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Management Sciences

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FEATURES

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ADDRESS
City Business Magazine
12/F, Lau Ming Wai Academic Building,
City University of Hong Kong,
Tat Chee Avenue, Kowloon Tong, Hong Kong
Phone: +852 3442 2266
Email: cbmagazine@cityu.edu.hk

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Management Sciences

The work of the management sciences is the forecasting, planning, management and decision-making of business operations. This field has evolved relatively recently, and in this issue we are fortunate enough to carry an interview with our founding head, Professor Wai-kee Kam, who tells the story of how the "MS" department got its name. Established back in 1984 as "Mathematics and Science," we were successively known as "Applied Mathematics," and then "Applied Statistics and Operations Research." Only in 1997 were we renamed to embrace the emerging field of "Management Sciences." This genealogy reflects the way in which maths and statistics have become increasingly operationalised over the decades, to the point that they are today fundamental to decision-making in business operations – and indeed essential to the digitalised global economy.

This issue of City Business Magazine ranges from deceptively simple management science topics to the more obviously complex. In *How to make the best decision – Choose one from many or combine them all?* Head of Department, Professor Alan Wan, argues that combining statistical models offers advantages in forecasting compared to selection of a single model. He suggests that this approach will likely become part of the statistician's standard toolkit in the future.

Weaving personal narrative with a description of latest industry developments, in *Alternative data, federated learning and supply chain finance*, Professor Houmin Yan anticipates that supply chain finance is the next promising domain for AI and machine learning applications. It will indeed be interesting to see if the concept of federated learning can provide a distributed machine learning environment that will in the future prevent the kinds of massive data leakages that we still see today.

Over the years, whilst teaching – along with research – has formed the bedrock of the Management Sciences mission, the advent of quantitative analysis has brought with it many challenges in teaching-learning methodology. The unrivalled reach and functionality of AI can push human agency into the background. In *Driving analytics by insight*, Professor David Li, advocates redressing the balance. He sees the role of business insights as central to students gaining a more holistic view of business problems.

There is no hotter topic than hot money, and in *Rethinking cryptocurrencies*, Dr Simon Trimborn takes a critical look at cryptocurrencies, arguing that they have strayed far from their initially conceived role as digital payment systems. Indeed, the very name "cryptocurrencies" suggests that these tokens are primarily deployed as currencies. So, will any of the current cryptocurrency uses prevail, or will new use opportunities arise?

Interdisciplinary research in deep learning and asset pricing factor investing has attracted a lot of interest in recent years, and Dr Gavin Feng has gained attention for his work in discriminating between useful and redundant investment factors. In *Deep learning in empirical asset pricing*, he takes the enquiry further with a look at the construction of asset pricing factors using a bottom-up deep learning model.

Many years ago, as Professor Yan-chong Chan reminisces in *Operational research, statistics and big data*, students were heard to ask "What kind of job can I find after graduating from operational research?" Nowadays, students no longer express concern! They are eminently employable in what is perhaps the foundational discipline of our times.

I do hope you enjoy this expansive celebration of the Management Sciences!

Frank Chen
Dean

How to make the best decision

Choose one from many or combine them all?

By Professor Alan Wan

***Professor Alan Wan**, Head of the Department of Management Sciences, argues that combining statistical models offers advantages in forecasting compared to selection of a single model, that the approach is an increasingly used analytical tool in applied statistical work, and will likely become a toolkit in the statistician's repertoire in the future. This article is related to a number of model averaging papers published by Professor Wan in the Journal of the American Statistical Association, Journal of Econometrics, and Journal of Business & Economic Statistics.*

Scenario

It's decision time: The CEO could ask: "Which board member do I trust most?" Or think, "Everybody has expertise. I'll listen to them all." Which approach is better?

One of Hong Kong's largest property developers is pitching towards the millennial market for its new waterfront project. The CEO has to decide whether it is worth building to outstanding environmental standard, with the aim of attracting a young "green-minded" clientele. The decision depends on a forecast for how big the millennial market will be in the coming year. There is an impressive array of ten professionals on the board including engineers, financial experts, marketing professionals, audit and risk management, etc. The CEO knows his advisors well and clearly has greater trust in some than in others. The ten advisors give their forecasts, and he is left with ten numbers. How should he make a final selection from these ten numbers? The CEO could ask himself: "Which board member do I place the greatest trust in?" And then take his or her advice. Another approach would be for the CEO to say: "All the advisors have some valuable expertise to offer, although not all of the same importance. Some professions are more significant in this forecast and should get a higher weighting." Which way of thinking is the better? Intuitively, most people would go for the second method, where a wide spectrum of professional advice is taken into consideration. You may be surprised, however, to hear that in standard statistics, up to now it is the first method that has won out. Let me explain how things are changing.

What is a model?

With several models to choose from, researchers like to know which one is more consistent with the data.

Researchers working in different fields in the hard sciences through to the social sciences come up with a variety of ideas in their attempts to explain various phenomena. These conjectures are typically referred to as "models" for the phenomena of interest. Often these models sketch out broad relationships and attributes that may be relevant, but do not contain numerical detail and hence are in this sense incomplete. To flesh out this detail, researchers use methods in statistics to estimate their models. Statistical analysis allows them to fill in the missing numerical detail. With several estimated models to choose from, researchers like to know which one is more consistent with the evidence provided by the data. Fortunately, statistics can also help them make this decision.

Deciding which model is best is referred to as "model selection".

But sometimes the model selection approach provides no clear winner with several models being equally good or equally bad descriptions. This motivated statisticians to come up with another approach. Instead of simply trying to decide which model 'fits' data best, they thought why not construct a new model that is a weighted average of the best models? This approach is referred to as model averaging.

With these two modelling strategies available, statisticians now have to decide which to use in different circumstances.

A further complication is that statisticians have come up with many different ideas about how to go about model selection and how to implement model averaging. And also, there are many ideas about how to determine which of these various approaches is the best to use. Statisticians have developed many different criteria to judge them by.

Model selection – not so easy

You have many potential models to choose from, and different strategies to arrive upon a final model.

On the face of it, model selection might appear to be straightforward. You have a

number of competing models and some criteria to judge which is best. But the process is not so easy. You have many potential models to choose from and many to discard, and different strategies to arrive upon a final model.

One strategy is the specification search approach. In this approach the researcher uses sequential hypothesis testing to "pretest" and eliminate or keep different variables or specifications and use the process to arrive at a final specification.

Typically, statisticians would start from a single model which they estimated from data and a simple hypothesis to test. Is the model correct or not? Is an estimated coefficient significant or not? In this context some very basic statistical approaches and ideas about hypothesis testing were developed to decide if a model "worked."

That sort of approach is not so problematic when you test a single hypothesis. But statisticians later demonstrated that this approach doesn't work so well when you have several models that you are testing, or have multiple hypotheses or specifications to be tested sequentially. Specification searches by pretesting or statistical selection criteria, including what is referred to as "step-wise" regression, are widely practiced. In these cases, the standard statistical tests that you might use for a single hypothesis were demonstrated to be no longer valid due to what is referred to as "pretesting bias", and adjustments to the hypothesis testing procedure need to be made. In applied studies, however, researchers usually ignore these issues and report their statistical results as if no specification search has been performed. Statisticians have long been made aware that ignoring pretesting can result in very serious consequences.

These problems encountered in model selection and in testing hypotheses sequentially resulted in the development of many different ideas and approaches.

Much of my earlier work involved developing and refining some of these approaches and exploring the problem of and correcting for the pretesting bias.

Model averaging offers advantages

The basic idea of model averaging is to minimise risk.

As mentioned, the hypothesis testing and other selection frameworks used in the model selection approach, where many competing models are discarded, create problems like pretesting bias.

One advantage of the model averaging approach is that there is no discarding of any of the competing models and no subsequent specification searches by hypothesis testing, hence the problems encountered with model selection no longer exist.

Model averaging is also a great approach because frequently no single model stands out clearly from the rest, so there are obvious merits in attempting to average them.

The basic idea of model averaging, that is to minimise risk, is used in many contexts. Individuals, businesses and governments use the idea and try to spread their risk by averaging in various ways. Individuals do it when investing. A wise investor avoids putting all their money into a single business if possible. Instead they prefer a diversified portfolio averaging the returns over several businesses and asset classes. Also, many large businesses will attempt to mitigate risk by diversifying so that if one part of their business is doing poorly they can still provide shareholders with a reasonable average return. Similarly, governments will rarely rely on a single expert when formulating policy. They frequently canvas a wide range of opinion and try to arrive at some sort of consensus or average position.

Model averaging was a natural idea for statisticians to adopt and an increasing number of researchers are now using the model averaging approach following the seminal paper "Frequentist model average estimators" by the Norwegian statistician Nils Lid Hjort and Belgian statistician Gerda Claeskens published in a 2003 issue of the *Journal of the American Statistical Association*. Since that paper, there has been a spurt of research activity on model averaging in the space of just a few years. A lot of my recent work has focused in this area.

Research has shown that by combining competing models you can generally produce more accurate predictions than those obtained from a single model. This is especially true when the underlying model or data has a high "noise" (i.e., unexplained irregularities) content, making it difficult for pretesting and model selection methods to single out one manifestly preferred model. Model averaging has been successfully applied in many disciplines including biomedical sciences, climatology, ecology, economics, finance and tourism.

Contrasting the different approaches

Here, I revisit two examples from one of my earlier papers published in the *Annals of Tourism Research* to illustrate the dangers of pretesting and model selection in terms of introducing bias by underreporting the variability of estimates and how model averaging can be used to overcome these issues and provide more accurate results.

Correct bounds wider; WALS more accurate

The first example is based on an analysis undertaken by the U.S. Department of Agriculture (USDA) in 2005 that investigated the degree to which recreation and tourism development influence various socioeconomic indicators including earnings per job, income per capita levels, death rates and others, in some 311 rural US counties in the year 2000.

Researchers from the USDA estimated a sequence of multiple regression models using a distinct socioeconomic indicator as their dependent variable. Their key explanatory variable was a Z-score which measures the county's dependency on recreation and tourism, and covers tourism-related employment and income shares of the local economy, as well as the share of total county homes dependent on recreational use. The higher the Z-score the more dependent a county is on recreation and tourism. The USDA was primarily interested in the coefficient estimate of the Z-score. The other explanatory variables are listed in Table 1.

Table 1: List of variables

Dependent variables	Explanatory variables (excluding intercept)
1. Employment-population ratio of ages 16-24	1. Z-score
2. Employment-population ratio of ages 25-64	2-9. Eight dummy variables identifying the Census regional subdivisions
3. Employment-population ratio of ages 65 and over	10-19. Ten dummy variables reflecting Johnson and Beale's (2002) recreation county types
4. Earnings per job	20. Dummy variable indicating whether the county is influenced by a nearby metropolitan area
5. Earnings per worker	21. Percentage of county population residing in rural areas
6. Income per capita	22. County population density
7. Median household income	
8. Median rent	
9. Population growth rate	
10. Travel time to work	
11. Poverty rate	
12. Percentage of population without HS diploma	
13. Percentage of population with bachelor's degree	
14. Physicians per 100,000 population	
15. Age-adjusted death rate per 100,000 population	
16. Crime rate	

Methods and Results

I used their study to analyse the effect of pretesting and highlight the merits of model averaging as an alternative to model selection.

To illustrate the effects of pretesting I used a popular stepwise regression procedure. This kind of model selection approach is so common that automated routines for stepwise selection are available in most statistical software packages. To produce the model averaging results, I used a technique known as weighted average least squares (WALS), introduced by the renowned Dutch econometrician Jan Magnus.

Estimates using both approaches, for the coefficient of interest, the Z-score, are in Table 2.

Column 2 of Table 2 provides the estimates based on the model selected by stepwise selection for each regression. The third column provides the 95% confidence bounds for those coefficients when pretesting has not been taken into account. These are the confidence bounds usually reported in applied work when the researcher assumes (erroneously) that the model has been chosen a priori and not as a consequence of model selection. The confidence bounds reported in Column 4, on the other hand, are the correct 95% confidence bounds paying due attention to consequent effect of stepwise selection on the variability of the estimates.

In all cases the commonly reported confidence bounds that ignored pretesting underreported the true confidence bounds. As this example illustrates, the difference between the reported and the correct confidence bounds can be very large. In the worst case, the true confidence bounds were almost 11 times as wide as the bounds that ignore pretesting; on average they are about three times as wide.

The WALS coefficient estimates and the 95% confidence bounds appear in Columns 5 and 6 respectively. In all cases the WALS and pretest coefficient estimates have the same sign and similar magnitudes. However, without exception the WALS estimates produced tighter confidence bounds than the (true) pretest confidence bounds. On average, the WALS confidence bounds are 43% the width of the correct pretest confidence bounds; thus notable reductions in estimator variability are achievable with the WALS approach. This is to be expected because model averaging usually leads to estimates that are of superior precision than those achieved by selecting a single model, as has been demonstrated in the theoretical literature. While these results are, of course, specific to the data example considered here, the evidence does provide an indication of the performance gains that are possible.

Table 2: Estimates of coefficient of Z-score in each regression and confidence bounds

Model[1]	Pre-test estimate	Reported Pre-test confidence bounds	Correct Pre-test confidence bounds	WALS estimate	WALS confidence bounds
1	1.19	(0.50, 1.87)	(-0.68, 2.96)	1.19	(0.48, 1.90)
2	0.89	(0.20, 1.59)	(-0.76, 2.60)	1.00	(0.29, 1.71)
3	1.01	(0.56, 1.46)	(0.08, 2.01)	1.13	(0.67, 1.59)
4	1.63	(-340.92, 344.18)	(-456.81, 440.90)	37.8	(-303.22, 378.82)
5	880.47	(514.87, 1246.07)	(-93.26, 1786.26)	898.9	(520.14, 1277.66)
6	1073.54	(558.91, 1588.18)	(-222.67, 2311.72)	1077.42	(550.79, 1604.05)
7	1538.95	(965.59, 2112.31)	(431.10, 2511.70)	1563.95	(992.77, 2135.14)
8	32.83	(23.84, 41.82)	(16.47, 48.72)	34.28	(25.29, 43.27)
9	4.48	(2.89, 6.07)	(-0.64, 9.82)	4.84	(3.11, 6.58)
10	-0.27	(-0.67, 0.13)	(-1.58, 1.07)	-0.26	(-0.69, 0.17)
11	-0.84	(-1.34, -0.33)	(-2.20, 0.50)	-0.81	(-1.33, -0.30)
12	-1.42	(-1.93, -0.90)	(-2.62, -0.13)	-1.41	(-1.94, -0.88)
13	2.22	(1.59, 2.85)	(1.14, 3.36)	2.36	(1.73, 2.99)
14	1.59	(-7.49, 10.68)	(-21.42, 22.82)	1.32	(-7.88, 10.52)
15	-25.88	(-37.60, -14.16)	(-62.03, 13.62)	-25.45	(-37.93, -12.97)
16	0.67	(0.50, 0.83)	(-1.05, 2.51)	0.65	(0.47, 0.82)

1. *Models 1-16 are based on, respectively, dependent variables 1-16 listed in Table 1.*

Table 3: Forecast Comparisons

Period	ActualValue	Forecasts (absolute percentage errors in brackets)		
		ARIMA(2.1,1)	ARIM(2,1,1)(1,1,1)	Averaged model
1988	451443	453721 (0.50%)	409067 (9.39%)	451980 (0.12%)
1989	461259	463343 (0.45%)	367310 (20.37%)	459600 (0.36%)
1990	432092	462613 (7.06%)	348448 (19.36%)	458163 (6.03%)
1991	394222	464243 (17.76%)	298296 (24.33%)	457775 (16.12%)
1992	385979	473952 (22.79%)	302413 (21.65%)	467266 (21.06%)

Model averaging – better prediction

The second example illustrates the benefits of using model averaging to improve forecasting accuracy when using common time series models.

To illustrate these advantages I used data on the number of long-stay visitor arrivals in Barbados between 1956 and 1992 from a paper published in the *Annals of Tourism Research*. In that paper the author, Gerald Dharmaratne, estimated two ARIMA models using the data up to 1987 and then used the models to forecast the remaining years, and evaluated the accuracy of the resulting forecasts.

Dharmaratne used a model selection approach to choose his preferred forecasting model. The criterion he used was the AIC score, where a lower score suggests a model should provide better forecasts. For the less complex ARIMA(2,1,1) model, the AIC score is only slightly better. Nevertheless, under the model selection approach this is the preferred model for forecasting. And as it turned out, this model's forecasting performance is significantly better.

My study demonstrated that when there is no predominant model to call on, forecast accuracy could be further improved by combining results from the two models. I applied model averaging using a smoothed AIC weighting scheme to generate forecasts for those same remaining years.

Table 3 presents the forecasts and a measure of their accuracy — their absolute percentage errors. The forecast performance of the second model, the ARIMA(2,1,1)(1,1,1)5, is rather poor. Except for 1992 its predictions are always worse, usually by a large margin. In comparison, the forecast performance of the averaged model is quite remarkable. In all cases the forecasts are closer to the true values than those obtained from the better of the two Dharmaratne models.

My averaged model has a mean absolute percentage forecast error of less than 9%, while the corresponding figures for the Dharmaratne models are almost 10% for the more accurate model and almost 20% for the other model.

Conclusion

The specific techniques I used in the preceding examples are just two of many model averaging techniques from the literature now available for researchers. Model averaging has been an increasingly used analytical tool in a lot of applied work. Undoubtedly, this approach will be used more extensively in the future.

Professor Alan Wan
Head
Department of Management Sciences

Alternative data, federated learning and supply chain finance

By Professor Houmin Yan

欲於待， 則書之成未有日也
宋， 戴侗， 《六書故》

Were I to await perfection, my book would never be finished
Dai Tong, History of Chinese Writing, Song Dynasty

***Professor Houmin Yan**, Chair Professor of Management Sciences, and Director, Hong Kong Laboratory for AI-Powered Financial Technologies Ltd. charts the chequered history of alternative data, ensuing concerns over data privacy, and how a federated learning model working in the context of supply chain finance can provide rich and transparent alternative data.*

I clearly remember my excitement at the news of AlphaGo defeating the top human Go players.

I clearly remember my excitement at the news of AlphaGo defeating the top human Go players back in 2017. To crack this complicated game, AlphaGo used 300,000 games to train the model. The occasion had been anticipated by an article about mastering the Go game with deep neural networks published in *Nature* the previous year. Subsequently, another article about applications of reinforcement learning for Go was published in *Science*. It generated great interest among my colleagues. Jeff Hong organised a study group on machine learning in the college and many young faculty and PhD students participated. We all hoped that with modern data technologies, AI algorithms would demonstrate their full potential. However, for many industry applications, data remained the issue. Did we have sufficient data to train AI? Could we answer concerns over data security and privacy? And in the light of these questions, were new algorithms or computational architecture necessary?

A detour to Cambridge

"Farewell to Cambridge," a poem by Chinese modern romantic poet Xu Zhimo, was in the back of mind.

