being tested, the research team felt that the SELENA+ algorithm had real-world applicability. As a commercial product, it could be used by multiple parties,

Regulatory approval in Singapore

To commercialise SELENA+, which was previously only used in R&D studies, the EyRIS team had to first apply for regulatory approval. It was a first for both—the Singapore medical regulatory authority receiving a request to approve an autonomous AI software system as a medical device, and EyRIS making a regulatory submission. Dr Gavin Tan, who was Clinical Director of the SNEC Ocular Reading Centre, often accompanied the EyRIS commercial team for their meetings with the Singapore regulatory authorities, and played an important role in answering medical and operational queries regarding screening and image evaluation, during the back-and-forth clarifications between EyRIS and the medical device regulator. EyRIS finally submitted its documents for regulatory approval in July 2019, and in October 2019, it was granted approval to use SELENA+.

This was an important milestone for EyRIS as it could now productise the software for operational usage in Singapore’s public healthcare sector via SiDRP and also in the private sector. Regulatory approval had another practical advantage. It eliminated the need for each patient to sign a consent form that granted the research team permission to use SELENA+ to analyse the patient’s eye image as part of a research study.

However, regulatory approval came with its own caveats. The team discovered that every time it fine-tuned SELENA+, it had to do so within a well-defined ‘limit’. If the changes exceeded this limit, they were considered a major modification, or the newly-revised algorithm was considered a new product altogether. Both scenarios would have required new submissions for regulatory approval. Hence, modifications to improve SELENA+ had to be very carefully targeted.

EyRIS introduces SELENA+ to the market

While Team EyRIS aimed to offer its software as a product to the public and private sectors, it knew that scalability in Singapore would initially come through public sector sales. Hence, after receiving regulatory approval, it commenced parallel discussions on deployment-related technical, regulatory, governance and commercial issues with IHiS, and with the two public healthcare units that would make direct use of SELENA+ as part of SiDRP, the centralised Ocular Reading Centre at SNEC (under SingHealth), and at the National Healthcare Group Eye Institute.

One of the more complex governance issues that had to be worked out was how to arrange for independent evaluation by knowledgeable medical staff at these two public healthcare institutions who had no direct interest with SELENA+ or EyRIS, especially given that four of the EyRIS founding team members were staff members of SNEC, and had been deeply involved in various aspects of SiDRP and SELENA+. It was critical for these evaluations to be above board to avoid any conflict of interest. Another complex issue was working out the proper procurement processes and evaluations for a multi-year exclusive contract. A third complex issue was preliminary planning for how SELENA+ would be integrated and used within the overall SiDRP process, as this would influence technical, regulatory, and commercial issues.

Obviously, these types of investigations and negotiations were complex, and would take a long time to come to fruition and yield revenue. During that time, the use of SELENA+ was put on hold within SiDRP. Then, in November 2019, the Singapore Smart Nation and Digital Government Office (SNDGO) released a national AI strategy document that mentioned the usage of SELENA+ as part of SiDRP as a marquee example of a national AI initiative in the country’s healthcare sector.⁸ This was an acknowledgement that Singapore’s public healthcare sector would likely be embracing the use of SELENA+.

At the same time, the team looked at selling SELENA+’s solutions to Singapore’s private sector market to generate near-term revenue. In January 2020, EyRIS signed a contract with the Singapore Optometric Association, which established the company’s very first stream of revenue. It had not come easily, as ironically, many private optometry practitioners were worried that the algorithm would eat into their existing revenue streams, while public healthcare sector practitioners were overwhelmed by the sheer number of eye disease screenings that had to be done. By September 2020, 23 private optometry shops had signed up to use SELENA+ to offer eye disease screening as a supplemental service.

While negotiating for licensing and usage within Singapore, the team also actively explored the possibility of entering international markets. After receiving Singapore’s regulatory approval, it prepared regulatory submissions to healthcare regulatory authorities in Malaysia, Brazil, Indonesia, and the European Union (EU). Singapore’s regulatory ‘stamp of approval’ was an important enabler in gaining the eventual approvals that followed.

Incorporating SELENA+ into SiDRP as an EyRIS product

Finally, in September 2020, IHiS signed a five-year contract with EyRIS to deploy SELENA+ within the SiDRP national screening programme. This was the world’s first implementation of an AI-driven software in a national screening programme. IHiS would pay EyRIS fees for up to 120,000 annual SiDRP screenings.

After finalising the contract with IHiS, another year-long phase of testing started in December 2020. It focused on the detailed operational aspects of how to integrate the SELENA+ system into the overall SiDRP data flows and work processes, and also how to combine the capabilities of both the human assessors and the AI system. SELENA+ was used to provide a ‘preliminary assessment’ of the retinal image and pre-populate parts of the SiDRP evaluation report template, followed by an accuracy check by both a Level I and Level II assessor.

This hybrid machine-human approach allowed the SiDRP effort to scale to higher levels of daily throughput and yearly output, and at the same time, provided a cautious pathway for assuring quality, managing risks, and gaining more real-world operational experience. It was envisioned that human labour requirements for Level I screening would gradually decrease as SELENA+’s performance within SiDRP was further fine-tuned and incrementally improved. A number of private sector clients chose to use SELENA+ in either a semi-automated mode or a fully automated mode as it had received regulatory approval to be used as a diagnostic screening device in this

fashion. This was especially since they did not have the resources and infrastructure of Singapore’s public healthcare system to use SELENA+ with Level I and II human assessors.

Despite the successes involved in using SELENA+ within SiDRP, some public healthcare system patients pushed back on the use of AI for their eye screening diagnosis. This concern was managed by informing them that the SiDRP screening process involved two levels of human image evaluation in addition to the first level algorithm assessment.

Strengthening and expanding EyRIS’ business development

To drive EyRIS’ business expansion, which included obtaining regulatory approval overseas, Lai invited dentist and oral surgeon Dr Steven Ang, who had entrepreneurial interests, to help him with his business development efforts. In April 2020, Dr Ang joined novaHEALTH, EyRIS’ parent company, and eventually was transferred to EyRIS to head its business development department.

The EyRIS team also explored leveraging relationships with companies that manufactured the special cameras used to capture retinal images. In November 2020, EyRIS signed a deal with one such manufacturer, Topcon, whereby the latter explored using SELENA+ software in the 18 Asian countries where it had a presence. However, this did not take off and Topcon eventually faded as a potential EyRIS customer and marketing channel. A private-sector expansion strategy that did gain traction though was inking agreements with international optometry professional associations, large optometry practices, and diabetes prevention associations. This approach yielded successful revenue-producing business relationships for EyRIS across multiple countries and in Singapore as well.

Between 2021 and 2023, EyRIS successfully gained traction in its regulatory, marketing, and commercialisation efforts. By early 2024, it had received regulatory approval from seven countries (Singapore, Malaysia, Indonesia, Thailand, Australia, Brazil, South Africa), Dubai, and also from the EU member countries. The team had also developed multiple partnerships and collaborations with medical institutions, health ministries, optometry clinics, and other relevant distribution channels in these and other countries.

Even with this level of progress, EyRIS faced many challenges in expanding its market reach. SELENA+ was by no means the only recognised player in the global market for using an AI-led software medical device to screen for diabetic retinopathy, or other eye diseases such as glaucoma or AMD.

A private-sector expansion strategy that gained traction was inking agreements with international optometry professional associations, large optometry practices, and diabetes prevention associations.



When evaluated by a research study back in 2021, a number of the other algorithms (excluding SELENA+) were found to not be “performing consistently”.⁹ The inconsistencies were attributed to the lack of testing protocols and insufficient patient diversity. Such studies reiterated the need for a cautious approach when using such systems in the medical community.

Dr Ang had to keep assuring his potential international customers of SELENA+'s validation and ongoing refinement in the Singapore public healthcare setting, and therefore, its quality and reliability. He further highlighted his acknowledgment that *any* means of making a prediction about the presence of a disease (either by a human expert or an AI algorithm) was imperfect and thus had some degree of associated error.

Adoption and business model challenges

As Dr Ang proceeded with EyRIS' business development efforts, he and his team realised that the challenge in scaling up EyRIS' operations was not predominately technological, but rather, it had a lot to do with changing the mindsets of various stakeholders and finding practical ways to realise workable win-win business models with its customers.

A commonly occurring obstacle was the cost involved in adopting the system if the client did not already own the necessary specialised camera—a fundus camera—for taking pictures of the interior of the eye (other key costs were licensing and service fees from EyRIS). A typical table-top fundus camera often costs between US\$10,000 and US\$30,000. For many smaller businesses, especially those in undeveloped countries, this was a rather prohibitive upfront cost.

