How did you become interested in Management Science, Operations Research and Economics?

Using mathematics to model, analyse and find optimal solutions to business problems has always interested me. During my Master’s degree in Management Engineering in China, along with my professor, I developed new approaches to determine weights for multiple attribute decision making processes, which was published in top journals on decision analysis in China. The results were also implemented by some local companies.

I was encouraged to pursue my doctoral degree in the Sauder School of Business at the University of British Columbia. I received rigorous training in doctoral level courses in Management Science/Operations Research and Economics. I had the opportunity to talk to world class researchers, and I was introduced to cutting-edge problems in the field.

What do you find most fascinating about your field?

I was deeply attracted to the beauty of using mathematics models to capture the essence of real-world business problems. I also wanted to explore solution procedures using the tools of Business Analytics and Economics, to provide predictions and descriptions about optimal or equilibrium strategies, and most importantly, to deliver key managerial insights to business practitioners and policy makers.

Can you describe the challenges that have arisen in the management and operation of value-added supply chains as a result of the globalisation of the world economy?

The globalisation of markets provides firms with opportunities to seek better quality supply chain partnerships at lower costs – but at the same time increases the risks that firms are exposed to. One of the new challenges is supply chain risk management: how can firms’ exposure to uncertainties and risk be diversified or mitigated? Supply chain globalisation also increases the complexity of the supply chain network, so how can this network be managed and how can indirect suppliers be efficiently coordinated?

Many suppliers thrive by reducing costs and focusing on economic incentives, often at the expense of social and environmental responsibilities. Recently we have witnessed many examples of unethical and incompetent behaviour from suppliers, such as the use of child labour or allowing hazardous working environments. Thus how to contract with and compensate upper tier suppliers so that the entire supply chain is environmentally and socially responsible is another interesting challenge in the management and operation of a value-added supply chain.

Advances in technology enable us as researchers to accumulate big data from supply chain networks. However, exacting useful information and applying data analytic tools to come up with useful insights is a huge challenge.

What are supply chain information and incentives, and have you made any new insights into this area?

When facing problems with hidden information, you need to use the available information to provide incentives to the agent, which induces the best outcomes. This is especially relevant in the supply chain context; when contracting with upstream suppliers or downstream retailers, you might not know whether or not the supplier is socially or environmentally responsible or how much effort the retailer puts into advertising or selling your product. In these cases it is important to design contracts that attract what you would consider desirable suppliers or to align incentives so that the contracted party performs the best possible actions.
I have published a number of works in this area, including a sole authored paper published in *Production and Operations Management*. One key insight I introduced to the area is that the type of contract you need to sign with your partner depends on your downstream market characteristics. If the market is highly price competitive, you need to subsidise your retailers for leftover inventories, while if the consumers are more likely to switch between vendors you need to punish your retailer for overstocking.

**What do you consider to be your most significant achievements to date?**

This is a very tough question! I am happy to be able to conduct and publish research projects that are interesting to me, useful to business communities and valuable to government policy makers. It is satisfying that my research projects can be used to make a real difference in society and are fully funded by government agencies. I have also been invited to give talks at other universities and prestigious conferences, and have received invitations to sit on research funding adjudication committees. I am also extremely proud of the dedicated postdoctoral fellows and Master’s and doctoral students who have worked closely with me, and all of them have successfully entered their desired jobs. My research journey is leading to more significant achievements – and I hope this will never end.

**THE JOURNEY FROM** resource to product to consumer is dynamic and complex. Supply chains involve multiple organisations – suppliers, manufacturers, retailers and consumers – who often have very different goals and incentives. Uncertainty can be introduced at any level of the supply chain; supply and production may be disrupted by natural disasters or financial problems, for example, while retailers may struggle with uncertain demands and new competitors. Meanwhile, consumer behaviour can vary enormously according to changing socioeconomic contexts, politics or current events.

Thus supply chain firms face the difficult task of ensuring that a product reaches the consumer in a way that generates profit for them while also being maximally beneficial for the system as a whole. The success of each organisation in achieving this depends on several factors, including devising appropriate strategies, accurately predicting the behaviour of upstream and downstream firms, and ensuring optimal risk management is in place. This is no simple task, and many aspects of supply chain dynamics have not yet been clearly outlined or modelled.

**Associate Professor Xuan Zhao**, based at Wilfrid Laurier University in Waterloo, is addressing the lack of knowledge about supply chain dynamics through the application of Management Science, Operations Research and Economics, including Game Theory, to a variety of key problems in this area. Her research focuses on supply chain management, marketing, revenue management, sustainable operations, behaviour operations and entrepreneurship. By analysing and modelling supply chain systems under different conditions, Zhao hopes to provide practical tools that can aid management decision making at different levels of the supply chain.

**EXPLORING SUPPLY CHAINS DYNAMICS AND STRATEGY**

Funded by the Natural Science and Engineering Research Council of Canada, Zhao has published 11 papers in prestigious journals, each tackling different aspects of supply chain dynamics and strategy. They consider how supply chain systems are affected by competition, information and incentives, and risk management.