Around this time three years ago, I was assigned by the European Foundation for Management Development (EFMD) as a member of the EQUIS peer review team for Nova School of Business and Economics, Portugal. It happened that CB had an EMBA overseas module running at Cambridge University at the time. The overseas module started on a Saturday and the EQUIS accreditation started on the following Monday. Knowing that I had not been to Cambridge before, my EMBA colleagues asked me if I could make a detour. How could I reject such an appealing proposal? There was the famous statute of Isaac Newton at Trinity College to see, and besides "Farewell to Cambridge," was in the back of mind. This poem by Chinese modern romantic poet Xu Zhimo, had been with me since school days, striving to loosen the Chinese traditional form and to reshape it using influences from western poetry styles. The prospect of a visit to historical Cambridge was alluring, but my visit was to pull me in more contemporary directions.

Early warning signs: Cambridge Analytica and the expandability of data

Facebook's default settings allowed Cambridge Analytica to harvest respondents' Facebook friends, a dramatic example of the expandability of alternative data.

On the first day I attended a lecture by Judge Business School Dean, Christoph Loch. But regrettably, I missed a second lecture by David Stillwell on the use of personal data. This was a big miss since that week the *New York Times* and the *Guardian* reported that British consulting firm, Cambridge Analytica, had obtained the personal data of millions of Facebook users. Stillwell and Aleksandr Kogan had developed an app surveying limited numbers of Facebook users for academic use, but Facebook's then default settings also allowed Cambridge Analytica to harvest respondents' Facebook friends, a dramatic example of the expandability of "alternative data" in this case with significant negative outcomes. Without user consent, Cambridge Analytica employed the data predominately for the political campaigns of Ted Cruz and Donald Trump. The scandal was widely reported resulting in Cambridge Analytica going bankrupt, Facebook settling the case with billions of US dollars, and in 2018 the EU's General Data Protection Regulation (GDPR) was to take effect.

Ant Group uses accumulated transaction data for loan approval

Ant uses accumulated transaction data to continuously optimise its business decision-making algorithms.

Another landmark instance of the use of alternative data relates to the Ant Group. Starting from 2004 as Alipay, Ant Group gradually started to provide innovative financial services such as financing, wealth management, and insurance to both consumers and companies. Their approach differed from traditional bank loan approval processes, which were heavily based on a firm's financial and accounting data, and in turn focused on various financial ratios, such as the ratio of the loan to the borrower's total assets, the current ratio, leverage ratio, and liquidity ratio. The Ant Group's approach uses accumulated transaction data (alternative supply chain data) to continuously optimise and train its business decision-making algorithms, thereby improving target customer identification and customer acquisition capabilities. For loans, Ant Group automatically sends repayment reminders to the borrower, with most repayments set to be automatically repaid through the borrower's Alipay account. According to investment bank reports, the company has the right to directly deduct both principal and interest from the person's Alipay account. In continuing to expand the use of transaction data, this alternative approach and alternative data clearly contributed to Ant's business model for facilitating billions of loans. The last-minute halting of Ant's IPO in November 2020 was probably another example of concerns over data monopoly and privacy.

The regulatory agencies suggest alternative data for credit scoring

The most common AI techniques have a central data processor that imposes risks in cross-sharing customer data.

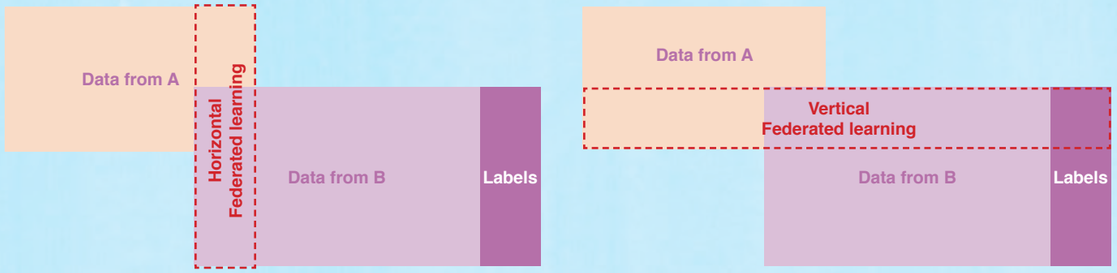
The use of customer data has understandably drawn the attention of the regulatory authorities. In November 2020, the Hong Kong Monetary Authority (HKMA) and Hong Kong Applied Science and Technology Research Institute (ASTRI) released a white paper "Alternative Credit Scoring of Micro-, Small and Medium-sized Enterprises (MSMEs)." Through Financial Technology (FinTech), the paper argued that an alternative approach and alternative data could facilitate loans to small and medium-sized enterprises. The paper indicated: "There has yet to be a treasure hunt to develop models that use alternative data for credit scoring. Machine learning and AI techniques seem to offer the best chance by far for the financial industry to crack the code." The most common machine learning and AI techniques have a central data processor that collects data from various sources. However, it imposes risks in cross-sharing customer data. In contrast with the traditional learning approach, federated learning makes use of raw data for training models to obtain intermediate results. To reflect a joint effort in developing useful models, rather than the raw data, the intermediate results are shared among raw data contributors.

With federated learning the data is available but not visible

Federated learning takes advantages of recent developments in machine learning whilst maintaining data security and privacy.

For data security and privacy issues, Google has developed a concept of federated learning to provide a machine learning environment such that datasets are distributed and data leakages are prevented. This approach was elaborated by Professor Yang Qiang of the Hong Kong University of Science and Technology, published in "Federated Machine Learning: Concept and Applications," in 2019. With different alternative data sets, Yang reckons that federated learning can be a good vehicle, taking advantages of recent developments in machine learning whilst maintaining data security and privacy.

Taking a two-party machine learning example, Yang classifies federated learning as *horizontal, vertical*, and *transfer* learning based on varying data needs. Horizontal learning applies when similar feature data exist but data is owned by different companies who serve different customers. Vertical learning applies when different feature data presents and data is owned by different companies who serve the same customer. Transfer learning applies when feature data is different and the customers served are also different. With federated learning structures, the objective is to make the other party's data available but not visible, and to make use of other party's data but not change data ownership.



The key issues for the financial industry are expandability and the lack of transparency of AI technologies.

In the last few years, various algorithms and architectures have been proposed for financial applications, but have generally fallen short of the full adoption of AI and machine learning for loan arrangements. One could argue that there is a lack of regulatory guidance on the application of AI algorithms. Obviously, current bank systems' governance processes for technology, digitisation, and related services deployments might not remain fit-for-purpose in AI-governed environments. But the key issues for the financial industry are probably concerns over the expandability and lack of transparency of AI technologies.

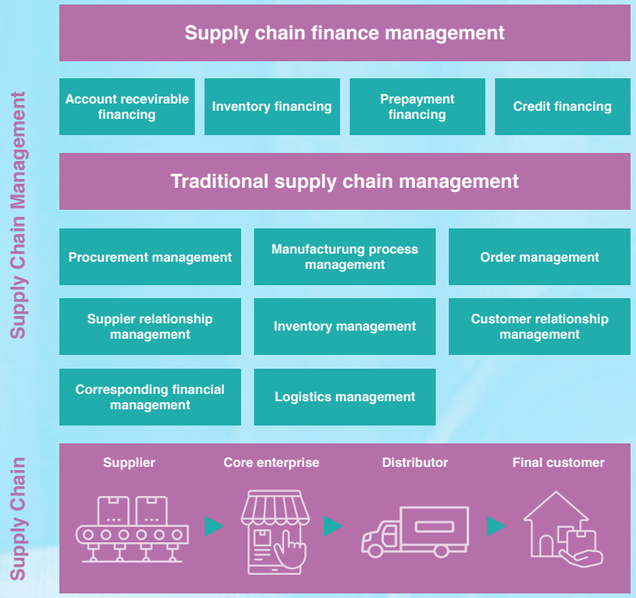
Safety first: Banks favour transparent algorithms

The EU's General Data Protection Regulation requires AI algorithms to explain their decision-making.

AI algorithms, such as deep learning algorithms implemented by neural networks, have been described as a "black-box." Banks favour transparent algorithms characterized by clarity. For example, if *age* is used as a factor in the credit screening process for lending in a traditional bank, can traditional algorithms, such as logistic regression or decision-trees, provide clarity on how age has played a role in the decision-making i.e., to approximate the relationship between inputs (e.g. age) and outputs (probability of default?). The decision-tree based machine learning algorithm has been considered as a promising candidate for understanding, interpretation, and visualisation. It has also been widely tested as being comparable with deep learning algorithms, which all depend on the nature of applications. If data is highly structured, the decision-tree based algorithm performs very well in competing with deep learning algorithms. But it may produce complex trees and become unstable because of small variations in data resulting in different tree structures. Another noticeable feature about the decision-tree based algorithm is the lack of support for horizontal federated learning. Actually, in addition to requesting data privacy and ownership, the EU's General Data Protection Regulation also requires AI algorithms to explain their decision-making. The research frontier is therefore two-fold: Firstly, to enhance cryptographic operations in the decision-tree based algorithms, and secondly to add linear proxy models or decision-tree structure to deep learning algorithms.

The promising role of supply chain finance

Supply chain finance, with its rich alternative structured data, can be a promising domain for AI for loan issuing and risk management.



To this end, we wish to suggest that supply chain finance can be a promising domain for AI and machine learning applications: it has rich alternative structured data, which banks have not made use of, or have no access to, for loan issuing and risk management. A supply chain is a network formed by manufacturers, suppliers, and distributors. The network has three flows: flows of physical goods, flows of information about the goods, and flows of payments of the goods and services. It involves processes such as resource integration, goods design and manufacturing, procurement and production, logistics, and sales and services. Supply chain finance involves financing and financial management for supporting the above-mentioned supply chain processes. Typical supply chain finance models include account receivable financing, inventory financing, prepayment financing, and credit financing. The following diagram represents the relationships of supply chain, supply chain management, and supply chain finance.

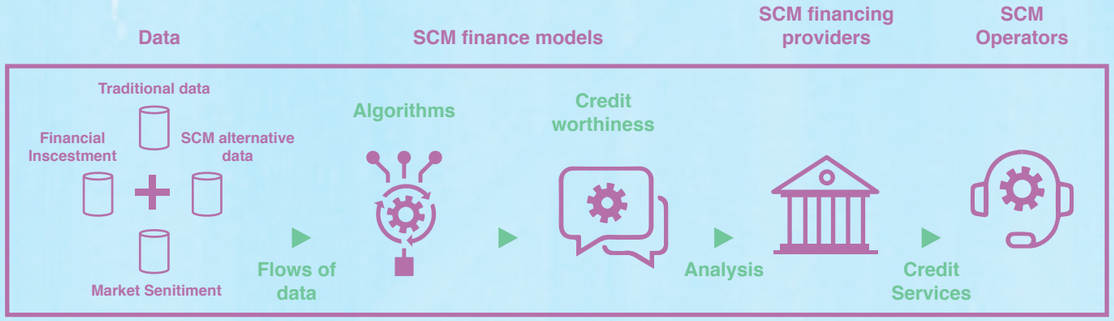
Leveraging on the traditional loan indicators, such as ratio of loans to total assets of the borrower, current ratio, leverage ratio, liquidity ratio and profit ratio, and on continuously improved credit risk assessments resulting from accurate models, FinTech applications in supply chain finance aim at speeding up the credit scoring/lending process and strengthening risk management, including liquidity management, business line allocation, product line allocation, and pricing.

Exploiting transaction data

Exploiting transaction data has also becomes a key competitive advantage in selling. Recently, I started working with a new IDBA student, Mr Lie Li. After graduating from the UK, Mr Li started a new business in cross-border e-commerce. His business turns out to be very successful. Mr Li demonstrated to me examples of how he exploits supply chain data in seeking best-selling products on eBay and Amazon. Take the eBay data for example, it not only provides dynamic pricing and sales data but also supplies website click information such as "other items customers have viewed."

Laboratory for Artificial Intelligence Powered Financial Technologies

In his recent budget speech, Hong Kong Financial Secretary Paul Chan indicated that the InnoHK Research Cluster programme will be officially announced in March, an announcement that has been delayed twice. When reporters asked for details of the programme, Secretary Chan declined to give further advance information. My friends asked me about my opinions of the Financial Secretary's speech on the InnoHK programme. I told them to count only the face value. "If you really want to read between the lines," I added, "probably CE plans to make the announcement, and he does not want to steal the limelight from his boss."Actually, CityU will host three laboratories and Laboratory for Artificial Intelligence Powered Financial Technologies (AIFT) is one of the three.



Rich alternative data

AIFT has identified three R&D themes: AI-driven financial services, AI-enhanced financial technology, and social media analytics.

AIFT will work with City University and Columbia University to assemble a team of professors and research students to conduct academic research, train local talents, and form start-up/spinoff companies. AIFT has identified three R&D themes: AI-driven financial services, AI-enhanced financial technology, and social media analytics. Among them, supply chain financing is one of the intended projects. We plan to extract business value from data, and to develop the augmented intelligence to facilitate credit and risk management decision-making. We have developed a conceptual framework as follows.

Accounting and financial information provide the traditional data. Supply chain information and market sentiment belong to rich alternative data. Because of the multi-party nature of supply networks, we propose a federated learning environment empowered by gradient boosting decision-trees. In addition to traditional and accounting-based loan indicators, we plan to make use of modern portfolio management and asset pricing theories to evaluate credit worthiness.

Novel research results at CityU

Novel research results at CityU also shed new light into exploiting supply chain alternative data and developing machine learning algorithms. For example, Dr Junming Liu of the Department of Information systems conducts research work in an attempt to find best-selling products. He has developed a GCN-LSTM Deep Ranking model that leverages social media activities and their implicit influences on product popularity. This information can be used, in conjunction with supply chain transaction information, as a leading indicator for future sales. Dr Yining Dong of the School of Data Science is working on algorithms to overcome the notorious lack of interpretability of machine learning algorithms by adopting gradient boosting decision-tree to federated learning. We are quite confident that AIFT will provide useful results and we welcome faculty, students, and alumni to join in our efforts.

Professor Houmin Yan
Chair Professor
Department of Management Sciences

Driving analytics by insight

By Professor David Li

***David Li**, Professor of Marketing and Management Sciences, argues that analytics should go beyond operational and technical levels and be driven by business insights. This presents business schools with opportunities to advance new perspectives, offering students a more holistic view of business problems. Professor Li runs the Decision Analytics Group which is dedicated to the research, education and application of decision analytics. This article is based on Mao, Huiqiang; Li, Yanzhi; Li, Chenliang; Chen, Di; Wang, Xiaoqing; Deng, Yuming / PARS: Peers-aware Recommender System. April 2020; The Web Conference 2020: Proceedings of The World Wide Web Conference WWW 2020. pp. 2606-2612; and Shen, H., Li, Y., Guan, J., & Tso, G. K. 2020 A Planning Approach to Revenue Management for Non-guaranteed Targeted Display Advertising. Production and Operations Management, forthcoming.*

Analytics drives creativity. At Netflix, analytics dynamically determines the course of a new series in response to viewership figures.

Analytics has long played a pivotal role in the success of landscape-changing companies. Google, Facebook and Amazon have all made full use of their vast data sources from the outset. But, impressively, analytics also drives creativity. Industries that traditionally relied on gut decisions now look to data. Take Netflix, famous for not only recommending favourite movies to users, but also for creating entertainment by data guidance. Analytics helps pick the right mix of talents and resources – programme types, casts, producers, and investment - and dynamically determines the course of a new series in response to viewership figures. This affects decisions such as increasing or downplaying the role of an actor, changing a storyline, or even pulling a series.

Companies derive valuable insights into their customers, operations and marketing strategy through analytics. The people who play critical roles in this process are data scientists, and they typically receive their training in computer science – especially machine learning and artificial intelligence, as well as statistics and applied mathematics. Such technical training equips students with the ability to work with data and search for answers. In some cases, the technical ability plays a differentiating role, a matter of whether a problem can be solved or not, especially when the problem is large-scale or complex. Imagine an e-tailer who needs to deliver parcels as required by its customers in specified time windows. Failing that would mean unhappy and possibly lost customers. Solving the problem at the scale of hundreds of thousands of customers with hundreds of delivery staff in a city is a very challenging task.

Unlock the full potential of data

To release full power, analytics has to incorporate business insights.

However, to release full power, I would like to argue that analytics has to be guided by and incorporate business insights. In this process, the new generation of tech-savvy business school graduates has a pivotal role to play. In business schools, we teach how to frame a business problem correctly and ask the important and critical question. We have accumulated a very solid and comprehensive knowledge database about the behaviour of consumers and decision makers, financial systems, and market dynamics. Such understanding should play a guiding role in exercising analytics, and needs to be incorporated into the analytics process. In this way, the full potential of data can be unlocked. Neglecting this can lead to undesirable consequences. I will elaborate my argument based on a couple of research projects we have completed over the past few years.

Optimising Tmall supermarket

We examined the current practice and identified some drawbacks.

Two years ago, The Decision Analytics Group worked with Alibaba on a recommendation problem for their Tmall Supermarket. Different from its traditional business, Tmall Supermarket runs a direct selling business model: Alibaba buys and owns the inventory and sells to its customers. To increase customer stickiness, Tmall Supermarket runs a channel called " 今日疯抢 (Today's Best Deals)," which is positioned to sell a selection of the most popular products from the tens of thousands of products on offer. A simple-minded approach for selecting the products would be to take those with the highest sales. A more sophisticated approach is to use the many established recommendation algorithms in machine learning such as collaborative filtering. Previously, Tmall Supermarket used a customised approach that combined some business rules such as "A and B cannot be sold together" as well as machine learning algorithms to select products. Typical recommendation algorithms rank items based on their relevance and recommend to customers the items with highest relevance.

We examined the problem and the current practice and identified some drawbacks. First, the objective of the problem was not clearly defined: Was it to maximise the clicks, the

revenue, or the profit? Maximising total relevance may not optimise any of these, though possibly positive related. Second, the previous approach ignored the mutual influence of products contained in the channel. For example, when two competing products were offered, their sales would be diminished by each other. Thirdly, customers' substitution behaviour, switching to another product when one's most preferred product is not available, has long been established as a trait in business research but was also ignored in the previous approach.

Boosting performance

The implementation of our approach on Tmall Supermarket brought a 7.4% improvement.

In view of these drawbacks, we proposed a new approach that clearly reflected Tmall's objectives and captured the customer behaviour and cross-product influence. In particular, we made use of the preference-ranking customer choice model, which is well researched in marketing literature. Marketing research shows that customers often follow a two-step process in their shopping process. In the face of overwhelming choices, they will first quickly scan the products and boil down to a smaller group, called the consideration set, and then deliberate more carefully on this narrowed selection to decide what to buy. This customer choice model allows us to capture customer substitutions for any given selection of products. The analytics model we built and the solution process are both simplified due to the incorporation of consumer behaviour knowledge.

The outcome of our business insight-driven effort was impressive. The implementation of our approach on Tmall Supermarket brought significant improvements: a 7.4% improvement on the conversion rate (the proportion of customers who purchased among those who clicked the products), and a 16.9% improvement on the amount of goods bought.

