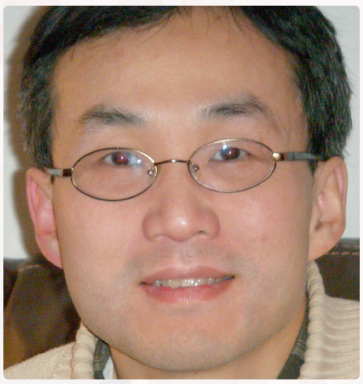
DR YAO ZHAO

Model management

Technology and globalisation have changed the way projects in many industries are delivered and led to new challenges within the supply chain. **Dr Yao Zhao** combines mathematical modelling with empirical study to develop novel solutions that help companies handle these challenges



To begin, could you describe your current job role within the department of Supply Chain Management and Marketing Sciences?

I am an Associate Professor in Supply Chain and Project Management. This involves research to understand and improve the management of operations, in particular, supply chains and projects; teaching to prepare the next generation of management leaders; and consulting and advising companies to improve their management practice on operations. My other roles are PhD Programme Coordinator and Faculty Fellow at the Rutgers Center for Supply Chain Management (SCM) and the Lerner Centre for Pharmaceutical Management Studies.

In what ways have businesses evolved with technological advances and expansion over the last 30 years? How has this affected the supply chain?

The advances in information technology and logistics infrastructure, as well as the removal of trading barriers by free-trade treaties (World Trade Organization, Asia-Pacific Trade Agreement and EU) give rise to the global market, global innovation and global supply chains. Companies are weaving their global networks of research & development, supply and market. Opportunities are irresistible: the significant market potential, the promise of obtaining the best-in-class technologies and talents, and the opportunity of reducing costs.

Challenges are also daunting: a global supply chain is likely much more complex than a regional one, with much higher risks, and involves many organisations with diverse strategic motivations.

How do you develop models and methodologies that can improve the understanding of the construction, pharmaceutical and aerospace industries?

The problems studied in this project share a common feature; project management and SCM decisions are intertwined. In practice, they are typically managed as projects without taking the supply chain perspectives into account. In academia, the connections and interactions between projects and supply chains are yet to be fully recognised and understood. We studied these problems by an interdisciplinary approach. In particular, by understanding the impact of material supplies on project operations, by exploring the trade-off between project and supply chain metrics, and by modelling project supply chains mathematically, we developed new models, solutions and insights.

One of your studies investigated the supply delays to the Dreamliner Boeing 787 project. What were your findings?

The 787 programme represents the current project supply chains where a significant portion of the development work is outsourced to global suppliers. By a comprehensive empirical study of the events and facts, we found strong evidence to suggest that a majority of the delays were intentional because Boeing and its suppliers did not want or care enough to carry out their jobs properly. To identify the economic drivers that led the firms willingly into the delays, we apply the game theory to the 787 'risk-sharing' partnership, which transforms tier-1 suppliers into stakeholders by having them share the risk of project delays.

The original goal was to encourage the suppliers to complete their work on time and cost efficiently. Our model shows that against its goal, the partnership actually led the firms into a Prisoners' Dilemma where Boeing and the suppliers were motivated to work slower and put in less effort than what was right for the programme, because each firm could save money by doing so and have other firms share the damages. Reconciling the model with the empirical evidence, we revealed the rationale behind Boeing and its suppliers' irrational behaviour that delayed this programme.

You have been involved in the analysis of some clinical trials with globally dispersed testing sites. What have you found that has been of interest to the pharmaceutical and bio-technology industries?

Clinical trial supply management offers a substantial opportunity to cut costs and improve efficiency as the cost of clinical supplies could account for 20 per cent or more of a company's R&D spending. The opportunity lies in the fact that companies typically manage clinical trials as projects, and set up the trials without considering supply chain issues. However, the project and supply decisions are tightly coupled; for instance, globalisation helps with project metrics (for example, patient recruitment), but imposes a huge challenge on supply metrics (cost and drug availability). Thus, integrating clinical trial project decisions (country and site selection, protocol design) with supply decisions (inventory levels, logistics network) offers a significant opportunity for companies to do more with less. We developed the first multi-echelon inventory model and mathematical programming based algorithm to aid inventory decisions in global trials, which are complementary to the simulation-based studies of the current literature.