To reduce the upfront cost of SELENA+'s adoption, Dr Ang contacted camera manufacturers in India which had created fundus cameras that could be attached to a commercially-available mobile phone such as Apple's iPhone. He worked with one of these manufacturers to customise a lower-cost solution that could be used with SELENA+. Dr Ang also created a subscription model where a client could lease the smartphone-based fundus camera for two years, for an upfront payment of US\$1,500. Of this, 30 percent would go to the Indian camera manufacturing partner and EyRIS could keep the rest. The subscriptions could be renewed thereafter. This approach also provided an added benefit: the mobile phone fundus cameras could easily connect to and transmit retinal images over the Internet in any country through the local telco operators or Internet service providers. Once the images

were transmitted, EyRIS' cloud system for SELENA+ did the evaluation and sent back the results.

Dr Ang continued to investigate local conditions across a variety of overseas markets, each with their unique set of circumstances. In some places, there was a business opportunity to take a mobile eye imaging camera to the patient. On the other end of the spectrum, some potential customers enquired if they could have a fully automated eye screening station at a fixed location where the patient could undergo screenings. The company also worked on the development of this type of solution with a manufacturing partner.

The team also kept working to further ensure the accuracy of the algorithm. Dr Tan, who was on EyRIS' advisory board, played a key role in the ongoing endeavour to incrementally improve the performance of SELENA+ in ways that remained within the scope of the regulatory approvals. Haslina Binte Hamzah, the Assistant Director at SNEC and one of the co-founders of EyRIS, oversaw the testing of the SELENA+ algorithm with various new types of cameras. Each time the team used a different camera brand, model, and lens, Haslina and her staff made validation adjustments to the disease threshold classification to reduce errors induced by hardware performance issues.

And since he joined the EyRIS effort, Dr Ang and his business development team had to figure out multiple ways to make the eye disease screening capabilities of SELENA+ more accessible and affordable to accommodate the varying needs of a wider range of customers.

LOOKING AHEAD

Team EyRIS recognised that, indeed, achieving success in Singapore's healthcare setting was a tough, multi-faceted affair. From a business perspective, it was essential to convince the government in each country it ventured to about the usefulness of its software, as adopting AI technologies in Asia depended on government-led deployment, given that many countries lacked private sector resources. And all these governments wanted to know the same thing: How has Singapore used this technology? That is why SELENA+'s incorporation into SiDRP was so strategically important for EyRIS.

Dr Wong concluded, “There are always three parties that needed convincing—the patient, the doctor, and the government. The patient had to be told what to do, the doctor could only be convinced of the technology if there was strong evidence to back it, and the government's adoption of the technology depended on the savings it accrued.” He further ruminated


and added, “...the heavy upfront investments, the paperwork, the quality checks, the algorithm itself, the hardware issues, the market decisions—there were so many mountains to climb.”

Nevertheless, the team counted itself lucky for all the national R&D funding and public healthcare institutional support it had received, and Dr Wong acknowledged that “without the strong backbone-like support from the government, this would not have worked”.

Looking ahead, the EyRIS team faced a number of questions. From a product perspective, should it focus on marketing diagnostic screening for eye diseases with its existing SELENA+ product, concentrating on creating additional ways to achieve workable business models and offer easier access? Or should it put in more effort into exploring diagnostic screening for other parts of the body such as the brain or kidney via the analysis of eye images though using different AI models (not SELENA+) trained specifically to detect these other types of diseases? It had looked into these types of possibilities, and even licensed another Singapore R&D solution in this space. It also wondered if it should venture into image-based diagnostic screening that was unrelated to eye image evaluation such as screening for melanoma, a type of skin cancer, as this was also an area in which it had done some exploration.

Also from an AI technology perspective, while SELENA+ was built with DL-based methods that were state-of-the-art in 2015, there had been substantial technological developments in this area that had occurred from 2018, including the use of the transformer architecture. Such technological developments coupled with rebuilding and retraining efforts had the possibility of making further performance improvements to SELENA+'s diagnostic accuracy. However, making such major changes to the existing SELENA+ software required new regulatory approvals. The team pondered over the cost of obtaining such approvals vis-à-vis the business benefits to be gained from doing so.

It also wondered if its strategy for international expansion should be concentrated on a focused subset of countries clustered in a few geographic regions, such as Southeast Asia and the Middle East, or if it should take a more expansive, global approach that would expand the addressable market but lead to more head-to-head competition with other international competitors.

Team EyRIS had tasted early signs of success, and at the same time, faced various barriers to expansion. How could it push forward, given the pathways it had already identified? 

Dr Steven M. Miller

is Professor Emeritus of Information Systems at Singapore Management University

Dr David Gomulya


is Associate Professor of Strategy & Entrepreneurship at Singapore Management University

Mahima Rao-Kachroo

is Case Writer with the Centre for Management Practice at Singapore Management University

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- ² CNA, “In a World First, Singapore-Developed Artificial Intelligence System Detects 3 Major Eye Conditions”, December 14, 2017.
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- ⁵ Ministry of Health Singapore, “Diabetes: The War Continues”, August 22, 2017.
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NAVIGATING THROUGH CHAOS

How AI and optimisation models can strengthen supply chain resilience.

by Lau Hoong Chuin

COVID-19 unleashed a wave of lockdowns globally that brought unprecedented supply chain disruptions between 2020 and 2021. The resulting estimated annual losses at some of the world's largest organisations topped US\$184 million during that period, with 2022 bringing some relief and an average 50-percent reduction in red ink.¹ Even Toyota, the inventor of the 'just-in-time' system of supply chain and inventory management, told its semiconductor suppliers to increase their customary three-month inventory levels to last them for five months in a bid to strengthen its supply chain resilience.²

In a joint project by IBM and Singapore Management University (SMU) that commenced in 2021, my colleagues and I developed a data-driven Artificial Intelligence (AI) optimisation model that considered the likelihood of COVID-19-related lockdowns in various cities where IBM sourced its hard disk drive (HDD) components. The model improved IBM's supply chain resilience, helping it save US\$1.8 million in the first year, and is projected to save up to US\$35 million annually across the entire IBM infrastructure globally.³ This project also won the 2023 Manufacturing Leadership Council Award in the Digital Supply Chains category.⁴

In this article, I will explain how we leveraged the power of AI to quantify risks to the supply chain and develop a scenario-based optimisation model. We also discuss how organisations can adopt the technology going forward.

BUILDING OUR MODEL: THE SCENARIO-BASED OPTIMISATION APPROACH

When considering possible supply chain disruptions, organisations traditionally look at the occurrence and frequency of situations such as natural disasters (earthquakes, floods, typhoons, etc.), labour disputes (strikes), and government policy adjustments (tax exemptions, tariffs, etc.). These geographical, political, and economic uncertainties are the traditional markers of risks associated with buying from any individual supplier, and years of data have been collected and built up to form a basis for risk assessment.

When the COVID-19 pandemic hit the world with full force in 2020, the questions became: How do you accurately predict such 'black swan' events, including the lockdowns? What data do you need to make such predictions? Companies that straddle cross-border supply chains were particularly vulnerable and had to come up with a quantifiable way to measure risk and use that information to formulate their procurement strategy.

For any organisation that brings together hundreds, or even thousands, of parts to make a final product—automobiles, high-end computer servers, mobile phones, etc.—supply chain resilience is much desired. Figure 1 illustrates what we did to help IBM build its supply chain resilience.

Under the 'General Risk Criteria', we considered standard risks, which were supplemented by the emerging COVID-19 risks such as border restrictions, factory closures, and regulatory changes that took centre stage during the pandemic. As part of its operating procedure, IBM has assembled a wide array of information sources that includes macroeconomic data from the EIU (Economist Intelligence Unit) database; manufacturing and catastrophic data from the proprietary, cross-tier customer-supplier collaboration platform Resilinc database; together with data available in the public domain that assesses, but is not limited to, natural disasters, geopolitical (US-China 'country-of-origin' tariffs) issues, and other factors that might affect the supply chain.

We analysed this data and the information presented by the COVID-19 data. We looked at 19 risk criteria that included political stability, tax policy risk, and natural disasters. We then applied a dimension reduction technique—factor analysis—to represent the data using just a few latent variables that can explain the correlations among these risks, with the final product being a number (ranging from 0.01 to 0.99) that describes the degree of correlation among the 19 risk factors.

All that information, which includes the probability of any single event happening, was crunched to produce a supplier risk score, which was then fed to the risk-constrained optimisation model that my colleagues and I developed for the project.