There are better revenue models than auction

Event-based auction has a few well-known drawbacks such as fraudulent behaviour.

Since the inception of the internet economy, advertising has been the most important revenue model. In particular, despite all the controversies about user privacy, the internet allows advertisers to target their customers effectively. For each search keyword or each user impression, there are potentially many interested advertisers, and a classical way of deciding the ad resource allocation is auction; simply speaking, whoever brings the highest payoff to the website wins. But event-based auction has a few well-known drawbacks. For example, the first time you are exposed to an ad, suppose you are aware of it, there is a higher chance you may click it. If you have clicked it, the chance you will click it again is extremely low. This applies to a targeted group as well. Therefore, the number of clicks you will receive from a targeted group for a particular ad first increases sharply, then increases slowly with the number of times you display the ad. In other words, the number of clicks is an S-curved function of the number of impressions.

In marketing theory, this diminishing marginal effect is termed "advertising wearout effect." Such dynamic effects are hard to capture by per-event based biddings, although the industry has proposed various measures to correct this; for example, dynamic updating of the click-through rate (CTR), which measures proportions of individuals who see an online ad and subsequently click on it. Another major drawback associated with the auction mechanism is that it may induce fraudulent behaviour. For example, advertisers may intentionally set very low prices at the beginning of the day and wait to win the bids until the later part of day when the budgets of other advertisers have been used up. To prevent such behaviour, again, the advertising firm has to introduce some smoothing-out scheme into the supposedly event-based auctions.

Advertising wears out over time

We tested our method at a world-wide leading advertising platform and found a 10% revenue boost.

In view of the drawbacks of the current selling mechanism, we proposed to plan the advertising delivery by a globally optimal allocation of ad resources. We no longer relied simply on event-based auctions, which by nature are short-sighted and cannot produce a coordinated strategy. Instead, we made use of existing advertising theory, namely, the characteristic S-curved function of ad clicks. To get the number of clicks, one may feel tempted to simply take the product of CTR and the number of impressions. This, however, would be wrong, since the CTR is changing dynamically. In other words, it is the insight that advertising will wear out over time that has inspired us to think about a planning approach, which then further creates the need to make a prediction of the number of clicks for a given number of impressions. In end effect we have produced an analytics task that is new to the community.

We developed a prediction model, and then based on that, an optimisation model to allocate the ad resources. We tested our method at a leading world-wide advertising platform and found an improvement of over 10% to revenue, a huge boost to profitability.

Ask business-savvy questions

When we ask, "Why are we doing this?" it may lead to fresh formulation of analytics problems.

Our two research stories above confirm a rather ubiquitous observation shared by many business executives. Current industry practice into customer behaviour may not be answering the right question, even though it may be technically efficient. As we often say, it is more important to do the right thing than to do things right. Business school education teaches a holistic and fundamental view of business problems. It equips our graduates with the ability to ask business-savvy questions, more relevant to business strategies, long-term goals or short-term objectives. When one questions, "Why are we doing this?" it may lead to different perspectives and fresh formulation of analytics problems.

Incorporating business insights like the S-curved customer response function will simplify the data analysis job and reduce the need for big data. In fact, unlocking the full value of analytics requires talents that know both analytics and have a sound grounding in business knowledge. As of today, engineering-trained talents learn business insights on the job. But the chances are that many take the status-quo for granted and do not ask the deeper question as to *why* things work in the current way. Many business school graduates, on the other hand, often lack the technical skills that allow them to embark on the analytics journey in the first place.

The new generation will win by doing analytics with insight

Analytics should go beyond operational and technical levels.

Analytics is becoming increasingly important to business success. To make the right strategy, design the right product, and deliver the right service all analytics need to be empowered by insight. After all, analytics is a tool that helps make more informed business decisions. Right now, business schools and business graduates are punching below their weight. They are not playing the important role that should be theirs. With more analytics courses introduced into our curriculum, our new generation of graduates will be better equipped to make a profound change to the current analytics landscape. Analytics should go beyond operational and technical levels. Analytics should be guided by business strategy and support the execution of strategy. The new generation of analytical competitors will win by doing the right analytics. Business insights will remain central to this process.

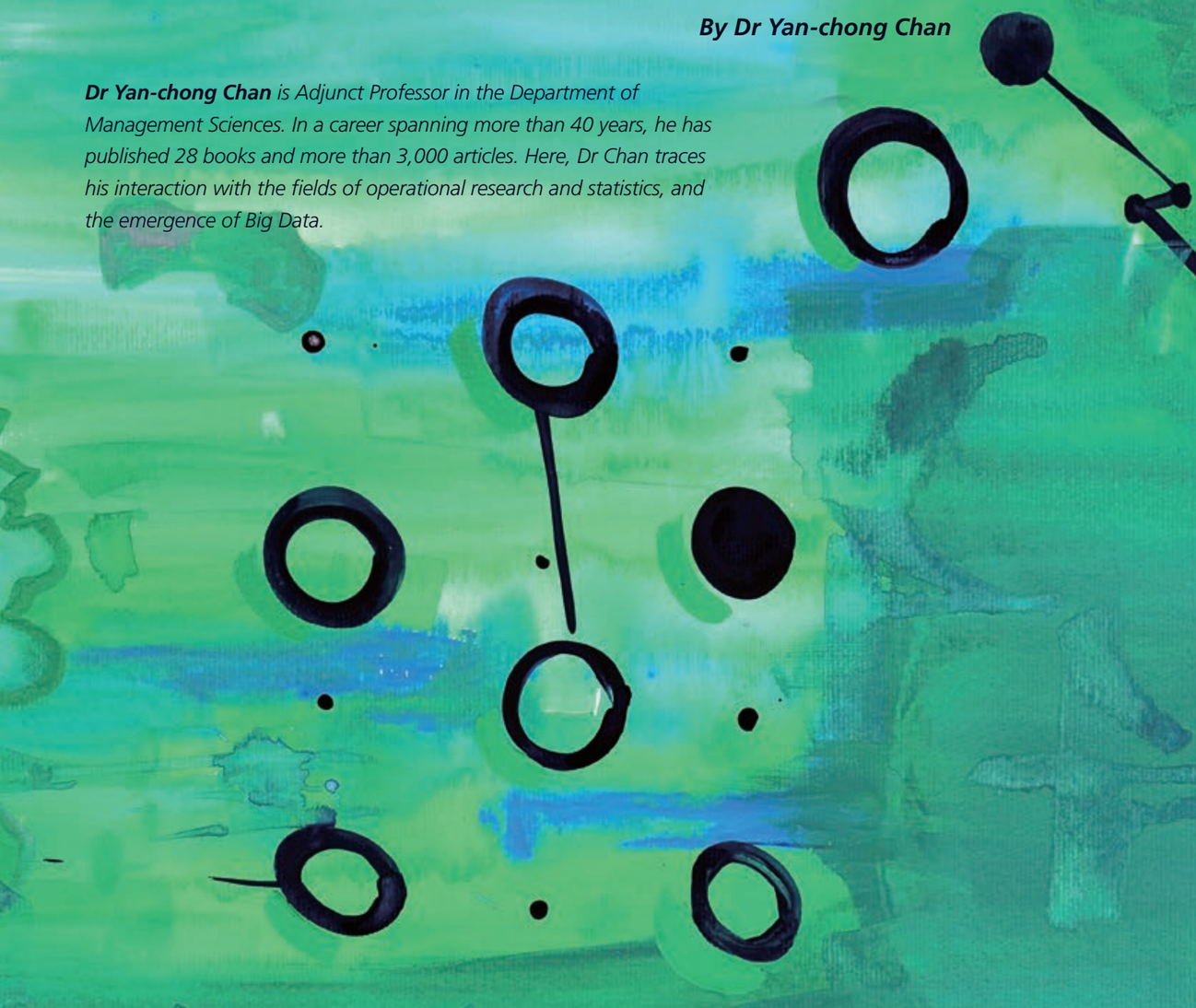
Let us be ready to make our unique contribution.

Professor David Li
Head
Department of Marketing
and Professor, Department of Management Sciences

Operational research, statistics and big data

By Dr Yan-chong Chan

Dr Yan-chong Chan *is Adjunct Professor in the Department of Management Sciences. In a career spanning more than 40 years, he has published 28 books and more than 3,000 articles. Here, Dr Chan traces his interaction with the fields of operational research and statistics, and the emergence of Big Data.*



The Department of Management Science at City University is composed of operational research and statistics. However, many years ago, when I studied for a Masters of Operational Research at the University of Lancaster in the United Kingdom, statistics was considered part of operational research. it is impossible to apply the mathematical models of operational research without the basis in statistics.

In the early days, many students asked "What kind of job can I find after graduating from operational research?"

In the earliest days, operational research was the application of mathematics to operation management, which was a branch of mathematics. It was only when I entered the mathematics department in the 1970s for my undergraduate degree that I came across the term operational research. In the early days, when I was teaching at City University, many students who like me, first learnt about operational research when they entered university, asked the question "What kind of job can I find after graduating from operational research?"

Back then, when operational research was still a branch of mathematics, the actual industrial or commercial use of operational research was indeed not extensive – as the ability to calculate was rudimental. Many operational research model calculations were impossible to calculate by hand or by a simple calculator. Even further back in the 1960s when I studied middle school, the calculator which started to be available to the public was very expensive; most calculations back then were still conducted with a pen and paper. In other words, the application of operational research needed to be matched by a similar ability to calculate, which is why the popularisation of computers was so important for this branch.

In exam questions, it was four variables maximum as anything more complex could not be easily calculated by hand or simple calculator.

By the early 1980s when I returned from England to Singapore to work in the F&B and Agro-product sector, my first challenge was to develop a computer calculated formula for pig feed. This was a classical applicational of linear programming which was taught during university. However, back then, in exam questions there wouldn't be more than four variables as anything more complex could not be easily calculated by hand or by a simple calculator.

Coincidentally, in the 1980s, Apple launched its Apple II computer and the company decided to purchase one, a computer with only 64K of computing power. That is 64k, not 64M, or 64G! Back then I could not find any linear programming software, so I wrote myself one with BASIC programming language. Guess how long it took to calculate at that time? What can be calculated in less than one second today took one hour back then. In the early 1980s, the writing of my own software and using Apple II to calculate feed formulas for pig farms was considered a big deal in the eyes of my boss. However, my identity in operational research and computer science was inseparable back then.

Operational research and statistics remain the backbone of big data.

Many years later the term big data emerged. In the stock market, the hype was extremely high. These stocks were called new economy stocks. When e-commerce platform Meituan was preparing to go public in Hong Kong and I was asked to sit in with management to understand more about the company, the management talked about big data and the best route for management to achieve the most effective meal delivery service. Isn't the best route management also the most classic application of operational research? Of course, a lot of data analysis and statistics are required for application, hence the term big data overshadowed operational research, however, operational research and statistics remain the backbone of big data.

It is indeed difficult to draw a clear boundary between different schools of learning.

Dr Yan-chong Chan
Adjunct Professor
Department of Management Sciences

Rethinking cryptocurrencies

By Dr Simon Trimborn

Dr Simon Trimborn, *Assistant Professor of Business Statistics in the Department of Management Sciences, argues that cryptocurrencies, and Bitcoin in particular, have strayed far from their initially conceived role as digital payment systems and that market participants are constantly re-inventing their use. This article is based on various articles and projects, most notably Trimborn, Simon; Li, Mingyang; Härdle, Wolfgang Karl I Investing with Cryptocurrencies – a Liquidity Constrained Investment Approach, published in the Journal of Financial Econometrics, 2020.*

The Bitcoin project sparked the emergence of numerous companies working on or around the new asset.

The launch of Bitcoin in 2009 marked the beginning of a radical realignment in the digital economy. The idea of having a medium for transactions without the need for a designated intermediary, such as a bank or Swift, attracted a fairly high amount of interest from people all over the world. Within a few years, the Bitcoin project had sparked the emergence of numerous companies working on or around the new asset. A combination of approaches from cryptography, computer science and economics created this new system. Please note, I say "without the need for a designated intermediary," an intermediary was still needed to process the transaction. However, the system ensured that no single entity had control of the system.

Going beyond the processing of payments

As original as the idea behind Bitcoin was, the system was not without flaws.

As original as the idea behind Bitcoin was, the system was not without flaws. As with any system, its properties are only present under certain conditions which means that the Bitcoin system could be attacked. To be clear, I am not referring to the blockchain. The Bitcoin blockchain works perfectly fine as it is, though its role is only to record transactions. Only in combination with other approaches does the Bitcoin system materialise. I will briefly mention three notable features here. Please note, this list is not exhaustive. These have been selected as features of Bitcoin which have triggered tremendous research activity to overcome the ensuing flaws.

Firstly, as mentioned, the Bitcoin system has no designated intermediary. Instead, the decision on the payment processor for the next block of transactions is conducted via a trial-and-error search for a cryptographic string, called Proof-of-Work. Since this is a competitive process, there is an incentive to utilise ever more computational power to find the said string and win the reward associated with it (winning Bitcoin). This leads to huge power consumption for the processing of Bitcoin transactions which is often criticised. (Note that other Proof-of-... concepts were introduced and are used in other cryptocurrencies which require significantly less power.)

A second notable feature of Bitcoin is its limited supply. Unless the Bitcoin community decides to change this feature, there will be a maximum of 21 million Bitcoin available. This is part of the Bitcoin system to counter inflation, though some see it as a limitation which has in turn led to some other cryptocurrencies having an infinite supply.

A third feature of Bitcoin is its privacy. Even though the transactions are recorded publicly on the blockchain, the identity of the parties involved is unknown. However, this only holds as long as the users follow rules such as using a new transaction signature, or "address," for each new transaction. Frequently such rules, are not applied by users and, as a result, Bitcoin users became traceable to some extent via their transactions. Other approaches were developed and are used in other cryptocurrencies which introduced privacy-focused systems to ensure a higher degree of anonymity than Bitcoin can offer.

In the early days, most of the alternative cryptocurrencies were merely copy-cats and attempted only to solve minor limitations of Bitcoin. Over time, however, new cryptocurrencies went well beyond the processing of payments. The market for cryptocurrencies has evolved in many different directions since 2009, and this calls for a fundamental rethink into their nature and use.

The coffee gets cold

The very name "cryptocurrencies" suggests that all of these tokens are primarily deployed as currencies. However, this is not the case.

The very name "cryptocurrencies" suggests that all of these tokens are primarily deployed as currencies.

However, this is not the case. Many constitute tokens with very different purposes, and even the ones which were originally intended as currencies like Bitcoin, barely qualify for a widespread use as a medium of exchange. Bitcoin transactions are posted every 10 minutes onto the public blockchain. Proof-of-Work decides who is the current designated payment processor via the search for a cryptographic string. It is possible that more than one entity finds this string at almost the same moment and then more than one person will post the transactions. In this case, over time the users will agree on whose block of transactions to use which will cause the other persons' blocks, and the subsequent blocks attached to those sidechains, to be invalid.

These payment processors may not post identical transactions to the blockchain. They have a choice on which transactions to include into their block of transactions, which means that one's transaction may not be posted to the blockchain by every payment processor. If your transaction is in an invalid block, then it will not be on the blockchain. The problem is: you will only know with time if a block, and therefore the transactions included, are valid or not. Usually, it is agreed that for Bitcoin it takes six new blocks until a block can be considered as highly likely to be valid. This means, if you were to try to pay for a coffee-to-go in a store with Bitcoin, you would have to wait until six blocks were posted to the blockchain. Only then would the Barista accept the payment. Given each block is posted only at a 10-minute interval, you would have to wait about one hour in the store until you could enjoy the coffee. Besides the coffee getting cold, the delay is a systemic problem impairing the widespread use of Bitcoin as a payment system.

Cryptocurrencies as a speculative asset

This limitation as a medium of exchange is widely acknowledged and in reality, Bitcoin, as well as many other cryptocurrencies, are typically used in very different ways. The most popular is as a speculative asset class. Due to exorbitant returns, cryptocurrencies and Bitcoin in particular have received strong attention, and their prices often move from one all-time-high to the next. However, frequently they go in the opposite direction and whoever buys shortly before a price crash, loses a substantial amount or even all of their previous investment.

A perfect "add-on" to an investment portfolio?

Cryptocurrencies possess a diversification effect with regards to assets from traditional financial markets.

High returns are not the only attraction. Financial econometricians have analysed the actual properties of cryptocurrencies and found that they possess a diversification effect with regards to assets from traditional financial markets. They are said to be a perfect "add-on" to an investment portfolio, given their low correlation with traditional assets. However, there are other factors to consider. Investing in cryptocurrencies is illegal in some jurisdictions, which has to be taken into consideration when making investment decisions. For the jurisdictions where it is legal, the question remains whether one can actually leverage on the diversification effect. Studies have shown that many cryptocurrencies feature too low-a-liquidity for an actual investment into them. An investor who buys too many tokens of a particular cryptocurrency would disrupt the price on the market or even buy off the entire supply. An investment amount of 1,000 US-Dollars would already be too high for some illiquid cryptocurrencies.

A store of value better than gold?

Certainly, one is not interested in storing valuables in an asset which is prone to large losses.

Another popular claim is that Bitcoin is a store of value similar to, or even better than gold. Defining an asset as a store of value implies that one is interested in preserving its value, otherwise it would be a speculative asset. Certainly, one is not interested in storing valuables in an asset which is prone to large losses. However, Bitcoin as well as other cryptocurrencies are exposed to strong changes in their market value. The volatility is exorbitantly high compared to gold, and has been the basis for a number of studies in financial econometrics. Of course, this does not mean that Bitcoin won't be able to act as a store of value in the future by establishing a more stable time series. However, gold still has one advantage over Bitcoin which it will never lose: it is a commodity used in manufacturing. This ensures that its price is much less likely to drop to zero.

Searching for a role: ICOs, smart contracts, decentralised finance

Initial Coin Offerings (ICOs) are another innovative idea. In an ICO a start-up sells the tokens of its newly founded cryptocurrency which often entitles the holder to participation in the success, or downfall, of the start-up. The founders of the start-up then use the allocated funds to finance operations. The concept is akin to Initial Public Offerings where a start-up sells shares of its company to finance future operations. Note, however, that in practice many ICOs have proven to be scams, and funds have been embezzled.

At about the same time the idea of smart contracts grew. These are programmes which are linked to a cryptocurrency and the clauses of the contract cause transactions on the blockchain. In this way, the specifics of a contract are publicly recorded and visible to whoever shall stay updated on the ownership of an asset. This could include information on ownership of a house, or obligations resulting from a contract.

A further recent trend in the cryptocurrency market is Decentralised Finance (DeFi). These are programmes constructed on top of a blockchain which offer financial services. Different to finance apps offered by financial institutions or other companies, DeFi apps store the information on a blockchain and function via smart contracts. All these applications have moved far away from the original notion of payment services, and are more in the area of investments.

Constant reinvention

It is not clear which – if any – of the current uses will prevail or if a new use opportunity will arise which will constitute a long-term application.