DR YAO ZHAO

Supplying solutions

With project supply chains a pressing concern in today's business world, a research group at **Rutgers University** in New Jersey is developing paradigms for integrating supply chain planning with project management

A SUPPLY CHAIN is a network of companies that are necessary to create, produce and deliver a product or a service. Supply chain management looks at how to optimise and coordinate different parts of a supply chain to achieve overall efficiency and cost effectiveness. Over the last three to four decades, advances in technology and the networked economy have led to the evolution of the business models in many project driven industries, from a one-company-does-all approach to a more collaborative and decentralised one. Whilst this has brought tremendous benefits, this model has also led to significant challenges in the coordination and management of the project (driven) supply chains.

Dr Yao Zhao's research group at Rutgers University in New Jersey analyses project supply chains, aiming to develop models and methodologies to improve the understanding and management for a range of industry projects. His approach involves discovering problems and identifying issues by case studies and/or empirical studies: "We then conduct mathematical modelling (optimisation, risk analysis, and game theory) to develop new insights and solutions beyond conventional wisdom, reconcile the models with practice and demonstrate the economic or social impact," he reveals.

The current National Science Foundation-funded project covers three research areas: recurrent projects subject to random material delays (found in the construction industry); one-of-a-kind development projects with an extensive workload outsourced (found in the aerospace and defense industry); and clinical trial projects with a global network of testing sites and investigative drug distribution (found in the pharmaceutical and bio-tech industries).

CONSTRUCTION RESOURCE MANAGEMENT

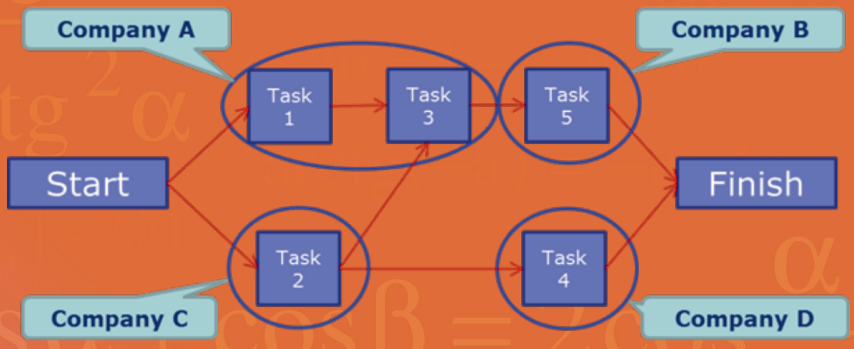
One aspect of the research was an empirical study of prefabricated housing and construction resource management, which involved compiling case studies and general statistics from three countries – the US, Japan, and China. Zhao explains the importance of the investigation: "Today, construction projects frequently spend a significant portion of their budgets (more than 50 per cent) on material supplies sourced from an extended supply network. While the project and supply chain operations are tightly coupled, project and supply chains are often managed in separation".

The group has been working alongside Intercontinental Construction Management (ICM) Inc; a middle sized construction management firm which specialises in military buildings. Structural steel is the most expensive material used in all ICM projects, which is subject to a long and unpredictable lead time. When the supplies are delayed behind the schedule, ICM has to struggle to expedite the rest of the project activities because of its project management practice, which involves treating each project as a separate and unique entity. However, material supply is not an issue specific to a project but an ongoing concern, as it is required by all the projects, as Zhao elaborates: "To resolve issues of this kind, we identified a new class of problem – recurrent projects with random material delays. We constructed a modelling framework to plan for supply chain and project operations jointly so that we could achieve an overall efficiency. The key idea is to plan material supplies not only for confirmed projects (project-based management) but also for potential projects yet confirmed (supply-based management)".

Applying the model back to ICM, the group was able to show that a certain amount of planned inventory, if placed in the right locations within the supply chain, could reduce and stabilise the schedule of the projects and greatly improve the company's overall performance.

AEROSPACE AND DEFENSE PRODUCT DEVELOPMENT

Zhao's team has also studied the development of the Boeing 787 Dreamliner, which was massively delayed and incurred a cost overrun of at least US $10 billion. It was shown that the delays were caused by the unprecedented scale of outsourcing because



THE DEVELOPMENT CHAIN: A SUPPLY CHAIN FOR A DEVELOPMENT PROJECT

PROJECT-DRIVEN SUPPLY CHAINS (PDSCS) – INTEGRATING SUPPLY CHAIN PLANNING WITH PROJECT MANAGEMENT

OBJECTIVES

To develop and analyse new models and methods that can help firms integrate supply chain and project decisions. This project will combine recent results in supply chain management with those in project management, to advance our knowledge for effectively managing project-driven supply chains (PDSCs) under risk. The following specific issues will be addressed: joint optimisation of inventory/safety-stock policies and project planning/scheduling decisions in project supply chains; determining the boundary between project operations and supply chain operations; designing and analysing mechanisms for vendor management in PDSCs; and incorporating the risk of project delay and failure into supply chain management.