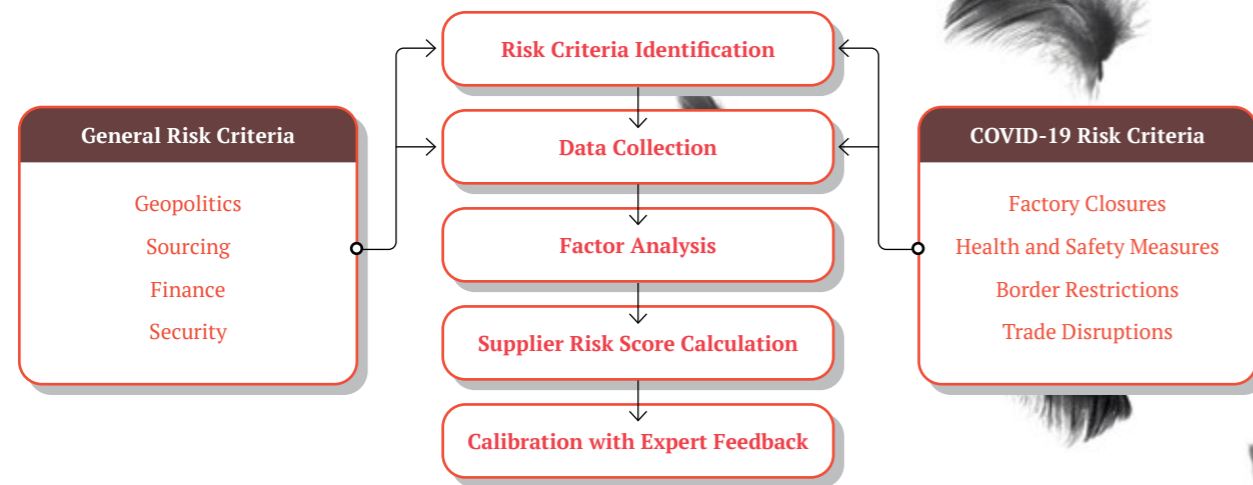


FIGURE 1

Source: Jonathan Chase, Jingfeng Yang, and Hoong Chuin Lau, "Risk-Aware Procurement Optimization in a Global Technology Supply Chain", International Conference on Computational Logistics 2022.

Thus, as observed from above, the COVID-19-related factors were not used to calculate the risk scores. Instead, they were used to generate scenarios for the scenario-based optimisation models. In other words, there are two categories: the traditional factors that contributed to the supplier risk scores, which were used in the optimisation model, and the COVID-19 factors which contributed to the scenarios that were fed into the model.

A key consideration for using the optimisation model is the presence of multiple suppliers for a specific interchangeable or replaceable component. Assuming a high-end computer server consists of 1,000 parts and each part is produced by multiple suppliers in various locations, a manufacturer must then decide how many units to buy from a specific supplier. If the supplier produces multiple necessary components, should the manufacturer procure from it more than just one component? One could adopt a broad-stroke approach by excluding all suppliers in locations that have experienced multiple lockdowns, but that is a coarse-grained way of decision-making.

Also, because our scenario-based optimisation approach is based on a high-fidelity model that is as close as possible to real-world uncertainty, we would be able to predict, with some scientific backing, the trigger and duration of lockdowns. The idea is that such a model can help inform the decision of which supplier to buy from, and how many units to buy, in anticipation of future lockdowns.

To illustrate, let us single out a single product we shall call Product Z1234, which is produced by 42 suppliers in our project. These suppliers are anonymised except for the country

where they reside. Their risk scores are computed using our optimisation model, and then ranked based on COVID-19 factors such as lockdowns. When these same 42 suppliers are assessed on traditional risk factors, we find that those in China have significantly higher COVID-19-related risks vis-à-vis those in other parts of the world such as North America, Central America, and other parts of Asia.

Securing the necessary COVID-19-related data was key. Our project is built on epidemiological data that illustrated patterns of infection, lending themselves to inferences of how subsequent lockdowns may play out (e.g., when lockdowns will be triggered, how long they will last, etc.). We built on existing works to determine the infection rate,⁵ while we developed a regression model to predict the duration of the lockdowns.

Hence, while we used historical data that is available online to build our optimisation model,⁶ in future cases where data might not be readily available, organisations might need to provide a 'best-guess' estimate to run the model.

DEPLOYING SCENARIO-BASED OPTIMISATION MODELS EFFECTIVELY

High-end hardware can cost upwards of thousands of dollars, which translates into millions saved—or wasted—when factoring in the scale of multinational heavyweight companies. Efforts to realise such savings must take into consideration existing customer demand, supplier obligations and inventories. The objective is to strike a balance between cost and resilience.

The findings of my project are applicable so long as there is a large number of parts or components that interact with one another such that an optimisation approach is deemed

Because our scenario-based optimisation approach is based on a high-fidelity model that is as close as possible to real-world uncertainty, we would be able to predict, with some scientific backing, the trigger and duration of lockdowns.

necessary. For companies looking to adopt a risk-based approach to procurement and supply chain resilience, having the right data will be key. Readily available information such as the identity of suppliers, the parts/components they supply, the frequency of orders, and the price, along with other key data, will improve the accuracy of the model.

For smaller companies without the resources of global heavyweights such as IBM, there are open data sources such as Open Data Watch from which one can find valuable information.⁷ Open-source initiatives proliferated during the pandemic, which led to innovative projects such as the Theia thermometer⁸. Resourceful use of such free and low-cost options can also produce concrete results.


CONCLUSION

Going forward, organisations large and small can look at scenario-based optimisation models beyond the context of COVID-19. The world may have seen off the last pandemic but the preparedness and resilience of businesses for the next one is unknown. The attack on commercial shipping traffic in the Red Sea is the latest reminder of the unpredictability resulting from geopolitical tensions, while the increased occurrences and severity of extreme weather have placed added demands on supply chain resilience. At the very least, such models represent a ready fallback if and when a pandemic-like event wreaks havoc on global supply chains.

A well-designed AI-based optimisation model can be adapted for use in fields beyond business. For governments, the scramble to procure masks, vaccines, and food supplies in early 2020 drives home the point that the 21st century is a

time of vulnerability. Those without a resilient model will be in for surprises, often unpleasant. Procurement strategies at a national level are essential. Early adoption of such strategies and models provides opportunities for feedback and refinement, thus enhancing resilience.

COVID-19 has caused the biggest shock to global supply chains in recent years, and multinational companies have learnt invaluable lessons dealing with the unprecedented scale of disruption. Moreover, AI technology has developed sufficiently to take into account a wider array of data than had been available ever before. In the case of our project, that data—infection rate, duration of lockdowns, etc.—is used to build the scenario-based optimisation model into which traditional data is fed to derive a quantitative score to help smooth out possible kinks in the supply chain.

Such a scenario-based approach can help planners make more risk-tolerant, cost-effective global supply chain decisions. It can also be applied to other situations where traditional and plentiful historical data can be allied with AI to help with decision-making. Access to reliable data will be key, but there are plenty of publicly available sources. Decision-makers, be they in private or public organisations, would do well to invest in such capabilities before the next black swan event hits. 

Dr Lau Hoong Chuin

is Professor of Computer Science at Singapore Management University.

He is also Senior Principal Scientist at A*STAR Institute of

High Performance Computing

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The Chatbot Challenge:

How SMEs Can Leverage AI for Growth and Engagement



Enhancing SME workforce efficiency with chatbots for improved business communication.

by Tamas Makany and Felicia Goh

Chatbots have experienced explosive growth in the last decade, with the global market expected to grow from US\$190 million in 2016 to a projected US\$1.25 billion by 2025.¹ In Asia, the use of this technology surged notably during the COVID-19 pandemic when some 63 percent of Internet users interacted with businesses in this manner.² From ChatGPT to Google Bard to many other Artificial Intelligence (AI)-based conversational tools currently in the works, there is no lack of attention from all stakeholders involved—businesses/brands, developers, and consumers.

Small and medium enterprises (SMEs), which represent over 95 percent of the region's businesses and account for nearly 70 percent of its workforce,³ are increasingly getting into the AI-chatbot game, but there is a lack of coordinated research on how best to leverage such emerging technologies. SMEs often have a limited understanding of consumers' expectations regarding chatbots, the costs to build and maintain a chatbot system, and how to measure the effectiveness of chatbots.

In a recent study on Singapore SMEs, we explored the perceptions and attitudes regarding chatbot use in business communication. The following is a brief discussion of how SMEs can best allocate their chatbot budget, and ways to overcome organisational obstacles against successful chatbot implementation.

CHATBOTS ARE TOOLS, NOT ENTERTAINMENT SOURCES

Almost 80 percent of local consumers surveyed interact with businesses via a chatbot,⁴ making Singapore an excellent candidate for filling the knowledge gap. After surveying over 500 customers and 400 SMEs (four in five were bigger SMEs that employed 51 to 200 employees), one thing became clear: customers use chatbots to find answers to a query or resolve specific issues. The top two responses in Figure 1 illustrate clearly that these are the two main reasons for customers using a chatbot, while some respondents chose to do so believing that their goals would be achieved more quickly than if they had called a hotline.