As we have seen, the actual use of "cryptocurrencies" has diverged far from their initially intended use in 2009: payment systems. The very term stems from the initial project description for Bitcoin. Within the community, various claims have since been made for crypto properties, such as "digital gold," intended to be a digital store of value. However, the actual market performance of Bitcoin does not support this claim, with strong market fluctuations disqualifying it as a payment system.

To counter this, some cryptocurrencies were introduced as "stablecoins," intended to pave the way towards use as currency. Commonly the stable price is achieved by backing with another fiat asset or currency with stable market performance, such as the US-Dollar, or by backing them with a basket of non-stable cryptocurrencies which are hedged against one another to achieve a stable price formation of the baskets value. In practice some stablecoins have not been able to hold their peg and were exposed to volatility after all. The vast majority of cryptocurrencies are non-stablecoins which are primarily used for investment, implying speculation on their future performance.

Throughout their history, market participants have constantly reinvented the role of cryptocurrencies. So far it is not clear which – if any – of the current uses will prevail or if a new use opportunity will arise which will constitute a long-term application. Only the future will tell. In the meantime, it will be certainly interesting to follow the ongoing developments in the cryptocurrency space.

Dr Simon Trimborn
Assistant Professor
Department of Management Sciences

Deep learning in empirical asset pricing

By Dr Gavin Feng

Dr Gavin Feng *is an Assistant Professor of Business Statistics at the Department of Management Sciences. In this article, Feng focuses on the interdisciplinary research between deep learning and asset pricing factor investing. The particular innovation is understanding the discovery and construction of asset pricing factors with a bottom-up deep learning model. This article is based on his co-authored paper "Deep learning in characteristics-sorted factor models" with Nicholas Polson and Jianeng Xu from the University of Chicago.*

Models for stock returns include Nobel Prize research such as the Capital Asset Pricing Model and the Fama-French 3-factor model.

Asset pricing models study why different assets attract different expected returns. Examples of such models for stock returns include Nobel Prize research such as the CAPM (Capital Asset Pricing Model) and the Fama-French 3-factor model. In 2020, we present a bottom-up approach based on deep learning applied to the construction of asset pricing models, which include firm characteristics (inputs), risk factors (intermediate features), and security returns (outputs). The question addressed using deep learning, one special method in machine learning, is how to improve asset pricing models to explain the cross-sectional average returns.

According to ICAPM of Merton (1973), a combination of common tradable factors captures the cross-section of expected returns, and the regression intercept should be zero.

$$R_{i,t} = \alpha_i + \beta_{1,i} * f_{1,t} + \cdots + \beta_{k,i} * f_{k,t} + E_{i,t}$$

Therefore, the model fitness for asset pricing is not about the explained variation in time series, but the magnitude of intercepts, alphas, in the cross-section. This non-arbitrage restriction on alphas implies that simply adding factors leads to statistical overfitting (time series R2) but does not cause economic overfitting (intercepts).

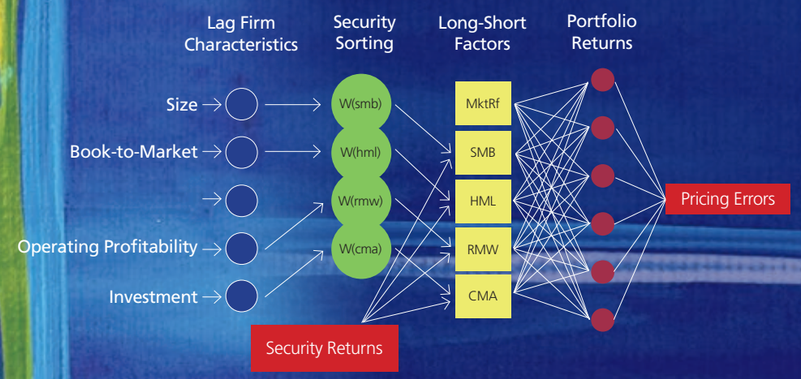
Researchers typically sort securities on firm characteristics and create long-short portfolios as common risk factors to build asset pricing models.

In empirical studies, researchers typically sort securities on firm characteristics and create long-short portfolios as common risk factors to build asset pricing models. The goal is to explain the time-series variation of multiple asset returns and their average returns' cross-sectional variation. For example, Fama and French (1993) add SMB (small-minus-big) and HML (high-minus-low) to CAPM. However, in the asset pricing literature, almost all proposed factor models have rejected the zero-alpha hypothesis. Therefore, we want to approach this puzzle, with a machine learning perspective, as an optimisation problem: How does one construct a factor model to minimise pricing errors or alphas?

How does one construct a factor model to minimise pricing errors or alphas?

The goal of their paper is to investigate the underlying mechanism of the characteristics-sorted factor models, which includes sorting securities, generating factors, and fitting the cross section of security returns. The particular focus is the cross-sectional variation of asset average returns. They define an non-arbitrage objective function, pricing errors, for the optimization problem. They show the characteristics-sorted factor models can be dissembled as a deep learning architecture (see Figure above).

This figure provides a deep learning representation of building the Fama-French 5-factor model using firm characteristics to calculate the objective function, pricing errors, for portfolio returns. The lag characteristics are inputs. The long-short factors are hidden neurons. The portfolio returns are outputs.



(1) *Inputs* are firm characteristics. The neural network starts from sorting securities on firm characteristics, which is a non-linear activation to create long-short portfolio weights.

(2) *Intermediate features* are risk factors. The factors are linear activations (long-short portfolio weights) on realised returns from the sorting directions.

(3) *Outputs* are security returns. Minimising an economic objective function is equivalent to minimising pricing errors for fitting the factor model to portfolio or individual stock returns.

The focus is on "training a factor model" rather than "testing a factor or characteristic."

Distinct from the literature on stochastic discount factors, we focus on training a factor model rather than testing a factor or characteristic. Apart from the PCA literature, their innovation is to apply dimension reduction on firm characteristics (inputs) rather than the characteristics-sorted factors (intermediate features). We argue the current literature is mostly about intermediate features and outputs (security returns), whereas ours illustrates the complete channel between inputs and outputs. We adopt a non-reduced-form neural network and develop such a bottom-up approach that includes security sorting, factor generation, and fitting the cross-section of security returns. The Fama-French-type characteristics-sorted factor models can be shown as "shallow" learning models.

Dr Gavin Feng
Assistant Professor
Department of Management Sciences

Selling through lotteries: an art to combat ambiguity

By Dr Zhi Chen

***Dr Zhi Chen**, Assistant Professor in the Department of Management Sciences explores whether randomisation based on a carefully designed device may lead to significant improvement over deterministic decisions. The article is based on the results of a working paper entitled "Screening with Limited Information: The Minimax Theorem and A Geometric Approach." Zhi Chen is grateful for the numerous contributions from his co-authors Zhenyu Hu and Ruiqin Wang from the Department of Analytics & Operations, National University of Singapore.*

From the seller's perspective, what are the motivations behind these different selling mechanisms?

There's a chill in the air, but the sun is out. Your best friend has just messaged you: "This is the perfect weather for getting out and into the countryside." You walk past your local bike shop and notice there's a mountain bike on sale. You think to yourself: "Wow, that's way below the price I was expecting." You go in and confirm the price with the shop assistant. You think to yourself: "A bargain." — You buy the bike!

You've had enough of the fresh air. You go back online. You see a pop-up message on your screen. There's an opportunity to pay for opening treasure chests with a high chance of buying rare in-game items. The price is at an attractive discount. You think to yourself: "A bargain." - You click on it!

From the seller's perspective, what are the motivations behind these different selling mechanisms? Selling a product to a customer whose valuation of the product is the customer's private information is a fundamental problem in revenue management. The key decision herein is to decide an optimal pricing scheme that maximises the seller's expected revenue, given the practice that customer valuation, often unobservable, is typically modelled as a random outcome from certain probability distribution.

The posted price mechanism

Announcing a fixed price to the customer is a simple yet powerful way to sell the product.

Announcing a fixed price to the customer, formally termed the posted price mechanism, is a simple yet powerful way to sell the product. In the posted price mechanism, it is assumed that for any given price, a customer whose valuation is above the price would buy the product. That is to say, the optimal posted price would maximise the seller's expected revenue by maximising the product of (1) a deterministic price and (2) the probability that the customer valuation is not smaller than that price. The practice of the posted price mechanism commonly appears, e.g., in brick-and-mortar stores. Indeed, it is a celebrated result in mechanism design that whenever the probability distribution of customer valuation is known to the seller, the posted price mechanism is optimal among all possible selling mechanisms the seller shall consider.

Alternative ways of selling

Selling using lotteries and randomized pricing are mathematically equivalent!

Of course, there are many other ways to sell. For example, the seller can sell a lottery: the customer pays a fee to enter the lottery and wins the product with certain probability. Alternatively, the seller can randomise the price (e.g., by rolling the dice): the seller posts a distribution of prices and randomly draws one price from the distribution. An interesting fact is that although framed in perspectives that seem to be totally different, selling using

lotteries and randomised pricing are mathematically equivalent! It is also worth noting that the posted price mechanism is a special case of the selling through lotteries mechanism, where the customer pays an entrance fee that is high enough would win the product for sure! At first glance, selling using lotteries (and/or randomised pricing) is less intuitive than the posted price mechanism. Nevertheless, the practice of using lotteries as a selling mechanism has been commonly seen in the online game industry, for instance, in the form of drop rates of rare in-game items.

Is there any incentive for a seller to use lotteries?

Let us consider the following simple example. The customer values the seller's product at $2 or $1 or no value at all. We assume here that the customer would purchase the product if she is indifferent between purchasing and no purchasing; and the customer would choose to pay the posted price if she is indifferent between buying the product and buying the lottery. The seller is aware of the possible values and is also confident that the average valuation is at $1. However, the seller does not have any further information on the probability at each possible value: $0, $1 or $2.

Suppose the seller presumes a uniform distribution over the values $0, $1 and $2. Then the optimal selling mechanism (under the hypothesised distribution) is to post a price of $1 or $2 with the hypothesised optimal revenue of $2/3; see Table 1.

However, if in the true distribution the customer values the product at $0 or $2 each with a probability of one half (with the mean valuation stays at $1), then with the posted price of $1 that is optimal under the hypothesised distribution, the seller's expected revenue would drop to $1/2 because the customer would buy the product with a half chance.

Consider now the following selling through lotteries mechanism. The seller posts a price of $4/3 and simultaneously sells a lottery priced at $2/3 with a winning probability of 2/3. Clearly, a customer with valuation zero would not purchase anything. A customer who values the product at $1 would prefer to buy the lottery because her valuation $1 is smaller than the posted price $4/3; while under the selling through lotteries mechanism, her net utility, i.e., the difference between her valuation times the winning probability and the price of lottery, amounts to $1×2/3 - $2/3 and is not smaller than $0. Using similar calculations, we can tell that the customer with valuation of $2 would pay the posted price of $4/3. One can then show that under the selling through lotteries mechanism, the seller's revenue is guaranteed to be $2/3, as long as the customer's valuation is distributed over the values of $0, $1 and $2 with an average valuation of $1.

In the above example, the power of the posted price mechanism is limited when facing the ambiguity in the probability distribution of the customer's valuation. Here, the ambiguity refers to the fact that the precise probability distribution is not known to the seller. This phenomenon is often the case in practice. In many real-world applications, the probability distribution of the customer's valuation is rarely known precisely, but rather, the seller only has a confident prediction of, at best, certain statistics of the customer's valuation, such as the maximum the customer is willing to pay or the average valuation of population. In such a case, the posted price mechanism may be suboptimal.

Price	$0	$1	$2
Selling Probability	1	2/3	1/3
Revenue	$0	$2/3	$2/3

Customer values the product at $0, $1 and $2 each with a probability of one third.

Is there a better mechanism that the seller can use?

The answer is a firm "YES!" The example above shows that the seller can indeed do better and achieve a robust revenue guarantee of $2/3 if he uses the selling through lotteries mechanism beyond the posted price mechanism. This motivates us to study the general problem of finding a robust selling mechanism when the seller has limited information on the valuation distribution.

Instead of having a perfect knowledge on the probability distribution of the customer's valuation, we assume the seller merely knows that it belongs to a family (termed the ambiguity set) of probability distributions that share certain identical statistics that are deemed reasonable and are easy to estimate through historical sales data or surveys. The seller then solves a max-min problem that seeks to maximise the worst-case revenue over all possible probability distributions in the ambiguity set.

Building upon the famous minimax theorem in game theory, for a very general ambiguity set, we show that the problem of finding the optimal selling through lotteries mechanism is equivalent to a min-max problem in which an adversary seeks to find a worst-case distribution to minimise the maximum revenue achievable by a posted price mechanism. Although in the min-max problem, the seller, who originally considers the selling through lotteries mechanism, is now restricted only to a posted price mechanism, he enjoys the information advantage of first seeing the distribution chosen by the adversary before choosing his own price. Our result demonstrates that the extra value brought by more sophisticated selling mechanisms over the simple posted price mechanism is exactly the value of information under a posted price mechanism. Quite interestingly, depending on the ambiguity set, the extra value can be just zero or can approach to infinity!

Our findings that show the selling through lotteries mechanism can outperform the posted price mechanism reveal the potential of revenue improvement from randomisation, when facing ambiguity in the probability distribution of the customer valuation. From this perspective, we once again confirm one of the most important takeaways in the field of decision-making under uncertainty: randomisation based on a carefully designed device, as an art to combat ambiguity, may lead to significant improvement over deterministic decisions. So, when launching your new product next time, please do remember to bring the dice with you!

Dr Zhi Chen
Assistant Professor
Department of Management Sciences

Interview with Professor Wai-kee Kam founding Head of Department

Interview by Professor Alan Wan

Throughout its 37 years of existence, the Department of Management Sciences has been known by a number of different names: Mathematics and Science (1984-1987), Applied Mathematics (1988-1991), Applied Statistics and Operations Research (1992-1997), before finally adopting its present name of Management Sciences in 1997.

Reading the history of the department, we should all be grateful for, and be proud of, the leadership provided by **Professor Wai-kee Kam**, our Head of Department from its inception in 1984 until 1993, when Professor Kam assumed the role of Pro-Director at the then City Polytechnic of Hong Kong. Professor Kam retired in 1995.

The changes experienced by the department and university under Professor Kam's 11 years of leadership were enormous, including the introduction of degree programmes in 1988, the formation of the Department of Applied Statistics and Operations Research within the Faculty of Business following a split in the Department of Applied Mathematics in 1991, and the transformation of City Polytechnic to become City University in 1994. In the late 1980s, the MS Student Society set up the Kam Wei Kee (Basketball) Trophy to honour his enduring contribution. The trophy remains up to the present day an annual award of the MS Student Society.

The hallmark of Professor Kam's career is a commitment to education and service to the university. I never had the privilege to work with Professor Kam, but in my second month as the Head of Department, I had the honour to interview him, our department's founding Head. Despite being over 85 years of age, Professor Kam's enthusiasm was infectious. The interview below took place at the Bistro Canteen on 1 December 2020, and was transcribed with the assistance of Ms Teresa Ng.

▲ Professor Wai-kee Kam in 1984

What prompted you to join the City Polytechnic of Hong Kong in 1984?

In 1982, the Hong Kong Government began planning a second polytechnic with a capacity of 8000 full-time students. The City Polytechnic of Hong Kong was formally established on New Year's Day, 1984, and I remember that Sir Edward Youde, the Hong Kong Governor at the time, officiated the Inaugural Ceremony. City Polytechnic was initially housed in Argyle Centre Tower II in Mongkok while the campus in Kowloon Tong was being planned out.

When did you become head of department?

I became the Head of the Department of Mathematics and Science in October 1983, two months before the formal establishment of the City Polytechnic. Prior to that, I was the Acting Head of Applied Mathematics at the Hong Kong Polytechnic. Several of my former colleagues at the Hong Kong Polytechnic, including Teresa Ng and H.P. Lo, also joined City Polytechnic at about the same time as I did. In the ensuing years I recruited others like Iris Yeung, Y.V. Hui, Teresa Ling, S.K. Tse, Y.C. Chan, Geoffrey Tso, C.K. Li, Sammy Yuen, Allen Ng, Josephine Lam and Carrie Lin.

Can you tell us about the department's teaching programmes under your leadership?

In 1984, City Polytechnic had no faculties or colleges. There were only six departments: Accountancy, Business and Administration, Computer Studies, Languages, Mathematics and Science, and Social Administration. The role of my department (Mathematics and Science) was to teach mathematics, as a "supporting" subject to students of other departments. In 1985, we began offering a Professional Diploma in Mathematics and Management, emphasising operational research, statistics and computing methods and their applications in business.

How large was the polytechnic at that stage?

By then, the City Polytechnic had grown to include eight departments, including the Departments of Building and Construction and Electronic Engineering. In 1988, we changed our name to Department of Applied Mathematics, to distinguish ourselves from the new Department of Applied Science that emphasised physics and instrumentation systems and techniques. In the same year, we also began offering a degree programme, the BA in Quantitative Analysis for Business and a Higher Diploma in Applied Statistics. A year later, in 1990, we started planning the MA in Quantitative Analysis for Business and BA in Applied Statistics.

Back then, very few statisticians and operations research analysts found their home in a business school. What gave you the vision to start a Department of Applied Statistics and

▲ From left to right: Professor Wai-kee Kam, Ms Teresa Ng, Dr Teresa Ling and Dr Iris Yeung, in 1992

Operations Research within a business school?

By 1992, City Polytechnic had thirteen departments. This expansion prompted senior management to adopt a new structure, whereby the thirteen departments were grouped under three faculties: Business, Science and Technology, and Humanities and Social Sciences. Our teaching programmes in mathematics always had a business focus. We decided therefore to join the Faculty of Business. The name "Applied statistics and operations research" became a natural choice for the name of the new department given that these two fields – statistics and operations research management, had been the main thrust of our BA, MA and Higher Diploma programmes. Some of the mathematicians in the Department of Applied Mathematics, e.g., Daniel Ho and Lawrence Wu, decided not to be part of the Faculty of Business but to join the

new Department of Mathematics within the Faculty of Science and Technology.

In retrospect, I think that paved the way to our department today. Our department is very unique for business schools. Not many business schools in the world have as large a group of statisticians and operations research analysts as we do. I really admire your vision to set up this department in the 1990s.

I have to say I am very impressed with the development of the Department of Management Sciences. We had a humble beginning. When we started, we did not even have our own degree programmes, let alone any talk of doing research. I could never have imagined that the very modest teaching department in a small polytechnic I helped set up nearly 40 years ago would one day become the best in Asia and among the top-30 in the world in terms of research. This is an extraordinary accomplishment, and I feel proud and am very happy to share in this achievement.

Is there anything in your career at CityU that you would single out as the most memorable or stimulating?

In my day, earning accreditation was very important. Back then, the City Polytechnic had no power to self-accredit its programmes. Between 1984 and 1990, our teaching programmes were validated by the Council for National Academic Awards (CNAA) in the UK. Whenever we proposed a new programme, such as the BA in Applied Statistics, we had to submit the proposal not only to the directorate at the City Polytechnic but also to members of the CNAA in the UK, for their reviews and eventual validation. Existing programmes and courses also required periodic reviews by the CNAA. The validation process would involve the UK validation committee members flying to Hong Kong to have a week-long meeting with us.