Zhao’s publications on inventory theory, trans-shipment and customer behaviour under competition tackle the challenge of competition in the context of market globalisation. For example, she has examined the role of simultaneous price and inventory competition on decisions of newsvendors, which sell perishable products and face uncertain demand. Using novel methods, she has shown that retail prices and safety stocks based on the classical newsvendor model are inaccurate when newsvendors are actually facing competition. Furthermore, retail prices and safety stocks increase in proportion to the number of customers switching to a competitor and that they decrease in line with the extent of price competition.

Further publications address questions as to whether shipment with intermediate destinations (trans-shipment) is worthwhile in competitive supply chains, how customers are likely to behave when their product of choice is unavailable, and how the structure of distribution channels in vertically differentiated markets determines appropriate pricing and quality strategies. She also considers the impacts of these issues on consumers.

Importantly, Zhao’s work provides practical, applicable tools for guiding managerial decisions within complex and uncertain environments.
MANAGING GLOBAL SUPPLY CHAIN, INCENTIVES, INFORMATION, RISK AND SUSTAINABILITY

OBJECTIVE
To use mathematics to model, analyse and find optimal solutions to complex business problems in a globalised world.

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XUAN ZHAO is based at Wilfrid Laurier University. She has a PhD in the joint fields of Management Science and Logistics from the University of British Columbia. Her research involves utilising the tools of Management Science, Operations Research and Economics (Game Theory) to model, analyse and derive insights into problems in the areas of supply chain management, marketing/operations management interfaces, revenue management, sustainable operations, behaviour operations and entrepreneurship. She has had many research papers published in prestigious journals.

decisions on strategy. This could include dealing with increases in competition, responding to customer behaviour or deciding how to ship goods between competing retailer outlets when one has leftover inventory and the other has unsatisfied demand.

RISK MANAGEMENT IN PRACTICE
Companies are constantly faced with supply and demand uncertainties, whether this means estimating the demand or spot price of upstream goods. In her studies, Zhao examined the influence of information updating on a supply chain with a spot market — that is, where goods are traded for immediate delivery. She found that improving available information on the spot price benefits the manufacturer at the cost of the supplier without changing the overall performance of the supply chain.

Zhao has also explored the role of information updating for a supply-side firm in the form of an advance booking discount (ABD) system, which is designed to encourage customers to purchase goods, allowing the supplier to monitor demand. She found that ABD makes sense for products with high profit margins, and also when raw material spot prices are particularly sensitive to trading volume.

In subsequent publications, Zhao proposes appropriate strategies for minimising the problems posed by demand and supply uncertainty. Her work suggests that contracts that include a returns policy between manufacturer and retailer, as well as wholesale price contracts between the raw material supplier and manufacturer, are better than those currently in use. This helps make the system more coordinated and leads to a win-win situation for all participants in the supply chain.

CROSSING RESEARCH DISCIPLINE
Zhao’s interdisciplinary work is remarkably diverse. Supported by the Ontario Ministry of Research and Innovation, she has recently been working on revenue management in the shape of dynamic and informed pricing strategies: “I provide guidance to manufacturing firms on how to decide pricing and capacity allocation in a competitive market, and how to provide pre-orders and return credits when facing strategic consumers whose purpose is to maximise the utilities,” she explains.

By analysing and modelling supply chain systems under different conditions, Zhao hopes to provide practical tools that can aid management decision making at different levels of the supply chain.

Funded by the Social Science and Humanities Research Council of Canada, Zhao is also working on sustainable operations, aiming to understand how government environmental policy impacts a firm’s operational decision making — and how strategic partnership decisions can lead to sustainable development for energy firms.

BEYOND THE SUPPLY CHAIN
Moving forwards, Zhao plans to continue studying emerging problems in supply chain management. She also hopes to hone in on the challenges of smaller, entrepreneurial firms — which are completely different to those of larger firms — and to determine optimal strategy for ensuring their survival in emerging markets with high levels of competition. Indeed, she has already produced three publications that provide insights into appropriate strategies for small, risk-concerned firms to meet their revenue and profit targets.

“In future, I am interested in connecting with more business startups,” Zhao says. “I will explore the hurdles they face to survive, identify research problems and use business analytics tools and methodologies to provide optimal solutions for startups.”

KNOWLEDGE IS PROFIT

Accurate information may be the difference between success and failure. As Zhao explains, firms within a supply chain “make individual decisions, and might have private information on their actions and market situations”. One solution to this is to design contracts that account for intense competition and yield uncertainty — something that Zhao has done by modelling one supplier selling a product to multiple retailers in the context of price and inventory competition.

Additionally, Zhao has examined retailer-retailer and supplier-retailer conflicts and designed mechanisms for mitigating the negative effects of competition and double marginalisation. She has also assessed the effects of outsourcing and contracting in the context of two competing assembly systems.