REASONS FOR CUSTOMERS TO USE A CHATBOT

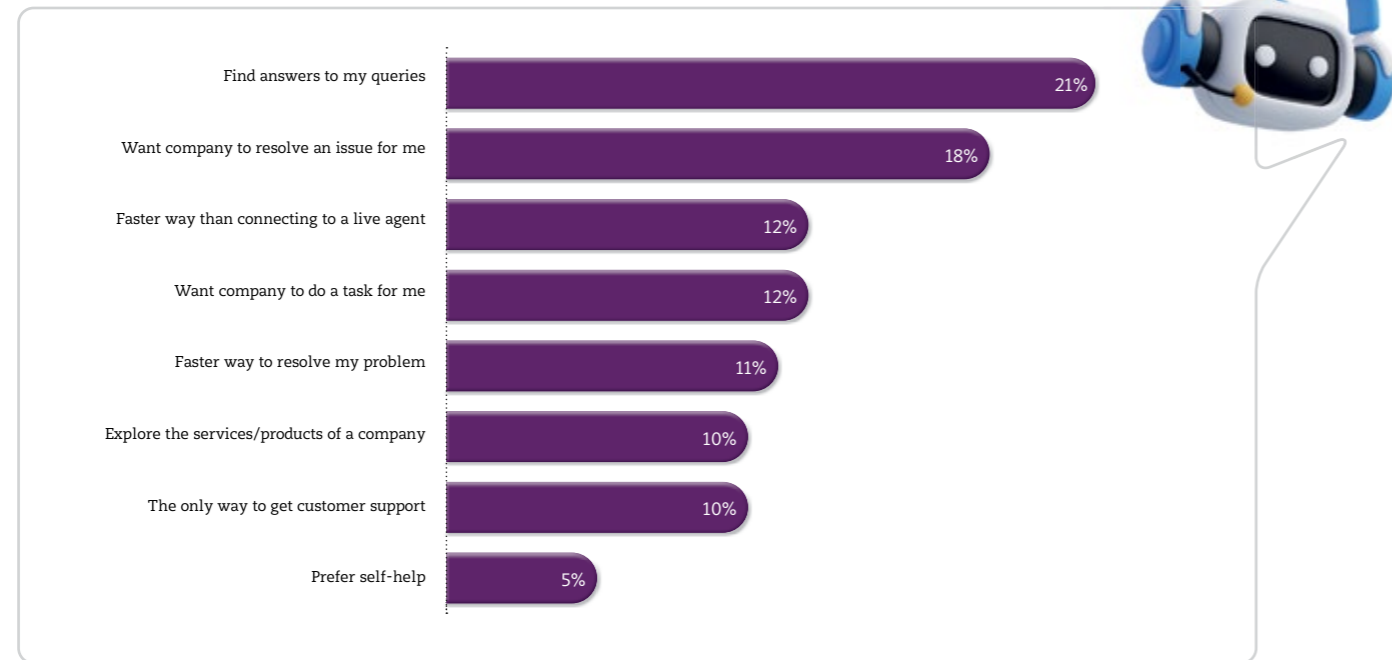


FIGURE 1

To that end, Singapore SMEs are investing in chatbots for the right reasons. Forty percent of SME respondents cited either product/service support or the answering of customer questions as the reason for building a chatbot, with another 13 percent

pointing to the filtering of customer questions as the main driver (see Figure 2). Cutting expenses on human service agents was the sixth most frequently cited reason, suggesting that fears of machines replacing humans might have been overplayed.

REASONS SMEs DECIDE TO HAVE A CHATBOT

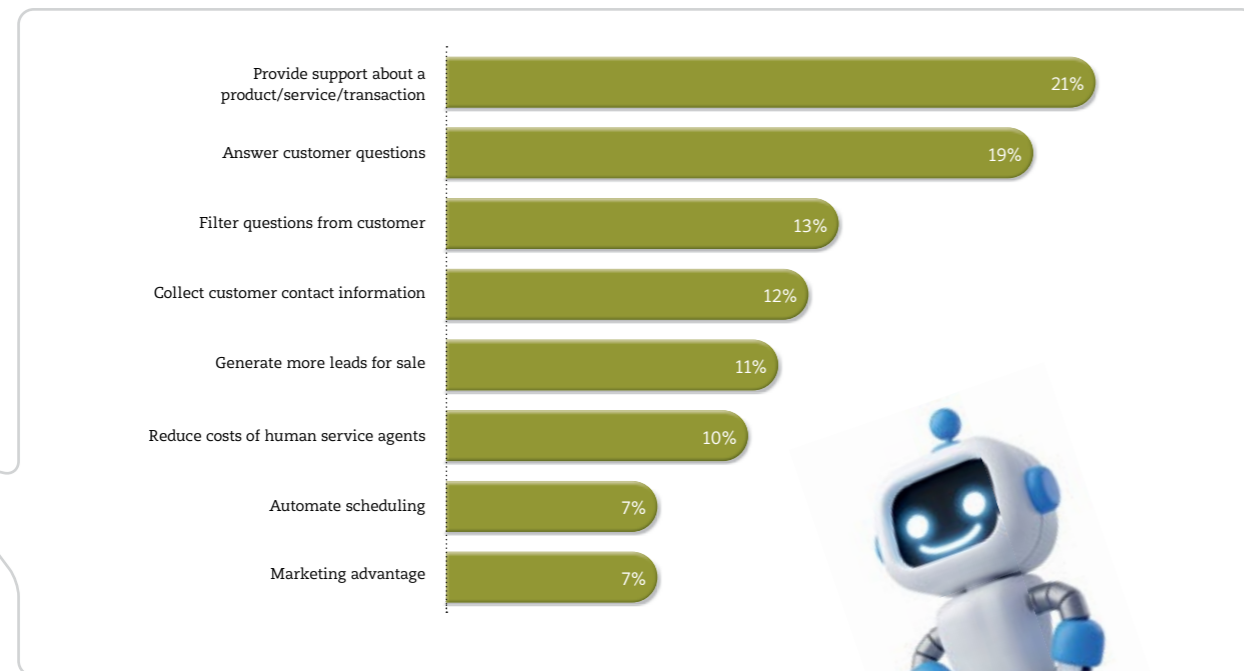


FIGURE 2

So far, so good. But here is where there is a misalignment between customers' expectations of chatbots and businesses' beliefs about what chatbots should perform well in. While three quarters (75 percent) of customers reported having their queries or problems addressed by the chatbots, less than half (46 percent) thought the process was efficient. Companies found that even natural language processing (NLP)—a branch of AI and machine learning that typically requires technical expertise and higher expenditure—was insufficient for chatbots to fully understand queries, which necessitated further tweaking.

Whereas about a quarter of SMEs surveyed operated machine-learning based systems, over six in 10 SMEs taking part in the survey deployed rule-based chatbots that feature branching

questions that lead to the most appropriate pre-stored answer based on a user's input. The rest deployed simple menu-based chatbots that work like automated phone menus (e.g., "Press '1' for credit card, press '2' for savings account").

Only seven percent of SMEs surveyed had voice-based systems, which might be more intuitive or natural than pressing buttons, be they on a screen or physical ones. While these systems may not be the most expensive in terms of one-time installation charges (refer to Figure 3), they cost more to run and maintain (refer to Figure 4). This partially explains the popularity of rule-based chatbots that generally cost the least to set up and incur lower monthly maintenance expenses via-à-vis those for machine learning.

ONE-TIME INSTALLATION CHARGES FOR CHATBOTS

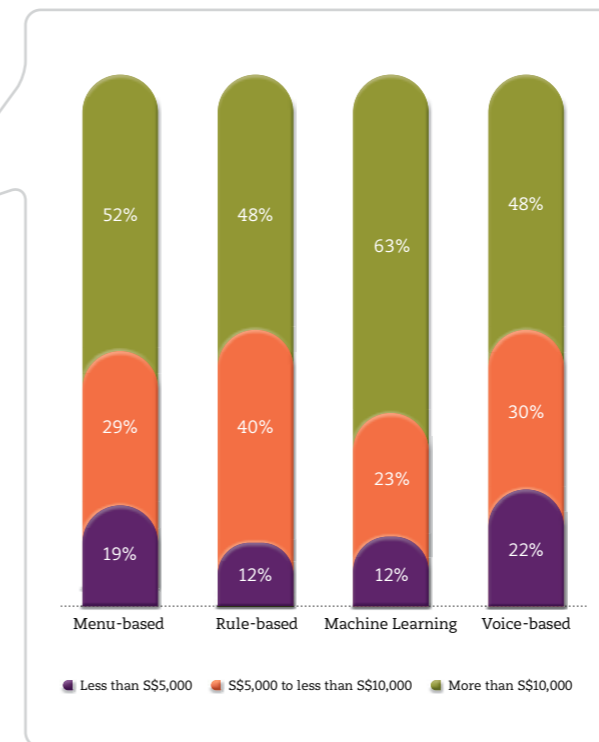


FIGURE 3

Note: Numbers in Figures 3 and 4 may not add up to 100% due to rounding.