How rigorous was the validation process?

They scrutinised our proposal very carefully, asked many questions during the meeting and almost always requested revisions to our original proposal. Typically, before the external reviewers arrived, we would spend time thinking about the potential questions and preparing the answers beforehand – somewhat like a "mock trial." Although that involved a lot of hard work, I took great pleasure and enjoyment working with my colleagues. There was a good deal of satisfaction seeing our courses and programmes validated in the end. Then things simplified in 1991, when Hong Kong established its own accreditation agency, the Hong Kong Council for Accreditation of Academic and Vocational Qualifications (HKCAAVQ). All validations between then and 1994 were done locally through the HKCAAVQ.

The City Polytechnic gained self-accreditation status shortly thereafter?

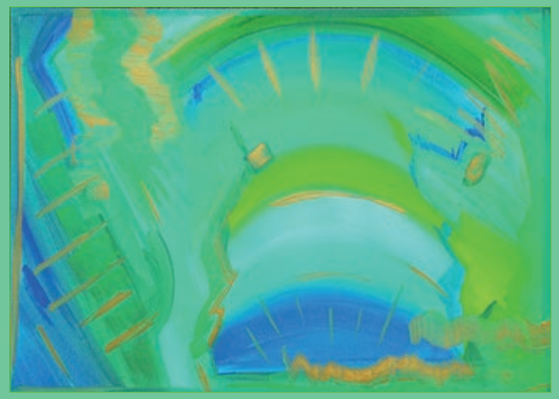
Yes, in 1993, the prospect of the City Polytechnic's gaining self-accreditation status led to a lot of excitement on campus. I was Pro-Director of the polytechnic at the time, and I remember that there were institutional review visits to the Polytechnic by the University and Polytechnic Grants Committee. The Committee members then flew to London to consult their UK counterparts before reaching a final decision. In the end, things sailed through, and that was like a quantum leap for us. The self-accreditation status we achieved in 1994 gave us more flexibility to introduce new programmes and courses without having to seek external approval. The past procedure where everything required external scrutiny was tedious and time consuming. Shortly thereafter, the polytechnic also achieved university status and changed its name to City University of Hong Kong.

Do you have any general advice to give to educators and students?

Hong Kong university students typically focus on their subject studies. I believe that a successful university education, in addition to providing students with specialised skills, should help students build some bedrock fundamental skills and help them learn on their own, adapt to changing environments and develop the ability of teamwork. The fundamentals are language and communication skills, a broad knowledge and the understanding of different cultures. Our teaching programmes should be multidisciplinary enough to help students see the world in a broad context with a global view. A broad education would help students compete in the workplace, and to enjoy modern living. Only after one learns, then one realises that there is more to learn in an ever-changing world. We hope that our graduates can be broad-minded, and well-trained professionals with an elevated vision to see the bigger picture. Understanding different cultures is also important – it can help one's mind think in more diverse ways and promote co-existence that will go a long way to create a better world.

One thing remains unchanged in the long and colourful career of Professor Kam: he is a gentleman – a true gentleman in both the English and Chinese sense of the word.

▲ Professor Wai-kee Kam and Professor Alan Wan in 2020



Phoebe Richardson

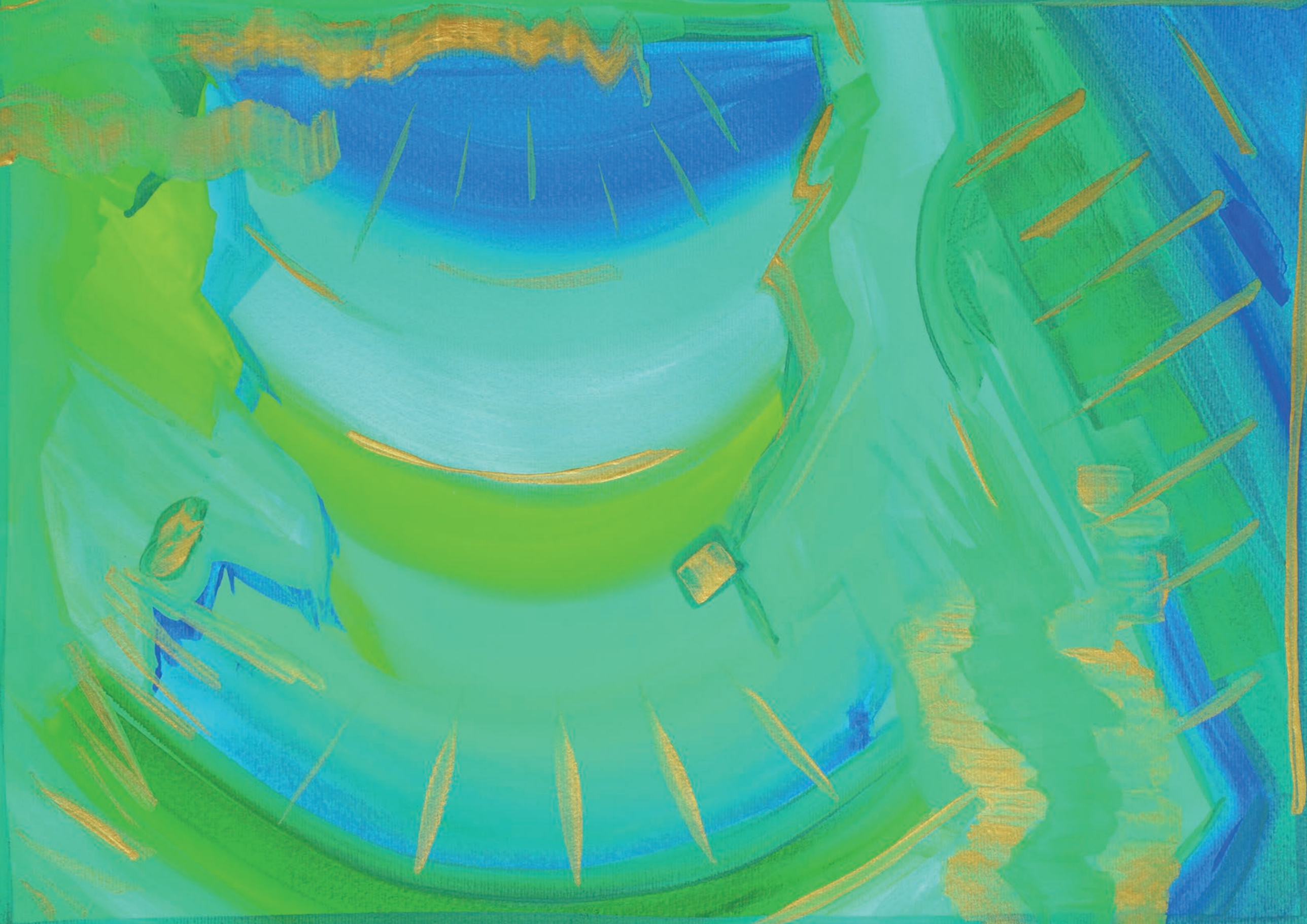
Green Monster, 2021

Poster Paint on Paper, 42x59cm

Painting the abstract pieces for this magazine gave me a new sense of freedom I hadn't felt before when painting my usual living subjects. Using each paper's title as a starting point, I would let the visual meaning pour out in any way it wanted to in colours and shapes that felt alive. To illustrate a paper about big data can feel daunting to someone who usually paints scenes from nature, however I soon realised that it is all the same; whether painting in response to a living thing, a feeling or a concept.

Green Monster is the culmination of many elements I absorbed whilst creating these pieces. The human creation of systems, currency, statistics, learning, insight, decision-making. To me, all of this is a confusing jumble, a slightly out of reach concept to grasp. A beehive-like, complex structure of economic society. Yet balanced with green; a natural, healthy, tranquil colour with gold flecks of prosperity, the monster, although large and frightening, has the ability to be our saviour or our demise.

If you would like to order a print of Green Monster or any of the other art pieces in this magazine you can contact Phoebe via her Instagram, @phoeberighteye.



Is information ignorance a strength?

By Dr Jianfu Wang

***Dr Jianfu Wang**, Associate Professor in the Department of Management Sciences, argues that it is unrealistic to expect all customers to have access to real-time delay information and asks whether real-time delay information systems suffer efficiency loss from the presence of uninformed customers? This article is based on "Efficient Ignorance: Information Heterogeneity in a Queue," by Ming Hu, Yang Li, Jianfu Wang, published in Management Science, 2018*

In today's service industries, real-time delay information is ubiquitous. The waiting time to cross the US and Canada border is posted online and updated in real-time. Information about traffic jams on major roads is distributed on radio, television, and the internet. Thanks to traffic-information-sharing apps like Google Maps and Waze, real-time traffic information is even available for roads that are not covered by government-funded traffic detection and monitoring.

Not everyone uses the information

"How often do you check traffic information before going out?" 47% answered, "I don't check."

Regardless of how widely real-time delay information may be available, a large percentage of customers remain uninformed. This may be due to information ignorance or rational behaviour in the presence of an information cost. For example, people may overlook up-to-the-minute information about delays before setting out. In an online poll, some 20,000 participants were asked, "How often do you check traffic information before going out?" 47% answered, "I don't check"; the rest checked various sources, such as TV, radio, computer, or mobile devices . Some people may be over-confident that they will be lucky. Some may check for information now and then. Another reason for information heterogeneity could be that small service providers may not be able to afford the technology for tracking and reporting real-time delay information. In that case, only drop-in customers can see the queue, whereas many potential customers cannot. Lastly, a substantial minority still do not possess a mobile device.

So, customers possess varying degrees of knowledge about real-time delays: some are fully informed, others completely out of the picture. In order to understand the impact of delay information on society, it is essential to investigate the interaction among customers in a system characterised by information heterogeneity.

Conventional wisdom

Conventional wisdom suggests that delay information benefits society.

Conventional wisdom suggests that delay information benefits society. The intuition is that congestion information helps better match capacity with demand: customers tend to avoid highly congested roads and follow more free-flowing routes. That rationale is consistent with the prevalence of real-time delay information in today's public service industries. However, we argue that it is unrealistic to expect that all customers have access to real-time delay information even if it is readily available. More importantly, does the system necessarily suffer efficiency-loss from the presence of uninformed customers?

Reassessment of conventional wisdom

We investigate a queueing model with two streams of customers who differ in their information structures in order to answer these questions. Informed customers decide to join or balk based on real-time delays. Uninformed customers are not aware of the real-time information and base their join-or-balk decision on their experience of long-run average delay. We characterise customers' equilibrium behaviour with information heterogeneity and investigate how the presence of a larger fraction of informed customers affects the overall social welfare of the system.

Does real-time delay information help society? Think again

Contrary to the conventional wisdom that real-time congestion information always improves social welfare, we discover that social welfare is "unimodal."

Contrary to the conventional wisdom that real-time congestion information always improves social welfare, we discover that social welfare is "unimodal," that is, it first increases and then decreases in the information level when the system experiences a high enough offered load. When the offered load is relatively low, the conventional wisdom is true – information prevalence always benefits social welfare. This is because growing information prevalence has both positive and negative effects on social welfare. On the positive side, if the real-time system congestion is visible to customers, system capacity can be more efficiently matched with customer demand intertemporally because informed customers seek service only if the service benefit dominates the waiting cost – when the queue is short. However, informed customers' self-interested joining behaviour might overload the system, especially when the customer arrivals are overwhelming. In this situation, uninformed individuals' presence mitigates system congestion: these uninformed customers are reluctant to join a busy system without real-time information. This disincentive helps free up the capacity to serve more informed customers, who contribute more surplus to the overall efficient running of the system.

Our results highlight the fact that some degree of real-time information heterogeneity in the population can lead to more efficient outcomes.

Nonetheless, when a large proportion of a high customer volume becomes informed, uninformed individuals eventually lose interest in the service. As information prevalence grows, the system suffers from rising externality inflicted by an increasing fraction of informed individuals if they all choose to balk. Hence the system's overall functioning deteriorates because of growing information prevalence.

Our results highlight the fact that some degree of real-time information heterogeneity in the population can lead to more efficient outcomes in terms of social welfare than can information homogeneity. The presence of uninformed customers does not necessarily harm the system. It increases social welfare when the system experiences high offered loads. Our results also imply that there may be value in intentionally introducing information heterogeneity and controlling real-time delay information availability.

Dr Jianfu Wang
Associate Professor
Department of Management Sciences

Delivering 21st Century Healthcare

By Eric Collins

A recently concluded CityU project led by **Professor Frank Chen**, *Delivering 21st Century Healthcare in Hong Kong - Building a Quality-and-Efficiency Driven System*, has made a very real contribution towards improving conditions in the Hong Kong public health sector. Using networked resources, the emphasis was on placing people at the centre of healthcare delivery in Hong Kong.

Patient waiting times for routine surgery at public hospitals are as long as 18 months.

Rising demands on health care services are pushing systems to breaking point around the world. Covid-19 has dramatically exacerbated an already difficult situation as populations age, and an ever-greater proportion of GDP is going to the healthcare sector. Worldwide, public health care services are fraught with high costs, low efficiency and poor quality of patient care service. Hong Kong is no exception, and patient waiting times for routine surgery at public hospitals are as long as 18 months.

Building sustainability into the system

"To help alleviate overcrowding, we developed algorithms to identify elderly patients at high risk of re-hospitalsation."

"We wanted to improve an overloaded system, and make it sustainable in the long run," said Dean Frank Chen.

The project focused on hospital resource planning, and was driven by healthcare data analytics and business services innovation, with a focus on quality-and-efficiency driven strategies and systems-oriented solutions.

"The Hong Kong public healthcare system is frequently functioning above 100% capacity. To help alleviate overcrowding, we developed algorithms to identify elderly patients at high risk of re-hospitalisation and then plan for more effective post-discharge care."

"We also wanted to explore how Public-Private Partnerships might provide long-term solutions to ease long wait-times in public hospitals and clinics," said Professor Chen.

Delivering 21st Century Healthcare, CityU's Theme-based Research Scheme and the first for the College of Business, was organised in collaboration with the Chinese University of Hong Kong's Jockey Club School of Public Health and Primary Care, Columbia University in the USA and others, and was funded by the Research Grants Council. The project started in November 2014 and completed recently with substantial achievements: over 115 publications in reputable, referred journals, and the training of around 50 PhD and a dozen masters' students. Research outputs included the applications of data science and artificial intelligence to identify target elderly patient segments for two areas: firstly, the most effective and affordable post-discharge care portfolios in the community. Secondly, to predict the onset of chronic diseases. The project also worked on the development of sensor technology for health monitoring of the elderly, and in management with scientific tools for hospital resource planning.

Project team members included Co-Principal Investigators Professor Eliza Wong, and Professor Eng-kiong Yeoh at School of Public Health and Primary Care of the Chinese University of Hong Kong; Professor David Yao at Columbia University; Professor Hengqing Ye at Polytechnic University of Hong Kong; Professor George Huang at the University of Hong Kong; and Professor Houmin Yan, Professor Kwok-leung Tsui, and Professor Kwai-sang Chin at City University of Hong Kong. Also, Co-Investigators Dr Eman Leung at the Chinese University of Hong Kong; Dr Qingpeng Zhang; Professor David ZLi; Professor Pengfei Guo; Dr Carrie Lin; Dr Yimin Yu at City University of Hong Kong; and Dr Calvin Or at the University of Hong Kong.

Five main impacts

- #1 Reducing emergency admissions
- #2 Improving efficiency of key hospital resources
- #3 Unlocking spare capacity in the private sector
- #4 Improved resource management
- #5 Data analytics tools for future healthcare research

Five main impacts on Hong Kong's healthcare

Delivering 21st Century Healthcare in Hong Kong has delivered on multiple fronts. Here are five main quality-and-efficiency impacts:

#1 Reducing emergency admissions

The team piloted a project at a large public hospital, in which they implemented a machine learning tool to identify elderly patients at high risk of re-hospitalisation and then plan for their more effective post-discharge care. Predicting the arrivals and managing patient flows are essential to hospitals. In the vital area of emergency healthcare management, the project has informed the deployment of transitional nursing care using predictive analytics to reduce emergency admissions.

#2 Improving efficiency of key hospital resources

The planning and management of patient flow is key to the efficient use of hospital resources. The team was invited to provide consultation to the development of the new Chinese University of Hong Kong Medical Centre on patient flow, operational planning, and physical design to maximise patient-centred care. They also advised on location decision for key diagnostics equipment in another new public hospital, on stocking locations and facility selection for consumable items, porter dispatch policies, and linear operations strategy, and to develop an appointment system for ambulatory care at a major public hospital.

#3 Unlocking spare capacity in the private sector

In 2018-19, the Hong Kong Government decided to set up District Health Centres (DHCs) in all 18 districts, to provide primary healthcare services through medical-social collaboration and public-private partnerships, with the focus on elderly residents. A DHC is a service hub with a core centre serving as headquarters, complemented by satellite centres in sub-districts at convenient locations. The Government envisages "the DHC to be a model for district-based medical-social collaboration, using big data to identify the areas of medical care services, establishing a framework to implement measures on disease prevention in a more systematic manner … and strengthening scientifically proven service provision and policy-led development work." (The Chief Executive's 2017 Policy Address).

The first DHC was implemented in Kwai Tsing District. In applying our TRS-developed algorithms to HK-wide Electronic Health Records (EHRs) made accessible by the Hospital Authority's Data Collaboration Lab (HADCL), we were able to characterise district-specific profiles of high-risk residents in the community and their secondary and tertiary prevention needs. These tools can be further developed and used to inform service planning for DHCs. Although Hong Kong public hospitals take up to 90% of total inpatients, the private sector possesses the lion's share of primary care capacity. However, utilising this extra capacity and advanced tech in the private sector has remained a challenge. These tools can be further developed to assist decision-makers at DHCs as well as general practitioners to unlock this capacity.

#4 Improved resource management

Resource pooling and sharing among hospitals are important topics in healthcare management research. The team advised on the Hospital Authority's ten-year plan for the non-emergency ambulance service by providing a consultative report reviewing its patient transport service.

#5 Data analytics tools for future healthcare research

Healthcare information and data analytics underlie the achievements and social impact of all other project tasks. The tool kits that have been developed will be of generic use in advancing future healthcare research.

The team developed a number of machine learning models to predict the onset of various diseases that are critical in Hong Kong, including heart failure, mitral regurgitation, acute myocardial infarction, dementia, suicide and depression risk assessment, etc. They also developed advanced machine learning models for predicting future high-cost patients, for example, COPD, and infectious disease models.

Sensor technology has been utilised in the project for monitoring and assessment of elderly's health, including general wellness, blood pressure, gait and balance. The team found that sensors provided researchers with important data, for comprehensive evaluation of health conditions and fall risk prediction.

A general framework of system health monitoring and management (SHMM) has been proposed. It covers continuous surveillance, analysis and interpretation of related data for system monitoring, management and strategic planning. The team provided a new perspective on health monitoring and the management of complex systems, such as health systems in a big data environment.

Legacy – a new phase of collaborative healthcare management

In November 2018, Our Hong Kong Foundation published a report on Hong Kong's health system, entitled "Fit for Purpose: A Health System for the 21st Century," which was led by Prof Eng-kiong Yeoh from the Public Health Team, Chinese University of Hong Kong. It was officially released at the "Our Hong Kong Foundation" Health Systems Summit, which was keynoted by the Chief Executive. The Hong Kong Hospital Authority also commissioned the CityU team at the College of Business to prepare the planning of services and business models of patient transport service (Non-Emergency Ambulatory Transfer Service, NEATS, and Elderly Transport Service, ETS), for the ten-year period of 2018-2027.

As Professor Chen put it: "We feel the successful completion of this TRS project is just the start of a new phase of collaborative healthcare management research in Hong Kong."

"The achievements in the past five years have provided us with an opportunity for long-term interdisciplinary collaboration and sustainable development in elderly care in Hong Kong."

HomAge: Home-based aging for transformative community care

The College of Business is actively pursuing their research work in healthcare. A team comprising CB faculty members alongside Jockey Club School of Public Health and Primary Care of the Chinese University of Hong Kong, has recently been awarded $23.8M funding from Bank of China (Hong Kong) Centenary Charity Programme (Secretariat: The Hong Kong Council of Social Service). "HomAge: Home-based aging for transformative community care," is a pilot project to implement the home-based care programme based on the Buurtzorg homecare model which has seen global uptake. This 3-year project will leverage on an IT platform for service planning and coordination, and deploy the AI/ data analytics tools developed in the *Delivering 21st Century Healthcare* TRS project to identify the elderly segment(s) for the most effective and affordable community-based cares, including post-discharge care portfolios. The proposed home-based care programme will provide care services that complement the DHC model.

Several Public Policy Research grants have been obtained by the Team, which will generate more policy reports for the government.

The College of Business looks forward to working with our partners across the educational and healthcare sectors in delivering further collaborative projects which will positively impact on quality delivery in Hong Kong's healthcare systems.

HSBC –150 years on the cutting edge of technology

By Eric Collins

Banks balance risk and return, with security of customer transactions always a prime concern. Over the past century-and-a-half, HSBC has seized opportunities whilst remaining cautious, pioneering banking services and safely adopting new technologies. In this picture essay we take a look at some of these technologies, from the arrival of the telegraph in Hong Kong in 1871, to the adoption of blockchain in 2019. HSBC is a generous sponsor of innovative education at the College of Business, which hosted the second HSBC Life Insurance Innovation Competition in February 2021, and the HSBC sponsored 2020 International Blockchain Olympiad Competition in July of last year.

The China Submarine Telegraph Company used CS Kangaroo, to lay **the first telegraph cable** from Singapore to Hong Kong in 1871. This foundational infrastructure allowed HSBC and other banks to communicate and make money transfers between branches and across continents.

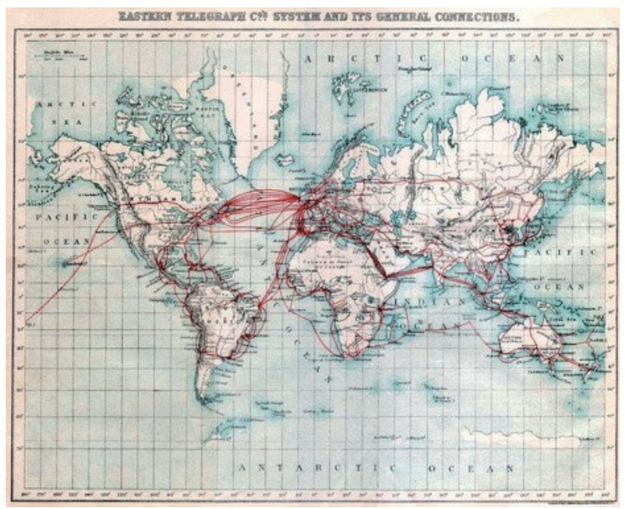
Image courtesy: atlantic-cable.com

The main deep-sea cable consisted of seven-strand copper conductor and twelve armouring wires. In 1883 the cable was extended from Hong Kong to Shanghai. This is a section of the original cable salvaged from the seabed in 1901.

Image courtesy: atlantic-cable.com

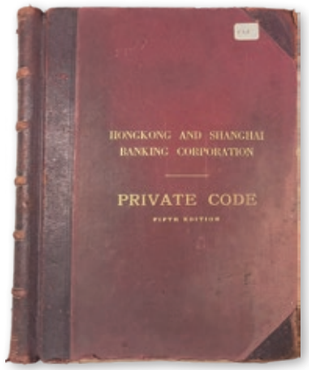
Eastern Telegraph Company's System and its General Connections, A.B.C. Telegraphic Code (London: Eden Fisher, 1901).

Image source: Wikimedia Commons.



The Comptometer machine. The first commercially successful key-driven mechanical calculator, patented in the USA in 1887, enabled mechanised customer statements.

The telegram was HSBC's primary form of internal communication until the 1950s. All telegrams were encoded, with a decoder usually living above a branch so that telegrams could be read first thing every morning. This code book dates from 1944.



The mainframe computer. This HSBC advertisement from 1967 promotes the new IBM system. The ad states: "From any 'on-line' branch in Hong Kong, Kowloon or the New Territories, the teller feeds the required information, and gets a processed answer back from the computer in our Electronic Data Processing Centre in seconds."

HSBC introduced Hong Kong's **first cash dispenser** in 1971. This was a big moment in banking: for the first time, customers could get cash from their account outside banking hours.

The first **electronic card payment terminals** were launched in the 1980s. Over the years the connection to the bank to authenticate payments has got faster whether over landline, WiFi or high speed 5G. Later, mobile terminals enabled merchants to accept payments by credit or debit card anywhere.

eBanking. HSBC launched PC Banking based on their own proprietary network in 1997, followed by an eBanking service based on the internet. By 1999, the service had been rolled out to more than 20 countries in Asia.

In 1999, **telephone banking** was taken a step further when HSBC issued banking services accessible by mobiles. In 2001, HSBC in Singapore launched SMS banking, allowing customers to access a full range of HSBC services via their mobiles.

Hexagon, HSBC's desktop global **Electronic Financial Services** banking system launched in the late 1980s, brought products directly to customers' home computers.

Blockchain arrived in 2019. HSBC leads the world's first cross-border Renminbi denominated blockchain-based Letter-of-Credit transaction. Conventional documentation exchange for paper-based LCs usually took five to ten days. This exchange of fully electronic documents was completed in 24 hours.

HSBC News Release

3 September 2019

HSBC LEADS WORLD'S FIRST CROSS-BORDER RMB-DENOMINATED BLOCKCHAIN LC

HSBC's latest blockchain trade finance transaction, announced today, marks two firsts:

- The world's **first** cross-border Renminbi (RMB) denominated blockchain-based Letter-of-Credit (LC) transaction
- The **first** blockchain LC in which both clients are based in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA)
- The transaction was the **latest** completed using the Voltron platform, a blockchain-based documentary trade finance network

Images courtesy of the HSBC Archives, unless otherwise stated.

Realising the potential of database intelligence

Interview by Eric Collins

***Andy Yan** is Head of Database Intelligence Department at the Hong Kong Trade Development Council, and a member of the Department of Management Sciences advisory committee. Here he talks about his start in the computer technology workplace, and through his experience at HSBC, Octopus and the HKTDC, how database management has evolved over the years.*

Andy Yan (right) is the head of the Database Intelligence Department of HKTDC

When did you first use a computer?

I had never touched a computer before I studied at the Chinese University of Hong Kong. Then, my family spent a small fortune on an Apple IIe, and that's my first memory of a personal computer. Somebody told me that if we had used that money to buy Apple stocks we would now be multi-millionaires.

How about the internet?

At university we started to connect some computers together, something like a PC LAN, and we had some limited access to the internet as students. Our initial impression was not very positive. It was difficult to surf because there wasn't a very good browser. And then we almost forgot about it when we graduated. But at work we started to use emails massively in the business world.

What did you study at CUHK?

I majored in computer science, with a minor in business management and I also took some elective courses such as fine arts, communication skills, and philosophy. This broadened my exposure. I also realised the most effective way to apply computer technology was to go into business management and marketing. So, I started as a management trainee at Cathay Pacific Airways, hoping to be part of the drive towards the application of computer technology. Looking back, I think that was the right choice.

Then you moved to HSBC at a very dynamic time for e-banking.

Yes, in the late 1990s there was a boom in internet applications in various industries but that did not start in the banking industry, which tends to be conservative. At first, top management and other colleagues hesitated to put banking services online, adopting a "wait and see" attitude. They let some small banks try first, and see which customers would trust to put their money on the internet. I was HSBC business project manager at that time, working on HSBC's corporate website and ebanking services. We were very aware of risk, so we did a lot of market and technical research to understand customer needs, service demand and the services available to see if they could protect customer transactions.

When did HSBC retail banking go online?

HSBC took an intermediate step called PC Banking in 1997. This had similar functionality to going online but it was riding on HSBC 's proprietary network. We needed to send an engineer to your home to install software, or we sent a disc and the customer installed some software on their own PC. It was extremely secure. Then we did some demonstrations to top management to show that even on the internet a similar level of security could be achieved, and finally we were able to launch eBanking service on the internet. By 1999, we were responsible for more than 20 countries in Asia, so it was a huge-scale project. There were many sleepless nights!

Did this involve databases?

Yes, at HSBC I worked on the first customer database in Hong Kong's banking industry and started the database marketing, customer segmentation, and data analytics in the largest retail banking database in Hong Kong.

You then moved to Octopus, at a time of great growth.

Initially, Octopus was mainly used for public transport. But it was evolving fast to become a payment provider for retail, so we moved into vending machines, convenience stores, and then supermarkets. My mission was to create new revenue streams by establishing an information business. With my background in computer science, I could see how databases would help the business. My boss at Octopus was quite visionary and he could see that we held a lot of customer data and it could be a goldmine. So we developed a new kind of business. We carried out customer analytics for our retail business customers with the cardholder data/behaviour we had. We could provide business insights, track and give offers to loyal customers. And we then developed a rewards scheme based on Octopus cards.

What attracted you to Hong Kong Trade Development Council?

Well, I must say before I came to HKTDC, I wasn't sure what their main business was and I asked myself, "Why do they need me to manage databases?" It wasn't like Octopus where the role of databases was more obvious. "Could they really leverage my knowledge and experience?" I wondered. In fact, I discovered that HKTDC maintains a database with several million companies, and it is core to the business.

What is the HKTDC business model?

It's a B-to-B business, and the mission is to promote Hong Kong as a platform for international trade, and to explore business opportunities for Hong Kong businesses all over the world. In order to achieve this, we build up our own customer database by keeping track of anyone who

has registered or joined our events and their profile details in order to do business matching. This means matching the suppliers and the buyers and HKTDC has been doing this for more than 50 years. So, our database is business-orientated, company-based, and it is global.

How do you leverage the database?

To my initial surprise, I found that we had quite a lot of targeted marketing technologies in order to serve event participants. Every year we host over 40 large-scale events in Hong Kong such as trade shows and conferences, book fairs and food expo etc., attracting more than one million people, and we also run more than 800 events worldwide. But our main offering is the trade fairs with exhibitors, suppliers and buyers from all over the world with growing emphasis on conferences which would end up as a conference and exhibition model.

How has database intelligence evolved over the years at HKTDC?

In the last five years we have been using more applied technologies to uncover the business opportunities hidden in our data base. Traditionally, our data source was mainly from our events, where we could track our customers' footprint in the physical events and our online eMarketPlace to see what they were interested in. Such analysis helped us understand each buyer's needs. We could also help vendors by analysing which buyers are interested in their products and their profile, etc. Nowadays, we aggregate online and onsite behaviour to give us a more comprehensive view of both buyers' and sellers' behaviour.

Is HKTDC migrating more online?

Yes, starting from last year, and partly because of the pandemic situation, we had to move all our events online. Before that everything was pretty much focused on physical events although we had some online services. For the future we realise that our events will be in a hybrid mode. The industry mode, and peoples' habits have changed.

How hybrid mode will HKTDC go?

For instance in the exhibitions or the trade shows, our focus will still be very much on the physical events. With the help of online interaction, we will extend the buyers' and sellers' interaction before and after the physical events. Of course, we will offer different kinds of packages for different kinds of customers in order to maximize our customer base, as each customer has different needs.

How does HKTDC leverage the potential of its database?

For the 40 large-scale events, we have totally more than 100 predictive models to identify potential customers, to increase the show-up rate, etc. We are also developing customer segmentation models based on their value prediction. Then we can offer tailored services to each segment of customers. Matching is our stand-out service, so we are developing a sophisticated AI engine for business-matching recommendations.

What makes HKTDC's offering unique?

Our differentiator is the internationality of our events, and the matching of global suppliers and buyers for both merchandise and service trade. Instead of competing with others by event size or investment, we package our event as a brand-building and promotion occasion for business services and products. Similar to the consumer electronics show in Las Vegas, the big companies rush to show off their products. We are constantly sharpening our matching algorithms. Our buyers and suppliers know they can count on us to achieve successful business outcomes.

What is Hong Kong's niche as a business service provider?

Diversity is one of the key competitive edges for Hong Kong. The international connections, along with the free flow of information, merchandise, and money. Also, the talents in Hong Kong and their flexibility. I believe we still have world-beating international exposure and connections with the external world.

What are Hong Kong's people's standout strengths?

In HKTDC, many of our colleagues start their career and spend their whole career here, which may help foster a unique culture in HKTDC. We have a strong "can-do" spirit because HKTDC always needs to develop new frontiers in order to capture business opportunities for HK SMEs in this ever-changing world. We are also action-oriented, attentive to detail, good at execution with accurate planning because we are actually in a show business which has no tolerance of failure. Even if there is a No.8 Typhoon signal or Black rain storm, "The show must go on!" How we surfed through the pandemic situation was another good demonstration of our spirit. We have a very strong can-do culture and I'm very proud of it!

Andy Yan
Head of Database Intelligence Department
Hong Kong Trade Development Council

BUSINESS STATISTICS

AdaBoost Semiparametric Model Averaging Prediction for Multiple Categories

Jialiang Li, Alan Wan
Published in *Journal of the American Statistical Association*, forthcoming

As the business world embraces the concept of big data, sophisticated learning tools based on massive data information are being developed rapidly for many real-life problems. How do we enhance data mining devices by using cutting-edge statistical methodology? This is the question that CityU's statistician Alan Wan tries to answer in his newly published article in the Journal of the American Statistical Association.

Together with Jialiang Li of the National University of Singapore, Alan Wan, Professor and Head of Department of Management Sciences, developed a new statistical methodology known as "semiparametric model averaging prediction." They combined this new method with the popular machine learning tool of adaptive boosting (AdaBoost) for further enhancing the predictive performance, especially for classification-related problems.

"The methodology developed in this article was motivated by a problem frequently encountered in transportation planning and operations, namely, automobile classification, which is important for surveillance, traffic congestion and accidents prevention," Alan Wan says.

Rigorous theoretical analysis and extensive numerical experiments show that the new method has excellent prediction ability compared to traditional statistical models and off-the-shelf machine learning classification tools.

Another important research merit of the new method is that it overcomes an often-cited criticism associated with semiparametric models, namely, the choice of a suitable index variable, as the method averages multiple sub-models each with a different index and the model weights automatically adjust the relative importance of these sub-models. As well, the proposed method can be applied without assuming any true model form which is hard to postulate for big data.

BUSINESS STATISTICS

Topic Modeling on Triage Notes with Semi-orthogonal Non-negative Matrix Factorization

Yutong Li, Ruoqing Zhu, Annie Qu, Han Ye, Zhankun Sun
Published in *Journal of the American Statistical Association*, December 2020

Emergency Department (ED) overcrowding is a universal health issue that impairs the public access to emergency care. The medical society has long understood the root cause of ED overcrowding, i.e., the prolonged occupation of ED beds by patients who are admitted and waiting to be transferred to inpatient beds. This phenomenon is also referred to as ED blocking. One initiative to alleviate ED blocking is to put in a request for inpatient beds at triage for patients who are very likely to be admitted, even before the patients are seen by physicians. Inpatient beds are scarce and expensive resources. Hence, such decisions are contingent on the prediction accuracy of the admission decisions.

In this case study, Dr Zhankun Sun, Assistant Professor in the Department of Management Sciences and co-authors, build a classifier to predict the disposition of patients using manually typed nurse notes collected during triage in a large teaching hospital.

"Our data analysis on 600,000 electronic health records shows that the triage notes contain strong predictive information towards classifying the disposition of patients for certain medical complaints, such as altered consciousness or stroke," says Sun.

This improvement could be clinically impactful for certain patients, especially when the scale of hospital patients is large. Furthermore, the generated word-topic vectors provide a bi-clustering interpretation under each topic due to the orthogonal formulation, which can be beneficial for hospitals in better understanding the symptoms and reasons behind patients' visits.

These predictions can potentially be incorporated to early bed coordination and fast track streaming strategies to reduce waiting times and alleviate overcrowding in the ED. However, these triage notes involve high dimensional, noisy, and sparse text data, which make model-fitting and interpretation difficult. To address this issue, they propose a novel semi-orthogonal non-negative matrix factorization for both continuous and binary predictors to reduce the dimensionality and derive word topics. The triage notes can then be interpreted as a non-subtractive linear combination of orthogonal basis topic vectors.

OPERATIONS RESEARCH AND OPERATIONS MANAGEMENT

Social Promotion: A Creative Promotional Framework on Consumers' Social Network Value

Haibing Gao, Huazhong Zhao, Ricky Tan, Lisa Lin, Lai Wei
Published in *Production and Operations Management*, December 2020

Red packets have symbolised happiness and good luck in East Asian and Southeast Asian societies for hundreds of years. Recently, online retailing platforms have adapted and modernised this ancient tradition by introducing the social red packet. This new form of red packet contains digital coupons that can be shared through consumers' social networks.

Inspired by this reinvention, Dr Huazhong Zhao, Assistant Professor in the Department of Marketing and co-authors conceptualised social promotion as a promotion customisation framework under which consumers with higher social network value receive better promotional rewards.

To test the effectiveness of social promotion, Zhao and his co-authors conducted an empirical study at a leading online food delivery platform in China. They aimed to answer the following research questions: (1) Does the social promotion strategy benefit consumers? If so, which segments of consumers can benefit most? (2) Does social promotion motivate consumers to enhance the commercial value of their social networks? (3) What characteristics of focal consumers and their social networks moderate the above effects in social promotion campaigns?

The study shows that social promotions can benefit both consumers and the platform. The vector autoregression (VAR) analysis reveals that under social red packet promotions, consumers with higher social network value enjoy larger promotional rewards due to the socially shareable design. Social promotion can benefit the platform as well: Larger promotional rewards motivate consumers to increase the value of their social networks by voluntarily recruiting new consumers or cultivating frequent consumers, which in turn helps the retailing platform reach its promotional goals.