MONTHLY EXPENSES FOR USING CHATBOTS

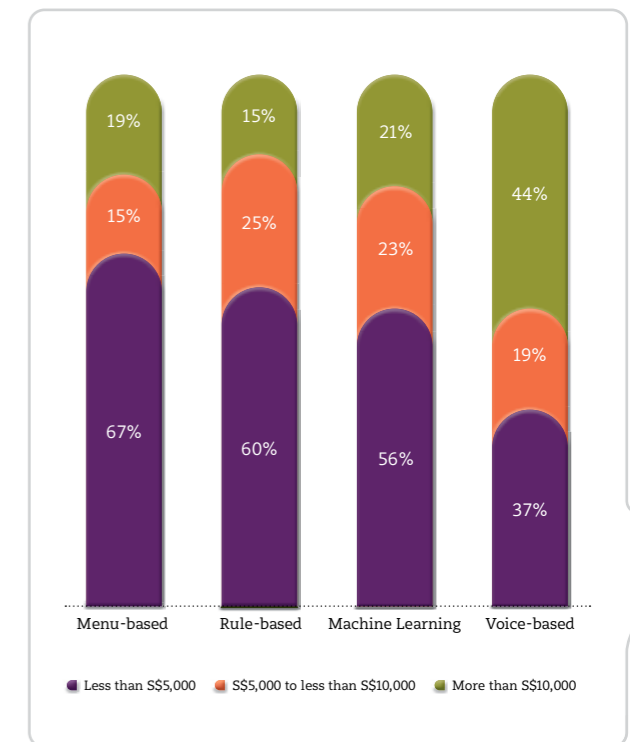


FIGURE 4

While three quarters of customers reported having their queries or problems addressed by the chatbots, less than half thought the process was efficient.



The low adoption rate for voice-based chatbots is consistent with the key survey finding that customers use chatbots as a functional tool, rather than as an open-ended exploration software. It also aligns with a separate study we did on businesses naming their chatbots in an attempt to impart some personality or human-like qualities, otherwise known as anthropomorphism.⁵ In that study, customers cared little for a chatbot's 'personality' or gender. Instead, they preferred the chatbot to identify itself as one to manage expectations. This is because some customers may communicate differently depending on whether they interact with a machine or a human being.⁶ There was no clear preference among customers on whether a chatbot should have a name.

In short, the recommendation is that businesses should focus on a chatbot's functionality, instead of making it entertaining or humorous. The lack of appreciation for that fundamental point may have contributed to SMEs slightly overestimating their chatbots' positive attributes relative to customers' perceptions, but businesses generally have a good grasp of the chatbots' limitations (see Figure 5). SMEs might also exhibit anchoring bias, i.e., "We have spent so much money on this, it has to be good!" Even if that were true, SMEs did realise that their chatbots could still have shortcomings.

IT'S ABOUT PEOPLE, NOT TECHNOLOGY

Despite common perceptions of chatbots being a tolerated but useful inconvenience, we found that chatbots (28 percent) and phone calls (29 percent) are the top two options which customers prefer to use when contacting businesses. Nearly 80 percent of customers discovered a company's chatbot either on their website's support page or via a pop-up elsewhere on the company website.

SMEs should view chatbots not just as a tool for customer support, but as a strategic asset that can enhance customer experience, provide valuable insights, and improve operational efficiency. Customers expect alternative business communication channels, such as chatbots, to get their problems resolved quickly and efficiently. However, the similar levels of preference for chatbots and phone calls suggest that human interaction remains important, and SMEs should provide options for customers to easily switch to human support when needed.

Our survey found that nearly 88 percent of SMEs outsourced the design and building of chatbots to external vendors due to the perceived technical difficulty of the endeavour. Because the survey period was completed shortly after the public launch of OpenAI's ChatGPT in late 2022,⁷ the survey results could be read as reflecting the 'pre-ChatGPT' era of business chatbot

use, and perhaps decision-makers might come to view chatbot-building as less intimidating. More pertinently, new technology might create chatbots that offer more than just a direct answer to a specific question. If that had happened, would customers have been interested in having those conversations with chatbots, instead of just using them to resolve problems or answer queries?

But before all that can come to pass, businesses must first get their chatbots up and running. More than a perceived lack of technical skills, SMEs cited organisational pushback as the biggest challenge to implementing a chatbot. Senior management are often the champions of chatbot projects, which was reflected in our survey results where CEOs or Chief Executive Officers (24 percent), CTOs (Chief Technology Officers)/Tech Leads (21.9 percent), and COOs (Chief Operations Officers)/Operations Leads (15 percent) were the ones pushing for chatbots in SMEs. Such a top-down approach often triggers pushback from others in the organisation.

To mitigate organisational pushback and enhance the integration of chatbots, senior management should focus on educating their teams about the benefits and potential applications of chatbots. This involves not just technical training but also an understanding of how chatbots can add value to the business, streamline processes, and improve customer experience. Furthermore, it is crucial for leadership to emphasise that digital transformation, including the adoption of

chatbots, is as much about people as it is about technology. By prioritising knowledge transfer and involving employees in the process, businesses can foster a more inclusive and supportive environment for successful digital transformation.

If all else fails, there is (almost) always a live agent to fall back on. The majority of the SMEs' chatbots (88.5 percent) have a function to connect to a live agent either on request or as an option after the chatbot interaction. While the former might represent 'fallback' or a failure by the chatbot to understand what a customer wants, it might not bother SMEs that much—'fallback rate' was ranked at the bottom of seven metrics that SMEs used to measure a chatbot's effectiveness (see Table 1). Instead, 'daily active users served by the chatbot' was deemed the most important success metric.

While SMEs focus on the number of users interacting with their chatbots and the duration of those interactions, the effectiveness of these interactions is not receiving enough attention. For instance, if a customer spends a lot of time talking to a chatbot but it does not resolve their issue, that is not an accurate measure of effectiveness.

Rather, small businesses should pay more attention to whether chatbots are actually resolving issues effectively. It is important to look at how well chatbots complete tasks and handle difficult questions. Shifting the focus to these outcome-based metrics could give a more accurate picture of a chatbot's value to both the customer and the business.