This research provides important conceptual and practical implications. Conceptually, social promotion is proposed as a new framework of promotion customisation. To the best of the authors' knowledge, this study is the first attempt to explore customised promotion strategies based on consumers' social network value. Like price discrimination, in which sellers manipulate prices based on consumers' willingness to pay, promotion customisation aims to manipulate promotional rewards based on consumers' value to the sellers. Social promotion aims to customise promotional rewards based on a consumer's social network value.

Practically, this study offers novel insights into the emerging social commerce research by identifying a segment of price sensitive but socially active consumers. Such consumers are considered to have low personal value among traditional promotion strategies targeting customer lifetime value, but they possess high value to the firm due to their social network connections. By identifying this promising segment, The study offers new insights on how to improve effectiveness of social promotion by targeting consumers with specific characteristics.

OPERATIONS RESEARCH AND OPERATIONS MANAGEMENT

A Planning Approach to Revenue Management for Non-guaranteed Targeted Display Advertising

Huaxiao Shen, Yanzhi Li, Jingjing Guan, Geoffrey K.F. Tso
Published in *Production and Operations Management*, October 2020

There are severe deficiencies in the current online targeted display advertising sell ad resources selling mechanism where selling is typically arranged via an event-based auction. Based on the results of extensive numerical experiments on a twenty-day sampled log data set released by a collaborating firm in China, Yanzhi Li, Jingjing Guan, Geoffrey K.F. Tso of City University of Hong Kong and co-author Huaxiao Shen of Sun Yat-sen University, Guangzhou demonstrate the effectiveness of a new planning framework.

"Our ad clicks forecasting method is more accurate than the traditional click through rate (CTR)-based method, and our solution approach is also very effective in producing high-quality solutions, with a revenue increase around 10% compared to the existing auction method," they say.

The authors propose a planning method to help ad publishers better allocate their ad resources in the spot market. The approach allows the publisher to take a holistic view of its resources and demand and thus to allocate the available resources in a more efficient way than can be achieved through an event-based auction mechanism. To implement their approach, they present a framework comprising two building blocks.

The first building block is a mixed-integer nonlinear programming model, in which the decision is an ad resource allocation plan that specifies the proportions of an audience unit's impressions that are assigned to different ads and the objective is to maximise the publisher's revenue. They propose an efficient algorithm for solving the optimisation model to obtain a near-optimal solution with a bounded optimality gap.

The second building block of the planning framework, is an arbitrary point-inflated (API) Poisson regression model, with which they directly forecast the number of ad clicks with non-decreasing and concave functions of impression proportions. This is in contrast to the existing method of estimating the number of clicks based on CTR, which is less accurate since CTR is changing over time.

OPERATIONS RESEARCH AND OPERATIONS MANAGEMENT

Price-Directed Cost Sharing and Demand Allocation among Service Providers with Multiple Demand Sources and Multiple Facilities

Hanlin Liu, Yimin Yu, Saif Benjaafar, Huihui Wang
Published in *Manufacturing and Service Operations Management*, June 2020

To reduce delays and increase service quality, service collaboration is increasingly popular among service providers. For example, In the face of escalating healthcare costs and in an effort to improve efficiency across the three levels of care, China is promoting collaboration among hospitals and community health centres. Hong Kong and the UK also adopt public private partnerships (PPPs) to reduce the waiting time for public hospitals. However, successful collaboration requires well-structured compensations and incentives for the different parties with regard to how the benefits and costs should be shared. There is also a need for coordination at the operational level to ensure that the collaboration is well executed.

In this research, Yimin Yu, Associate Professor, Department of Management Sciences and co-authors provide a framework for studying the sharing of facilities and the allocation of demand among independent firms or business units with multiple facilities and multiple demand sources by taking into account delay costs, service fulfilment costs and service level requirements.

Yu and co-authors identify a cost allocation scheme that is in the core (i.e., a cost allocation that guarantees that no subsets of firms would have an incentive to form sub-coalitions on their own). Their cost allocation is simple to implement and involves three components. A firm is responsible for the delay cost customers incurred at its own facilities; pays a price per unit of demand it sends to other firms; and receives payment per unit of demand from other firms that it fulfils in its own facilities.

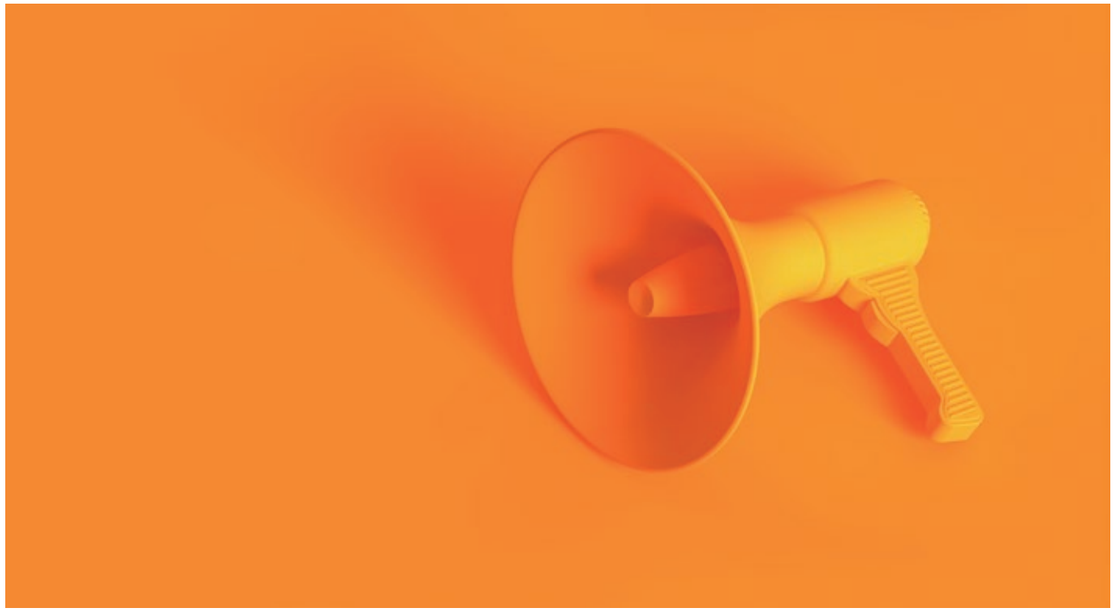
“We show that these payments can also be implemented in a decentralised fashion through a market mechanism, where the payments correspond to clearing prices in a market where service capacity is bought and sold by the various firms. Our results also can incorporate service priorities and capacity decisions,” says Yu.

The framework and the price-directed cost allocation provide guidelines and insights on how to allocate patients and how to compensate the private sector under the PPP scheme for the healthcare in Hong Kong and the United Kingdom.

OPERATIONS RESEARCH AND OPERATIONS MANAGEMENT

Quality Disclosure Strategy under Customer Learning Opportunities

Han Zhu, Yimin Yu, Saibal Ray
Published in *Production and Operations Management*, October 2020



Quality is an important factor in determining both customers' willingness-to-pay and firm profits. However, for goods that needed to be experienced (e.g., products like consumer electronics, appliances, auto and services such as hotels), it is often difficult for customers to know the true quality without actually using them.

Potential customers can nowadays collect quality evidence via social media sites or user-generated content. Examples include websites like epinions.com, consumerreports.org, booking.com, mafengwo.cn, yelp.com, and Google as well as social media sites like Facebook, Whatsapp, and Instagram. Experimental and empirical studies show that customers' quality perceptions are indeed affected by other customers' experiences in a variety of sectors.

In this new research, Yimin Yu, Associate Professor, Department of Management Sciences and co-authors study a firm's optimal quality disclosure strategy for experience goods whose quality cannot be easily assessed without usage, but for which potential customers can learn from experiences of past customers.

“We find that the incorporation of the learning behaviour significantly alters the optimal disclosure strategy of the firm from its single threshold structure in the extant literature to a multi-threshold policy,” says Yu.

Specifically, firms with high- or low-quality goods prefer not disclosing quality information; on the other hand, a medium-quality firm might disclose its quality level. This in fact is not uncommon in practice. For example, there is empirical evidence that medium-quality restaurants and business schools tend to disclose their quality.

The results suggest that when disclosure is expensive, high-quality firms are better off educating potential customers through advertising or social media, rather than disclosing their quality levels. They also suggest to policymakers that mandatory quality disclosure may not be socially optimal as more customers obtain quality information through peer learning.

Around the world in eight business case competitions

Interview by Ronny Torres

Students and teacher talk about their shared case competition journey

This article is an edited and condensed version of a conversation that took place on 26 January 2021.

List of acronyms

- CB = The College of Business at City University
- BCC = Business Case Competition
- ICC = International Case Competition
- CB3045 = A case consulting course offered by CB, which was developed and taught by Dr Zachary Leung

Could you introduce yourselves briefly for the benefit of our readers?

Ms Frances Fung (FF)
BBA Business Operations Management (2019)
I'm from Hong Kong, and I'm working as a Digital Senior Analyst at Accenture.

Ms Martyna Chmielewska (MC)
BBA Business Economics (final year)
I'm from Poland, and I'm working part-time as a junior marketing executive at Oxygen Inbound.

Dr Zachary Leung (ZL)
PhD Operations Research from MIT (2014)
I'm from Singapore, and I've been working as an Assistant Professor in the Department of Management Sciences since 2015.

Jessie Cheng (JC)
BBA Accountancy (2020)
I'm from China, and I'm working as a financial analyst at J.P. Morgan.

Mr Ronny Torres (RT)
BBA Global Business (second year)
I'm from Colombia, and I'm working as a teaching assistant for Dr Leung in the course CB3045.

What are the eight competitions in your global journey?

ZL : They are: (1) the HSBC/HKU BCC that we're invited to each year; (2) the BBICC 2018 in Belgrade, Serbia; (3) the AUBCC 2018 in Sydney, Australia; (4) the ICC@M 2019 in Maastricht, The Netherlands; (5) the NHHICC 2019 in Bergen, Norway; (6) the MBSC 2020 in Washington DC, USA; (7) the UNICC 2020 in Navarra, Spain, which was cancelled due to COVID-19; and (8) the VCC 2020 which was run virtually and organised by Universidad Panamericana in Guadalajara, Mexico.

That's quite amazing — how did CityU get invited to these case competitions?

ZL : I became the advisor/coach CityU's case competition team in 2017. I was introduced to the advisor of the University of Belgrade case competition team when our team participated in the 2017 HSBC/HKU Asia Pacific BCC. She graciously invited us to their university's ICC, where I met other advisors, which led to invitations to their case competitions, and the rest is history.

Dr Leung – Let's go back to the beginning, what motivated you to develop the course CB3045 and to coach our case competition team?

ZL : Initially, CB would send a team to participate in the HSBC/HKU BCC each year, and it would arrange one faculty member from each CB department to form a committee to train the team for the competition. I felt that this was a "too many cooks spoil the broth" situation, because it was difficult for six busy faculty members to coordinate how to best teach students. I therefore decided to take upon the responsibility of being the "main" coach for the case competition team. I also decided to establish a formal university course CB3045, because this would lead to a higher level of commitment from students, as well as awarding them with academic credit for their work and their skills gained in the course.

Students – What attracted you to CB3045 and case competitions?

JC : I met Dr Leung during the interview for the CB Young Scholars Program. He encouraged me to take CB3045, and I signed up because I wanted to try something new.

FF : CB3045 sounded really interesting because students were required to work in teams to solve challenging real-life business case studies.

MC : When I was a student in CB3045, one of my classmates was an exchange student who was a member of the Queensland University of Technology's case competition team. I was impressed and inspired by how well she was able to present her ideas.

▲ Belgrade Business International Case Competition at Belgrade, Serbia in April 2018

What was your experience in CB3045?

JC : I found CB3045 to be a challenging but rewarding experience. The format of the course was very different from other courses; for example, we had tight deadlines (one week per case) to solve a business case study with our team.

FF : I had the opportunity to work with classmates who had different backgrounds and different working styles.

MC : I was surprised at how much public speaking was required in CB3045. I used to feel very nervous when speaking in public, but giving case presentations in class and in competitions has helped me become more comfortable with public speaking.

ZL : I had never taken a case competition course as a student, so at the beginning, it was quite challenging for me to teach CB3045. Over the years, I've gotten more experienced and the structure of the course has improved as a result. I'm also grateful for the support of CB colleagues such as Dr Chak-fu Lam (Management), Dr Alvin Leung (Information Systems), and Dr Huazhong Zhao (Marketing), who have participated in CB3045 as guest lecturers, helping us with cases related to their areas of expertise.

How do you prepare to take part in an ICC?

FF : After we were selected into the case competition team, we would spend our weekends together to train and prepare for the upcoming ICC. We would work together to solve various cases, and discuss how to improve our time management and slide-making. We would also learn from the top global teams by watching and analysing their case presentations, and incorporating some of the things they did into our own playbook.

▲ Australian Undergraduate Business Case Competition at Sydney, Australia in Novermber 2018

MC : The HSBC/HKU BCC uses a very diverse set of cases, covering topics from marketing to HR to crisis management, so solving a variety of cases during the training sessions really broadened our general business knowledge.

What happens during an international case competition?

ZL : In an ICC, teams of 4 from top global business schools travel to the organising university. Teams are given a case study about a client company, and the goal is deliver the most persuasive recommendation for the client via an oral presentation, supported by PPT slides. A key feature of ICCs is the short case-solving time: 3–6 hours for short cases; and 24 hours for long cases. Most ICCs take place over 5 calendar days, so the schedule is really packed – for example, there could be 4 full days allocated to case-solving and presentations, leaving only evenings and one full day for socialising and recreation. It also takes two full days that we spend travelling to the competition location and back to HK; but we try to arrive a day or two early to get over the jet lag, and to spend some extra time doing touristy things.

MC : Although the primary goal of an ICC is working hard and competing, it's also a great place to network with students from top global business schools, and to learn about their culture.

International travel sounds fun but also expensive – how much does it cost students to participate in an ICC? Does CB provide any financial support?

ZL : We're really grateful for CB's generous financial support, which covers all competition-related expenses. The students don't have to pay for anything, except their own meals.

What did you learn from interacting with students from the world's top business schools?

MC : I learnt from Copenhagen Business School students that we need to be more decisive in zeroing in on our solution.

JC : I heard from some teams that they're forced to learn on their own because their advisors are too busy to give them guidance. I realised that the CityU teams are really fortunate to have Dr Leung, who is able to spend a lot of time teaching and training us.

RT : I used to think the students at top business schools were super geniuses; but after speaking with them, I realised that they're just like us – we all find the cases challenging, and we all have similar abilities and opportunities to succeed, regardless of university ranking or country of origin.

ZL : Our students definitely have the smarts and the drive to succeed! We won the HSBC/HKU Asia Pacific BCC in 2017, the HSBC/HKU Hong Kong BCC in 2019, and placed third in the Universidad Panamericana VCC in 2020.

What is your favorite memory from an ICC?

JC : I was proud of how our team at AUBCC 2018 was able to stay positive despite adversity. There were three rounds of competition, and our team at the time was quite inexperienced, so we came in fourth out of four teams in our division for rounds 1 and 2. For the third and final round, we trusted our gut and went for an out-of-the-box solution, which earned us second place!

▲ International Case Competition at Maastricht, Netherlands in April 2019

▲ McDonough Business Strategy Challenge at Washington DC, US in February 2020

▲ The CityU team won US$ 10,000 as the champion of the HSBC/HKU Asia Pacific Business Case Competition 2017

▲ The CityU team was the champion of the HSBC/HKU Hong Kong Business Case Competition 2019

FF : We became really good friends during the competition in Maastricht, and we still find time to hang out nowadays.

What is the most difficult part of an ICC?

ZL : During an ICC, students are required to solve a complex case within a very short period of time, usually around 24 hours, so students are super stressed and exhausted. It's not surprising that interpersonal conflicts can arise, like a reality TV show. I have heard from several teams where students found it frustrating to work with a teammate who was stubborn or unable to take criticism.

Has participating in case competitions been helpful to your career?

FF : It was really helpful. I use case-solving frameworks everyday in my work as a consultant. My colleagues are often surprised that I'm a fresh graduate, as I demonstrate a deeper business sense compared to my peers. I'm also confident about my ability to speak off the cuff; for example, there was an occasion when I had to give a presentation in place of my manager who was suddenly unable to attend, and I hit it out of the park.

JC : It has helped me especially in how I organise my ideas, and how it's essential to have a good understanding of the bigger picture. If you need to solve a problem, and communicate your solution to others, you'll definitely benefit from CB3045.

ZL : Teaching CB3045 and working with students for ICCs has helped me develop into a more effective communicator and teacher. I've learnt how to structure my ideas better, and also how to arouse the interest of students by presenting course material in an engaging manner.

Case-solving sounds like an amazing experience! Would you recommend CB3045 and ICCs to all CB undergraduate students?

FF : It's not all fun and games – you do need to be extremely motivated, and put in the time and energy for weekend training sessions.

ZL : Case-solving is really meaningful and fun, but it's also hard. I've found that not all students are comfortable with the complex and open-ended situations that they encounter in business case studies.

Any final advice for students who are interested in CB3045 and/or ICCs?

MC : You can feel overwhelmed at first, but don't despair. All of us started with zero experience in case solving, and practice makes perfect!

FF: Having a growth mindset is essential. Do listen to feedback from your peers and Dr Leung.

JC : Don't be afraid to ask questions!

ZL : Try to make it easy for your audience to understand your ideas by putting yourself into their shoes.

NEWS

Professor Houmin Yan receives CRF funding to combat Covid-19

A cross-institutional team led by **Professor Houmin Yan** has received HKD 4.3 million in funding to support the battle against COVID-19 over the next three years. As Project Coordinator, Professor Yan will head a project entitled "Resilient PPE Supply Chains for Hong Kong Health Systems: Current and Post Covid-19 Pandemic." This is the first Collaborative Research Fund (CRF) project attained by the College of Business.

"The Coronavirus is a vivid example of how new and deadly noninfluenza microbes are emerging and mutating in unpredictable ways," said Professor Yan.

"We are grateful to the RGC for this timely support which will enable us to leverage cross-disciplinary expertise to help mitigate the Covid-19 threat."

The team is composed of experts across the fields of supply chain management, demand forecasting, and public healthcare, and brings together a rich array of Co-Principal Investigators and practising collaborators:

City University of Hong Kong

- **Professor Frank Chen**, Dean (CB) and Chair Professor of Management Sciences
- **Professor S. Joe Qin**, Dean and Chair Professor, School of Data Science
- **Professor Yanzhi Li**, Professor, Departments of Marketing and Management Sciences
- **Professor Stephen Shum**, Professor, Department of Management Sciences
- **Dr Geoffrey Tso**, Associate Professor, Department of Management Sciences
- **Dr Qingpeng Zhang**, Associate Professor, School of Data Science

Other Institutions

- **Professor Tinglong Dai**, Associate Professor of Operations Management and Business Analytics at the Johns Hopkins Carey Business School
- **Professor Hong Fung,** Professor of Practice in Health Services Management at the Jockey Club School of Public Health & Primary Care, The Chinese University of Hong Kong
- **Professor Eliza Wong**, Jockey Club School of Public Health and Primary Care, The Chinese University of Hong Kong;
- **Miss Phoebe Lau**, Advanced Practice Nurse, Queen Elizabeth Hospital

In the One-off CRF Coronavirus Disease and Novel Infectious Disease Exercise, four CityU-led projects have been funded. One other CRF project, "Hong Kong Insolvency and Restructuring Law and Policy in Times of COVID-19 and Beyond," under Project Coordinator Professor Wan Wai-yee of the School of Law, has participation from the College of Business, namely **Professor Phyllis Mo** of the Department of Accountancy and **Dr Yaxuan Qi** of the Department of Economics and Finance.