COMPARISON OF ATTITUDES TOWARDS CHATBOTS BETWEEN CUSTOMERS AND SMEs

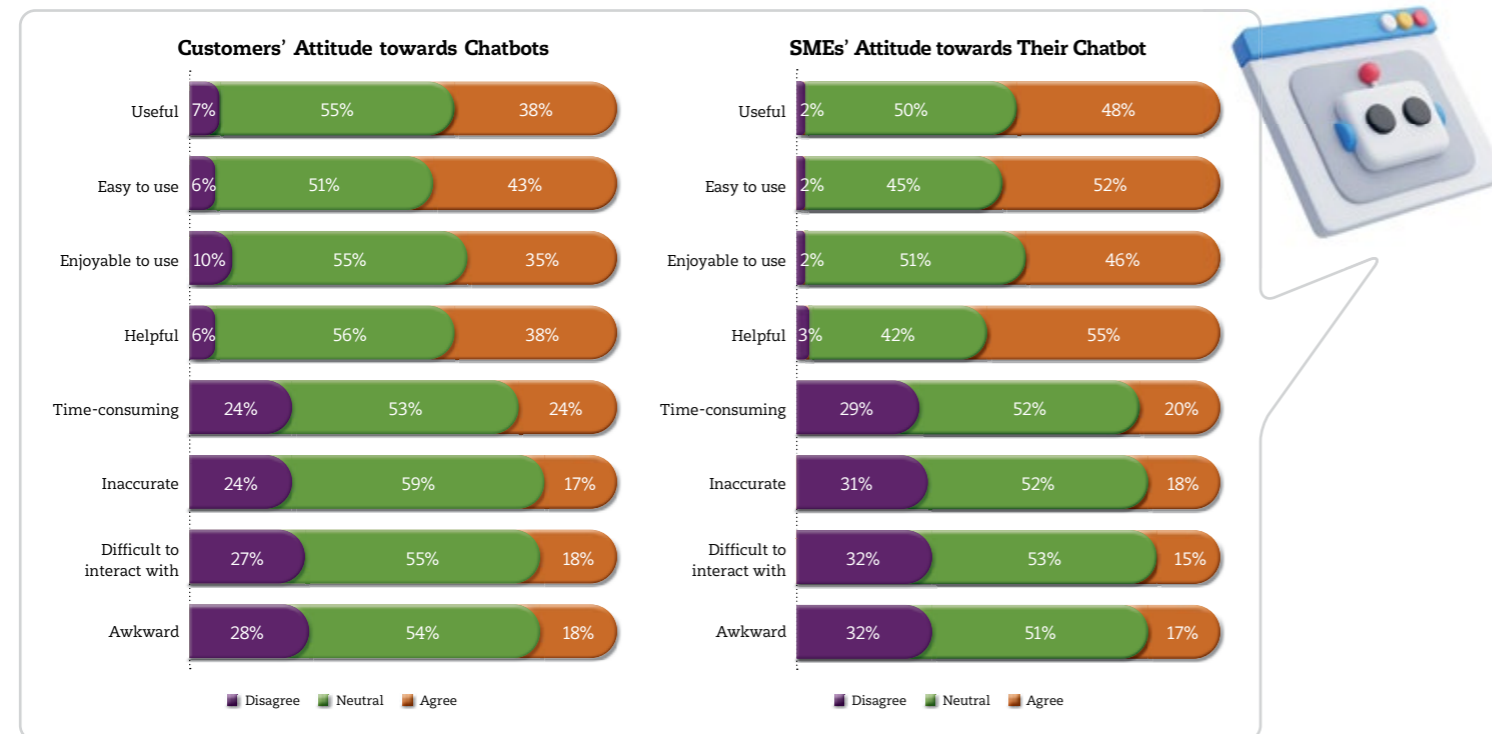


FIGURE 5 Note: Numbers may not add up to 100% due to rounding.

RANKING OF CHATBOT SUCCESS METRICS



TABLE 1

PRACTICAL CONSIDERATIONS FOR BUSINESSES

For SMEs that have already incorporated chatbots into their customer service strategies, the effect is not just seen on the bottom line. They are often deployed with specific goals in mind—to improve call and chat handling times, and provide quick and accurate responses—which they do. However, SMEs must realise the true potential of these chatbots can be further unlocked. The next frontier would be to train chatbots to handle complex queries, and for all this initial information to provide an evermore tailored and accurate experience every time. Just as importantly, SMEs need to invest in continuous improvement, as chatbot references keep evolving both as their customers increasingly use AI-powered virtual assistants, and general technology advances.

The starting point for SMEs taking their first steps towards AI transformation remains the same: identifying the core needs of their customers. This first step is crucial as it ensures the chatbot will be functional and serve a purpose, rather than be a novelty. When deploying your first chatbot, keep the scope clear and manageable, and set clear, achievable goals, whether it is to reduce time spent on answering generic queries or delivering around-the-clock basic support. Once it has proved its worth and you have gained confidence, you can increase the importance of the chatbot as part of your customer service strategy.

Introducing more advanced generative AI does not change any of these fundamental lessons but it does mean we need to be even more alert and responsive to new capabilities that will keep emerging. SMEs need to prepare for a world where customer expectations will be set by the cutting-edge digital technology they interact with, not the ageing last release.

The feedback loop is essential. Establish mechanics for capturing customer feedback on chatbot interactions directly. Review this feedback regularly, not just in terms of content, but also sentiment and satisfaction levels, to ensure that both AI and human learn and adapt accordingly.

No matter how advanced chatbots become, they must continue to be able to address the genuine needs of the customer.

THE SME CHATBOT CHALLENGE: BALANCING HUMAN TOUCH AND AI

Generative AI technology is getting faster and better all the time and as it does, it will change customer expectations. SMEs are at the forefront of that shift. Today, for instance, chatbots for business communication represent one of the main uses of generative AI. To gain the most value from digital transformation, it is important not to just understand the capabilities of chatbots, but also how they can better provide for human needs—the heart of all successful customer service, whatever generative AI may bring.

So, no matter how advanced chatbots become, they must continue to be able to address the genuine needs of the customer, while SMEs need to understand what the generative technology behind their chatbots can add to their service capabilities to improve the customer experience. All this while, the success of the business will still rest on its ability to identify and fulfil true customer needs with functional value (top line) and a commitment to continuous improvement as increasing functionality propels chatbots into uncharted waters.¹

Dr Tamas Makany

is Associate Professor of Communication Management at Lee Kong Chian School of Business, Singapore Management University

Felicia Goh

is Research Assistant at School of Social Sciences, Singapore Management University

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MAXIMISING THE AI REVOLUTION IN SOUTHEAST ASIA

For that, the region must narrow the digital divide.

by Shoeb Kagda

Galang Ramadhan often speaks to his consultant when making strategic business decisions. The 30-year-old founder of start-up Agri Sparta is hoping to improve Indonesia's rice production yields to feed a fast-growing population. Galang's consultant however does not work for a management consultancy or even run a consulting firm. That's because his consultant is not human—it is none other than the biggest AI (Artificial Intelligence) sensation in recent memory, ChatGPT. "I often have really long conversations with ChatGPT on strategic business decisions such as going to market, adopting new technology, or understanding trends in agriculture," Galang noted. "The power of AI will save entrepreneurs and business leaders huge amounts of time and help them make better decisions," he added.

The rise of generative AI models such as ChatGPT is revolutionising traditional sectors such as agriculture, healthcare, and education in developing nations across Asia. Southeast Asian governments have taken steps in advancing AI, with Singapore leading the charge when it launched the National AI Strategy in 2019. Neighbouring countries such as Indonesia, Malaysia, the Philippines, Thailand, and Vietnam have all formulated their respective AI strategies.

According to a 2020 study by global consulting firm A.T. Kearney, more than 80 percent of the region is in the early stages of AI adoption with the communication and media sector at the forefront.¹ But other sectors such as financial services, transport and logistics, government safety and smart cities, and agriculture are also using AI to improve their service levels. The benefits of AI adoption have been clearly spelled out by A.T. Kearney, which noted that while AI use is still in the very early stages, it has the potential to contribute US\$1 trillion to the Association of Southeast Asian Nations (ASEAN) economy by 2030.

Indonesia's National AI Strategy 2020-2045 lays the groundwork for AI growth by promoting collaboration among the government, industry, academia, and the public.² The

government anticipates that AI will add US\$366 billion to the economy over the next decade and is therefore accelerating the adoption of technology in sectors such as healthcare, agriculture, and manufacturing. In agriculture, AI applications in crop monitoring, disease detection, and yield optimisation can revolutionise farming practices, especially in food production.

According to the country's National Research and Innovation Agency, Indonesians consume 114.6 kilogrammes of rice per person per year, one of the highest per capita consumption rates in the world.³ The country of 270 million people is the third largest rice producer in the world after China and India, producing nearly 35 million tonnes a year. However, it still needs to import between two and three million tonnes of rice per year to meet local consumption.⁴

Increasing rice production is thus critical in light of the country's growing population. However, with production dominated by smallholder farmers and not by private or state-owned enterprises, increasing yields has been a major challenge for the sector. But a raft of agri-tech start-ups is tackling that challenge by adopting innovation, AI, and deep tech to solve the country's food security issues. Start-up firms such as Agri Sparta Indonesia are working with farmers to improve yields by utilising multi-spectral cameras mounted on drones, and using AI to analyse data and identify fields that require intervention.

"We use computer vision and AI to monitor the rice fields and identify the health of the rice plants," said Galang. "Our basic premise is to help farmers uplift their yields on the current available production land."

He added that an Indonesian rice farmer currently produces five tonnes of padi per hectare per year. "Our goal is to raise that to 6.5 tonnes per hectare per year, and in the process, improve both rice production, as well as the income of the farmers." In a sector dominated by ageing farmers and low yields, the adoption of AI and other new technologies could potentially unleash an agricultural revolution in Indonesia.

BUILDING DIGITAL INFRASTRUCTURE

However, much work lies ahead if the region is to fully benefit from AI technologies as huge investments will be needed to build foundational digital infrastructure and data ecosystems. The region still lags behind the US and China in terms of investment in AI solutions.

According to the report released by A.T. Kearney and Singapore's EDBI, a subsidiary of the Economic Development Board, for the period between 2015 and 2019, AI-related investments in the US amounted to US\$155 per capita, while that for ASEAN was about US\$2. Meanwhile, China, with its much larger population, invested US\$21 per capita in 2019.⁵ The report surveyed over 110 AI users, providers, and investors, and interviewed representatives of more than 25 companies and government agencies across the region. It covered applications including machine learning, robotic process automation, smart robots, chatbots, virtual reality, computer vision, and speech recognition. Singapore stands out among its regional peers with US\$68 worth of AI investment per capita in 2021, but Indonesia, Malaysia, the Philippines, Thailand, and Vietnam all put in under US\$1 per capita.

Managing the large amounts of data needed to run AI is also a concern as many analysts and social commentators lament the potential loss of jobs in sectors that have been traditionally highly labour-intensive. Governments in Indonesia, the Philippines, and Thailand are still highly focused on job creation, given their larger, unskilled labour pools.

Youth unemployment, in particular, is a real challenge and a social time bomb for many countries even as they race to digitalise. According to the Asian Development Bank, the unemployment rate for young people in the region before the COVID-19 pandemic was 8.9 percent.⁶ That figure rose by 2.4 percentage points to reach 11.3 percent in 2022, which suggests that 25.4 million youths in ASEAN were left unemployed as a result of the pandemic. Finding jobs for these unemployed youth would thus be a major challenge for governments.

Equipping these youth with the requisite digital skills is therefore imperative if they are to be economically productive and contribute to the digital economy. A LinkedIn report titled *Jobs on the Rise in Southeast Asia* noted that at least 41 out of 67 job positions from 15 sectors require proficiency in basic digital skills such as the ability to operate basic office software, manage cloud computing, and digital communication skills.⁷

In Indonesia, for example, the jobs most in demand include content planners, data science specialists, and talent acquisition specialists, all of which require some degree of digital skills. Most of these skills, however, are not taught within the current education curriculum and must be acquired after leaving school. Universities

are waking up to the challenge and many now include a certain number of digital courses under the Kampus Merdeka programme, where students are encouraged to explore jobs outside their academic background. The Indonesian Ministry of Education, Culture, Research, and Technology also gives incentives to industries that provide tech curricula through the Independent Study Program.

There is no doubt that the application of AI and other digital technologies has the potential to positively impact millions of people in Southeast Asia, especially those who have been underserved or marginalised. From farmers to financial analysts, numerous professions can benefit, which in turn will drive economic growth and more importantly, foster greater inclusivity.

As ASEAN's digital economy continues to grow, greater focus will also need to be paid to cybersecurity and data protection, given the rising number of digital scams. Based on current projections, ASEAN's cybersecurity sector is projected to triple from US\$2.1 billion in 2023 to US\$6.7 billion by 2028.⁸ The AI market value is also expected to triple to US\$27 billion in 2030 from US\$8 billion in 2023.

Backed by over 460 million digital consumers and strong fundamentals, Southeast Asia's digital economy has plenty of growth potential.⁹ The region has young tech-savvy populations and rising Internet penetration. But for the region to fully realise this potential, it has to narrow the digital gap and the urban-rural divide and most importantly, improve digital literacy amongst its population.

The disruption in traditional sectors applies across the Southeast Asian region. According to the McKinsey Global Institute, if harnessed well, AI technologies have the potential to contribute to positive social outcomes in ASEAN such as greater financial inclusion, better preventive healthcare in remote areas, and improvements in the diagnosis of medical conditions, as well as the speeding up of new drug development.¹⁰

Shoeb Kagda

is Centre Director (Jakarta) at the Office of Overseas Centres, Singapore Management University

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FROM EMERGENCY ROOMS

TO BOARDROOMS

How doctors think can improve business decision-making.

by **Lim Tow Keang**

More than two decades ago, the landmark report by the Institute of Medicine (US) Committee on Quality of Health Care in America *To Err is Human: Building a Safer Health System* highlighted the issue of patient safety in healthcare.¹ Since then, doctors and healthcare systems have implemented a wide range of interventions to reduce medical errors and mitigate patient harm. The most effective and popular solutions have involved quality improvements and systemic changes. In these two domains, the medical community has learnt from, adopted, adapted, and applied many lessons and tools from the business world. Particularly, the disciplines of behavioural economics or ‘nudges’ and high-reliability organisations are seen as exemplars.²

Now, let’s take an inverse perspective by asking, “Can business decision-makers learn from clinicians?” Important decisions made in the boardroom and at the bedside occur under very similar conditions. They involve judgments in uncertain situations, are time-sensitive, and carry high stakes. These decisions also engage the same human cognitive processes, both as individuals and as a group.³

I organise this article using two phases of clinical thinking—diagnosis and treatment. It is in making the correct diagnosis that a clinician can then decide on the appropriate treatment plan. I will show how higher-order thinking can be deployed to optimise decision-making under clinical or medical settings. During my discussion, I will highlight the role of human cognition which is based on the idea of the predictive brain (PB) and active inference. This is an advanced theory of how the brain works that has been developed recently by leading neuroscientists, where it considers the brain as a highly evolved, proactive, and predictive machine.

DIAGNOSIS: AN EPISTEMIC PROCESS

Clinical diagnosis is fundamentally an epistemic process. This means that the steps involve various aspects of knowledge—from understanding, belief, justification, and methods used to acquire and evaluate such knowledge to arriving at judgements, decisions, and actions. Expressed in another way, the epistemic process encompasses how we ascertain our knowledge, the dependability of our understanding, and the methodologies we employ to gather and appraise information. It is most apparent when we try to make sense of mistakes—not only what went wrong but also how it has gone wrong, i.e., the causal mechanism underlying the illness and its manifestations.

Following the PB perspective, this process involves abduction and inference to the best explanation (IBE). Abduction is how we generate possible explanations or hypotheses to account for observed phenomena when there is limited or incomplete evidence. This cognitive process focuses on proposing various explanations and selecting the most likely one based on available information. For example, a patient who presents with a one-day history of fever, runny nose, and cough would most likely have an acute respiratory tract infection. The specific cause however could be any one of many respiratory pathogens which may present with very similar features. Abduction is also often used to generate initial ideas or hypotheses that can guide further investigation.

On the other hand, IBE involves evaluating multiple explanations or hypotheses for a given set of evidence and selecting the one that provides the most comprehensive and coherent account of the data. It aims to choose the explanation that best fits the available evidence while considering simplicity, explanatory power, and coherence. IBE is more about selecting the most compelling explanation among competing options. Thus, in the case of our patient with an acute respiratory tract infection, the coronavirus obviously becomes the most likely suspect in the COVID-19 pandemic setting.

This approach is also applicable when investigating problems in the business world. Take the situation where market trends are to be assessed before launching a new product in business. Instead of relying solely on intuition, an epistemic approach would involve gathering data from a range of sources, conducting rigorous market analysis, and critically evaluating the reliability of each piece of information. This process enhances the accuracy of predictions, and acknowledges the

dynamic and uncertain nature of markets. Hence by incorporating such epistemic principles, business leaders will be able to make more informed decisions.

The fictional detective Sherlock Holmes simply referred to this whole process as “thinking backwards”, contrasting it with rational-logical deduction or “thinking forwards”.⁴ The PB efficiently performs this “backward thinking” by proactively matching new bottom-up sensory information with prior top-down case memories and experiences of similar situations in the past, quickly identifying predictive errors when the two streams of information do not match.⁵

In clinical practice, this is manifested in familiar cases as making a ‘spot diagnosis’ based on pattern recognition, while in more difficult cases, it involves carefully comparing and contrasting the presenting features before arriving at a diagnosis. Similarly, in business, we try to make sense of emerging problems by matching them with similar situations from past experiences. This process involves recalling representative cases encoded as grid maps in long-term memory.⁶ An efficient approach to quick decision-making involves using the ‘gist’ or a small number of key features that differentiate among different conditions.

Gathering new information through diagnostic tests to either exclude unlikely diseases or confirm likely ones is a critical step in this process. The prescriptive method for interpreting diagnostic test results is known as Bayesian inference, a statistical method that involves updating beliefs or probabilities about a hypothesis as new evidence or information becomes available. It is based on the principles of Bayesian probability theory, developed by Thomas Bayes, an English mathematician/philosopher in the 18th century. In fact, in everyday practice, we

are already performing an approximation of Bayesian inferences intuitively without relying on formal calculations.⁷

Of course, diagnostic tests are never perfectly accurate. Thus, a crucial factor to consider when conducting diagnostic testing is the careful assessment of the projected risks and their costs relative to the potential benefits of the test. There are scenarios in which pursuing additional diagnostic tests might not be in the best interests of the patient and therefore should be steered clear of. This concept is elucidated through the lens of decision analysis, referred to as the ‘threshold approach’, where a pivotal juncture balancing risk against benefits guides the selection of suitable tests.⁸

For example, if a severe bacterial bloodstream infection is suspected, an antibiotic should be administered as soon as possible instead of waiting for testing to locate possible sources of this infection. Likewise, in business, senior executives do not and should not wait to act only when they have gathered perfect information. When expanding into new markets, they rely on strategies that involve understanding market characteristics, choosing the right partners, and dealing with regulatory issues, among others. All these involve careful observation and constant probes for feedback as to whether the decisions require timely adjustments based on changing conditions or new information.