The College of Business is proud to be playing a part in developing a comprehensive strategy to combat the pandemic, demonstrating the critical role that our research can play towards solving pressing societal issues.

Professor Kim Jeong Bon lands top place in Accounting Author Rankings

Professor Kim Jeong Bon, Head and Chair Professor of the Department of Accountancy, has been ranked 1st worldwide for research over the last six years, and 2nd worldwide over the past 12 years in the latest Author Ranking for Financial Accounting released recently by Brigham Young University.

Professor Frank Chen, Dean of the College of Business, said, "The College congratulates this exceptional achievement of Professor Kim. Please join me in extending our warm congratulations to Professor Kim for his outstanding research performance."

The BYU Author Rankings are based on peer reviewed articles in 12 accounting journals and provide widely recognized rankings of researchers' mid- to long-term contribution to accounting research.

Professor Jane Lu elected AIB Fellow

Professor Jane Lu, Head and Chair Professor of the Department of Management, has been awarded Fellowship of the Academy of International Business (AIB), in recognition of her contributions to the association and the field of international business as a whole.

"I am honoured to be elected as an AIB Fellow. I hope my experience can help foster cross-border knowledge exchange and collaboration in various areas related to international business," said Professor Lu.

One of seven newly elected AIB Fellows, Professor Lu will join 104 existing fellows in participating in various AIB workshops, conferences and award selections, etc.

Established in 1959, the AIB is a community of international business scholars aiming at promoting impactful research, improving business education and practice, and collaborating with leaders in policy and interdisciplinary research.

Professor Lu received her PhD in General Management from the University of Western Ontario, MBA from the China Europe International Business School, and BA in Economics from Shanghai Foreign Studies University. Her research interests are in international business, organisational and management theory, entrepreneurship, non-market strategy, corporate governance and stakeholder engagement.

The College of Business congratulates Professor Lu on her exceptional accomplishments.

Professor Alan Wan elected President of the Hong Kong Statistical Society

Professor Alan Wan, Head of the Department of Management Sciences, has been elected President of the Hong Kong Statistical Society. The society has a threefold mission to provide formal recognition and promote professional development through accreditation of qualifications and training experience; to organise and sponsor statistical conferences, workshops and seminars, and to improve statistical literacy. This is achieved partly through the Statistical Project Competition for secondary students, an annual event which has been organised by the society since 1986.

The society was founded in 1977 by Professor John Aitchison of the University of Hong Kong. Members include academics, government statisticians and a growing number of data scientists and quantitative analysts working in the private sector.

The College of Business congratulates Professor Wan on his new role with the Hong Kong Statistical Society.

NEWS

Dr David Xu named as AIS Distinguished Member with Cum Laude designation

Dr David Jingjun Xu, Associate Professor of the Department of Information Systems, has received the honour of "Distinguished Member - Cum Laude" by the Association of Information Systems (AIS). His recognition in December 2020 is for significant impact and commitment to the association.

The honour is only given to those who have held continuous AIS membership for at least 10 years, served in a leadership role in AIS or AIS-related activity and have been published in at least four publications in an AIS or AIS-affiliated journal.

"I am delighted to be recognised as an AIS Distinguished Member with Cum Laude designation. My thanks to the AIS's selection. I am also grateful to the College and the IS department for the generous support given to faculty to conduct research and make contributions to the field," said Dr Xu.

Dr Xu's research effort was also demonstrated by his recent accomplishments in the information systems field. In December 2020, Dr Xu received the Best Associate Editor Award at the International Conference of Information Systems (ICIS) for the "Digital Commerce and the Digitally Connected Enterprise" track. In addition, according to the AIS Research Rankings released in January 2021, Dr Xu is ranked the 4th most productive (the first-author count, tie) information systems scholar worldwide for publishing in the top-4 (and top-8) IS journals during the past ten years (2011-2020).

The College congratulates Dr Xu on his remarkable achievements.

CityU hits top in information systems research rankings

The College of Business has marked another significant achievement in research excellence. In the latest research rankings of the Association for Information Systems (AIS), CityU is ranked No.1 in Asia and No.6 globally based on publications on MIS Quarterly and Information Systems Research, two top journals in the information systems field.

The AIS Research Rankings are based on research published from 2018 to 2020 in top journals in the AIS Senior Scholars' basket. When considering the "Basket of Six" journals, which includes MIS Quarterly, Information Systems Research, Journal of Management Information Systems, Journal of the Association for Information Systems, Information Systems Journal, and European Journal of Information Systems, CityU remains No. 1 in Asia and rises to No. 3 globally.

"The achievement reinforces our Department's global reputation as a powerhouse for knowledge creation in the information systems field," said **Professor Yulin Fang**, Acting Head of the Department of Information Systems.

"Our thanks go to the relentless hard work of our faculty, who are committed to research excellence and exploration of frontier knowledge. We aim to maintain our leading academic position and at the same time cultivate business professionals for the industry."

Seven CB faculty members listed in the world's top 2% of scientists

Seven faculty members of the College of Business of City University of Hong Kong are among the top 2% of the world's most highly cited scientists, according to metrics compiled by Stanford University.

At CityU overall, over 140 faculty members are recognised as being part of the top 2% of the world's most highly cited scientists. Compared to faculty size, CityU's representation is among the highest in Asia.

This report was prepared by a team of experts led by Professor John Ioannidis of Stanford University. The publicly available database provides continually updated information on the work of the world's top scientists includes standardised information on citations, h-index, co-authorship-adjusted hm-index, citations of papers in different authorship positions, and a composite indicator.

The College congratulates our faculty on their achievements.

Professor Yin-wong Cheung
Professor, Department of Economics and Finance

Professor Robert Davison
Chair, Assurance of Learning Committee,
Professor, Department of Information Systems

Dr Raymond Lau
Associate Professor, Department of Information Systems

Professor Matthew Lee
Vice-President (Development & External Relations)
Chair Professor of Information Systems & E-Commerce,
Department of Information Systems

Professor Jane Lu
Head and Chair Professor, Department of Management

Professor Jian Ma
Professor, Department of Information Systems

Professor Maris Martinsons
Professor, Department of Management

Inaugural joint seminar with the School of Law

With the vision of **Dean Frank Chen** and Professor **Cheng-Han Tan** of the School of Law, a joint seminar series was launched on November 12th to explore common research interests of the business and law disciplines. The aim is to encourage collaboration between scholars in the two disciplines and address problems impactful to the world.

In his opening remarks, Professor Tan said that this would be the start of a fruitful relationship that will improve interdisciplinary collaboration between the two disciplines.

Professor Chen said that the joint research effort would attract seed funding for research between the two schools, and looked forward to increased collaboration.

The inaugural seminar was presented by Professor Wei-thoo Yue from the Department of Information Systems, on "Implementing Transaction Fee Mechanism in Permissioned Blockchains: An Economic Analysis."

The seminar marked the beginning of what we trust will be a long and fruitful partnership with the School of Law.

NEWS

College of Business Distinguished Alumni Award 2020

The College is proud to announce the results of the Distinguished Alumni Award 2020. The award recognises the outstanding achievements and contributions of our distinguished alumni to their professions, the University and society as a whole.

The five award winners for 2020 are:

Dr Chordio Chan (DBA, 2019), Head of Investment at Bank of China (Hong Kong) has over the years provided extensive service to the community. He has served amongst others as Executive board member of TMA, Chairman of the Market Practices Committee of TMA, Chairman of the Market Standard Committee under The Hong Kong Association of Banks and Deputy Chairman, Leveraged Foreign Exchange Trading Arbitration Panel of Securities and Futures Commission.

Dr Shengjun Yan (DBA, 2016) founder of China Tianying Inc. was recently named as "2020 China Economic News Person" (2020 中國經濟新聞人物). In response to China's "Belt and Road Initiative," Dr Yan has worked at integrating resources on a global level, attaching great importance to green development and building a state-of-the-art industrial ecosystem. Under Dr Yan's leadership, CNTY has donated large quantities of personal protection equipment and funds in the fight against COVID-19.

Mr William Pang (BBA SOM, 2008), Vice President of Credit Suisse AG, specialises in anti-money laundering and in providing transnational views in financial crime and terrorist financing. As an alumnus of CityU, Mr Pang has engaged in industrial mentoring, and shared his experience in public talks and workshops. He has recently taken up a role as the external member of the Management Sciences Departmental Advisory Committee.

Ms Paula Yang (BA BS, 1996) began her career as a media executive with FCB Hong Kong. She then joined PCCW IMS in 1999, and then served successively as Chief Business Manager of on.cc, Digital Head of Dentsu Media Hong Kong, and General Manager of NDN Group. Ms Yang was named "Digital Marketer of the Year 2018" by the Hong Kong Association of Interactive Marketing. Over the years, she has been consistently supportive of our student development.

Ir Susanna Shen (EMBA, 2004), is Head of Corporate IT at The Hong Kong and China Gas Company Ltd (Towngas). Ms Shen serves on various advisory committees in the public sector and also universities and professional bodies. She has been the Chairperson of CIO Board, HK Computer Society since 2017. She has been recognised with various awards during her career, most recently by IBM in 2020 as one of the 35 most influential global Women Leaders in AI.

We extend our congratulations to the winners, and thank them for their contributions to their profession, the University and the wider society.

Comings & Goings

We welcome our new faculty who joined CB between September 2020 and February 2021.

Professor Pengfei Guo

Chair Professor
Department of Management Sciences

Professor Pengfei Guo received his PhD in Business Administration from Duke University, his BSc degree in Information System from Xi'an Jiaotong University and MSc degree in Management Science and Engineering from Shanghai Jiao Tong University. Prior to joining CityU, he was a faculty member at the Department of Logistics and Maritime Studies, Faculty of Business, the Hong Kong Polytechnic University. His research work has been published in leading academic journals such as *Management Science, Operations Research, Manufacturing & Service Operations Management, Production and Operations Management, Naval Research Logistics, European Journal of Operational Research* and others. Prof Guo's research interests lie in service operations, queuing economics, healthcare policy, and supply chain management. He is an Associate Editor of *Manufacturing & Service Operations Management* and a Senior Editor of *Production and Operations Management*.

Dr Muhammad Akhtar Azim

Assistant Professor
Department of Accountancy

Muhammad Azim completed his PhD in Accounting from the Rotman School of Management, University of Toronto. He holds the Canadian CPA, CA, designations and has an MSc in Finance from Queen's University. Dr Azim's current research interests span two broad areas, financial accounting, where he studies financial markets frictions as they apply to accounting questions, and managerial accounting, where he studies contracting issues. Prior to the above, Dr Azim was in Deloitte's Real Estate & Resources group within the Assurance & Advisory practice. He has worked with public and private companies across four continents and has significant international experience. Dr Azim is a Canadian of Bangladeshi heritage. He is passionate about research, teaching and building communities. He enjoys hikes, travel, and learning about different cultural cuisines.

Dr Xueyan Yin

Assistant Professor
Department of Information Systems

Xueyan Yin received her PhD in Information Systems from Arizona State University. Her research focuses on digital media data analytics such as multimedia content design, use of internet water army and game-based promotion strategy. She applies numerous research methods in her studies including machine learning and econometrics analysis. She has strong interest in pursuing projects with high-societal and practical impact. Her research methodology includes computer vision, machine learning, econometrics research, and her interests are multimedia content design, entertainment analytics, and social media analytics.

Dr Kyeonggook Park

Assistant Professor
Department of Management

Kyeonggook Francis Park's main area of research is in platforms, and how platforms and other firms deal with technology change. His research has been published in *Academy of Management Annals and Strategic Management Journal*. In addition, Kyeonggook has contributed to *The Palgrave Encyclopedia of Strategic Management*. Prior to joining CityU, Kyeonggook worked as an Assistant Professor of Management at Tilburg School of Economics and Management in the Netherlands. He holds a PhD and an MPhil in Business Administration and Management from New York University, Stern School of Business and a BA *cum laude* in Economics and Psychology with Honors from Northwestern University.

We extend our best wishes for future happiness, professional fulfilment and prosperity to faculty who left us between September 2020 and February 2021.

Professor Juan Feng

Professor
Department of Information Systems

Dr Francis Leung

Associate Professor
Department of Management Sciences

Dr Paul Poh

Assistant Professor
Department of Accountancy

Dr Bonggeun Choi

Assistant Professor
Department of Economics and Finance

Dr Hyewon Cho

Assistant Professor
Department of Marketing

Alumni class notes

Share your news with classmates and CB alumni! Tell us about the highlights of your year – family, career, accomplishments, and interests. We will publish your updates in the "Alumni class notes" section of City Business Magazine and on the CB website.

Simply submit your information (name, major, graduation year) and your news to us. Don't forget to attach photos with your write-up!

Dr Lawson Law

BA Quantitative Analysis for Business 1992

According to a paper issued by The Hong Kong Monetary Authority, the most important skills in future banking are technological and data skills, which will help banks to generate insights, make decisions, solve problems, and deliver a better customer experience. We should be familiar with all of these skills as they have been offered by our College since the 1980s. They have also enabled me to apply what I have learnt in various analytics positions such as marketing, branch network, credit risk management, and SME business. Now, I am the Head of Data & Analytics of wholesale banking in Hang Seng Bank, formulating data and analytics strategy. Staying competitive in today's digital era requires acquiring new knowledge continuously. Therefore, I obtained an Engineering Doctorate degree in machine learning in 2021. Don't stop, keep learning and take challenges!

Mr Ben Wong

BA Quantitative Analysis for Business 1993

New way of managing project from SSADM to Agile approach.

30 years ago, we learnt about logical data, data flow and entity behaviour modelling to resolve business operational issues from CityU QAB training. We discussed multi-cultural business cases during advanced modelling classes. Nowadays we further enhance project execution through agile approaches to introduce platform concepts. I act as regional product owner, digital distribution at SunLife, and need to seek business opportunities and high impact values for our target users, defining backlog prioritisation. I also need to use new tools such as JIRA and Confluence for user stories and knowledge building. I still find the CityU training of 30 years ago very useful and applicable to my existing role to manage regional project execution.

Professor Christy Cheung

BA Managerial Statistics 1998
MPhil Information Systems 2001
PhD Information Systems 2007

I am a Professor in the Department of Finance and Decision Sciences of Hong Kong Baptist University. I always appreciate the intensive training in statistical analysis, research methodology, and programming given during my studies at CityU – BA MST. The training helped me develop a solid foundation to conduct scientific research. Further, the final year project and the project-based courses with a focus on critical and logical thinking, and writing and presentation skills prepared me to pursue my academic career in universities. I have recently been conferred the title "RGC Senior Research Fellow" in the inaugural Research Grants Council (RGC) Senior Research Fellow Scheme (SRFS). The fellowship scheme continues to support my academic research into the impact of information technology on individuals, groups, and societies. The statistical techniques that I learnt from my BA programme remain relevant and important for me to do significant original research in the management information systems area.

Bergman Wong

MPhil Management Sciences 2006
BBA Managerial Statistics 2004

The LAST piece of the puzzle! Hanson, our third kid, says hello to everyone. He has two lovely sisters aged 5 (Hannah) and 2 (Hannie). Do they look alike? :) We wish you all everlasting joy and happiness with the families.

P.S. Bergman Wong is an alumni of the Department of Management Sciences, graduating in 2006 with a major in BBA Management Sciences. He is now Head of Big Data Analytics & Machine Learning at China Construction Bank (Asia).

Dr Crystal Lee

PhD Management Sciences 2015
BBA Management Science 2008

Recalling one of the most precious things CityU established, which is friendship.

I met good friends and mentors here, and we have shared happy moments and tackled life's difficulties together. This photo is from the trip to Tibet with nine alumni in 2014, one of the happiest moments of my life.

Myron Wong
BBA Management Science 2008

Hi all CB Alumni, this is Myron! I have dedicated to embrace the challenge as the President of Alumni Association of Department of Management Sciences (MSAA). It is really a challenge to build and sustain the relationship amongst the alumni during the pandemic. The committee has tried the best to achieve just that. Please follow us on Facebook "CityU MSAA."

Dr Kuan Sun
PhD Management Sciences 2018

Hi all CB Alumni, Kuan here! It always brings back so many great memories when we talk about the life at CB and Hong Kong. I lived five amazing years here and got enormous treasure from this experience. I was a major in Financial Engineering when I took a PhD at CB, and now I am running a quantitative investment start-up with a turnover of billions of US Dollars in Beijing. A lot of stuff in my current work roots from my study back then, so I am more than grateful to what I have got from CB, the knowledge, the friends and the something that makes me a real adult.

Tim Wong
BBA China Business 2010

Sometimes it's not so easy to put your academic knowledge into practice. How grateful I am to be able to apply what I have learnt from CityU in my business and different aspects of life. When I first graduated from CityU, I got a golden opportunity to station in China as a management trainee at China Resources Enterprise. I was soon promoted and was assigned to manage two shops in Beijing. It was a demanding role but CityU equipped me with valuable experience to get familiar with China. For the last few years I have been running my education centre in Hong Kong which is another great challenge for me. It has been my honour to have studied here at CityU.

Jigang Yang
EMBA Chinese 2016

Life is full of uncertainty in the era of transformation. How can we find our direction in life and career?

In the autumn of 2014, I embarked on my studying journey at CityU EMBA, where I gained much knowledge and valuable insight, experienced growth and widened my horizon. Over the years, I applied what I had learnt at CityU into my expertise in transformation consultancy service. I have provided customised transformation consultancy services for 73 Fortune 500 companies and 165 renowned Chinese companies. I also wrote two best-selling books in management and sales, and published several articles in famous publications including "Harvard Business Review", "Tsinghua Business Review", "China Industry and Information Technology", "Enterprise Management", etc.

Jiang Yang
MA International Accounting 2020

At a turning point in my life, I decided to apply for a PhD degree after graduating from CityU Business School. Things are much more difficult than I thought. Personal statement, CV, research proposal etc., all need to be prepared by myself. During the process I find that beyond the passion to devote to accounting and accountability scholarship, professional expertise is also essential. I really appreciate what City U offers me: not only knowledge, but also selfless help and care from Dr Raymond – my taxation class teacher. My application continues; I have no idea what will happen next.

Xilu Ding
EMBA Chinese 2021

I joined the CityU EMBA family in the fall of 2018. CityU is internationalised and I can feel it is a frontier of information technology throughout my more-than-two-year school life here. I work on chips and sesnors, learning at CityU really brought me a lot of new inspiration and helped my career. In September 2019, I was promoted from General Manager of China to General Manager of Asia Pacific, and I led the team to create new highs in performance and profit in 2020.