I suggest that business decision-making may also be improved by applying the principles of Bayesian inference and the threshold approach heuristically or as rules of thumb. When Netflix expanded its streaming service globally and subsequently started creating original content from 2015, it took calculated risks by tailoring its content and strategy to different markets, while recognising that it did not enjoy complete understanding of local content preferences and the media regulatory environments. The company had to adapt and learn quickly from the new markets as it went along, which, in a nutshell, follows a Bayesian approach to responsive and adaptive decision-making. In two years, the once DVD-by-mail movie rental provider had operations in more than 190 countries where close to 50 percent of its 130 million subscribers were outside the US, its country of origin.⁹

In the medical field, there is also significant interest in understanding and preventing diagnostic errors. Biased thinking is recognised as a common cause of diagnostic errors. However, attempts to improve diagnostic accuracy by recognising and avoiding biased thinking (de-biasing interventions) have proven unsuccessful.¹⁰ The main reason for this failure is that biased thinking is simply part of our default intuitive problem-solving process. And thus, it is only in hindsight, when the outcomes

In business, we try to make sense of emerging problems by matching them with similar situations from past experiences. This process involves recalling representative cases encoded as grid maps in long-term memory.

are clear, that we can go back and say that one decision was right, i.e., a ‘heuristic’ versus another one that was wrong and so label it a ‘bias’. Going forward, in real time, it is impossible to tell a bias from a heuristic, so we do not have the agency to prevent or avoid it. As highlighted by Daniel Kahneman in his most recent book *Noise: A Flaw in Human Judgment*, the Nobel Economics Prize laureate recommends that we work on identifying and reducing ‘noise’ or variations in our work.¹¹ This search for better reliability and consistency, he thinks, may be more do-able than trying to reduce bias.

An effective way to reduce variability in clinical decision-making is to adhere to management protocols based on clinical guidelines and gather consensus from independent experts. Likewise, in business, just as in medicine, decision-making can vary greatly among individuals which may lead to inconsistency and inefficiency. To minimise such variability, companies often adopt established protocols and guidelines within their domains, such as best practices or standard operating procedures, especially for routine decision-making. By following these, managers are more likely to make decisions that are aligned with the organisation’s goals, values, and past successful strategies. In the same vein, businesses have practised gathering consensus from external advisors with relevant knowledge and expertise. Apple’s position at the top of the consumer electronics market owes as much to protocols and guidelines that ensures aesthetic consistency as it does to sparks of innovation and design genius. While creativity can be cultivated in-house, the Cupertino-based tech giant ensures it stays abreast of market trends by working with external consultants such as Accenture and IBM.

THE PREDICTIVE BRAIN

The PB concept in neuroscience suggests that the brain primarily functions as a prediction-making machine that is constantly generating and updating its hypotheses about the world based on incoming sensory information and past experience. Take driving as an example. The PB concept emphasises how a driver anticipates potential hazards. The driver’s brain continuously predicts and prepares for various scenarios, like a car in front suddenly braking or a pedestrian stepping off the pavement and into its drive path. This notion differs from previous concepts of the brain that have only highlighted the brain’s reactive processing as simply responding to stimuli. Using the same example, when the driver brakes after seeing the brake lights of the vehicle ahead, it is not because the individual is scanning for hazards (as suggested under the PB theory), but it is simply a stimulus-response action only.



TREATMENT: PRACTICAL DECISIONS AND ACTIONS

Similar to diagnostic testing, the process of making treatment decisions necessitates a meticulous equilibrium between weighing risks and benefits prospectively in predictive error processing.¹² This delicate balance of top-down expectations or predictions based on *a priori* experience and bottom-up new information as the case evolves is instrumental in selecting the optimal course of treatment within the framework of the ‘threshold approach’.¹³ For example, a low threshold might apply in cases of proven therapies for the critically ill, but a higher threshold would be more appropriate when considering invasive or potentially harmful treatments such as chemotherapy.

Evidence-based medicine (EBM) has sparked a rethink of this therapeutic decision-making process. EBM is the integration of the best available scientific evidence with clinical expertise and the individual patient’s values and preferences. It involves systematically reviewing and appraising clinical research

studies, clinical trials, and other forms of medical evidence to inform medical decision-making. Essentially, EBM encapsulates the most recent breakthroughs in medical science, which are then transformed into optimal practices. The most powerful tool in the armamentarium of EBM is the randomised controlled trial (RCT). This was experienced personally by all of us during the COVID-19 pandemic in which life-saving vaccines and treatment modalities were rapidly identified and differentiated from ineffective ones by globalised and rapidly publicised RCTs.

In similar ways, business decision-making may also be improved by applying evidence-based, scientific methods to rigorously test potential solutions before large-scale implementation. Thanks to the idea of ‘nudge’ in behavioural sciences, many are familiar with Google’s use of A/B testing, which is a method that allows the tech giant to compare two versions of a web page or app feature to see which performs better. For instance, when Google updates its search algorithm or introduces a new feature in Gmail, it often conducts A/B tests with a small segment of users. This data-driven approach helps it to understand user preferences and behaviours better and more quickly, ensuring changes made are beneficial to the larger user base before they are eventually rolled out globally.

Such science-based practices are not limited to tech or engineering companies. Take Starbucks as an example. By analysing customer data, market trends, and feedback, the coffee giant identifies potential new products or makes modifications to existing ones. Before a new product is launched, Starbucks typically conducts market tests in selected locations to gauge customer response, allowing it to refine the product and its marketing strategy based on real-world feedback, thus improving its success upon wider release.

Despite stringent experimental methodologies and rigorous peer review standards for publication in medical journals, we are unable (and likely never able) to account for all relevant variables and conditionalities in the real world. Thus, uncertainties persist in every aspect of our practice. To better cope with this, we need to go beyond EBM. Fortunately, we are endowed with extended cognitive capabilities to self-appraise and fine-tune our primary thinking processes. We only need to pay more attention to, and practise to improve upon these higher thinking tools, such as our ability to reflect upon our own thinking processes (i.e., metacognition).

METACOGNITION: UNCERTAINTY AND PRECISION

Metacognition or higher-order thinking about our own thinking is an important cognitive tool for coping with uncertainty. This is the universal capacity to perform continuous, parallel self-

appraisal of our own thoughts. At the basic level, it is manifested and described as ‘gut feeling’.¹⁴ A better, more reliable way to measure metacognition is by assessing our levels of confidence in making each judgement in relation to its accuracy.¹⁵ In everyday decision-making, it represents the estimated value of new bottom-up information for this task, indicating the level of attention required. Cognitive philosopher Andy Clark dubs this the ‘precision-weighting toolkit’, the core of fluid intelligence in discussions on the PB.¹⁶ For decision-makers, this means paying careful attention to the feeling of confidence or trust in our own judgement.

There is emerging evidence that better metacognition improves decision-making in cases of confirmation bias.¹⁷ In complex decision-making involving teams, transparent communication of metacognitive representation among individuals in the process of social or distributed metacognition may be an adaptive way of coping with uncertainty.¹⁸ Simply put, this means that team members, whether in a clinical or business setting, need to communicate openly about their uncertainty and confidence clearly and frankly to one another. This may be especially important for the person who is most senior or the one leading the team, in part to signal the significance of being committed to such an open (and vulnerable) process.

As an example, a multinational corporation may have to deal with a crisis due to a major flaw in one of its key products which had already been distributed globally. The leadership team, instead of rushing to a decision, may choose to meet for a quick ‘huddle’, where team members are encouraged to openly express their initial gut feelings about the best course of action, whether it is a product recall, a public announcement, or a strategic silence. By vocalising these intuitive responses, the team could better understand the diverse perspectives and areas of uncertainty. This collective introspection leads to a more informed and nuanced decision-making process. To be clear, this approach is still considered a novel domain in medical practice and education, and has to be fully evaluated before large-scale implementation (which is in line with the scientific, evidence-based approach to decision-making).

CONCLUSION

I have shown how the PB makes effective and efficient decisions in the clinical diagnostic and management settings. This model incorporates the optimising tools of probability theory, Bayesian inference, EBM, RCTs, and metacognition. This approach may also be relevant in solving complex problems in business decision-making.

We are still actively evaluating recent important technological advances in deep learning from multi-faceted information sources and problem-solving through large language models in the clinical domains. It is certain that this will impact our everyday clinical work in ways that we have yet to fully delineate and understand. ■

Dr Lim Tow Keang

is Professor of Medicine at the Yong Loo Lin School of Medicine, National University of Singapore and Senior Consultant in the Respiratory and Critical Care Division, Department of Medicine, National University Hospital, Singapore

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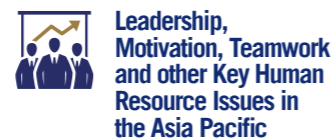
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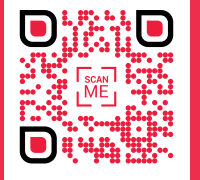
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