KEY COLLABORATORS

Adam Fleischhacker, PhD, Assistant Professor at the Alfred Lerner College of Business & Economics, University of Delaware; **Junmin Shi, PhD**, Assistant Professor at the J Mack Robinson College of Business, University of Georgia; **Xin Xu** and **Anh Ninh**, PhD candidates, Rutgers University, USA; **Ching-Yu Chen, PhD**, Assistant Professor at the College of Management, Tunghai University, Taiwan

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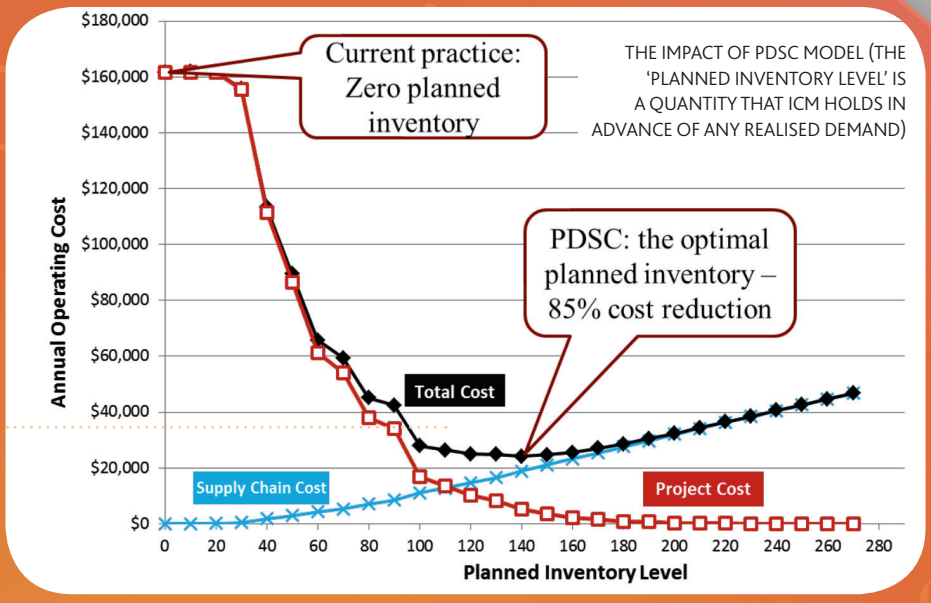
YAO ZHAO is an associate professor of Supply Chain and Project Management at Rutgers – the State University of New Jersey. He holds a PhD degree in Industrial Engineering and Management Sciences from Northwestern University, Evanston, Illinois. Zhao conducts research, teaches and consults in the interface between supply chain and project management, with applications in aerospace, pharmaceutical and construction industries.



THE IMPACT OF PDSC MODEL (THE 'PLANNED INVENTORY LEVEL' IS A QUANTITY THAT ICM HOLDS IN ADVANCE OF ANY REALISED DEMAND)

of the numerous lapses of the suppliers, who strove to optimise their own interests rather than those of the project. To align the suppliers' incentives, Boeing devised a risk-sharing partnership, which made the suppliers stakeholders with a share in the risk of delays: "What Boeing overlooked is that the risk-sharing partnership forces the firms to share the risk of controllable delays, such as careless errors and mismanagement, which is not fair because a firm should not be held responsible for others' mistakes. More importantly, sharing the risk of controllable delays encourages such delays and may lead to a suboptimal project performance on both time and cost".

To better align the incentives of the partners, Zhao suggests a new 'fair-sharing' partnership, which allows firms to share the risk of uncontrollable delays (such as unexpected technical issues) but assumes each firm the full responsibility for its own controllable delays. In this way, firms can reducd their risk and achieve investment diversification; meanwhile, they can align their incentives with those of the project. "Had Boeing utilised the fair-sharing partnership, a majority of the delays could have been avoided or at least mitigated because both Boeing and the suppliers would have taken a much greater responsibility for their delays and thus been much more committed than they were under the risk-sharing partnership," Zhao reflects.

CLINICAL TRIAL SUPPLY MANAGEMENT

In the third work stream of the project, the group has looked at clinical trials; the most costly and time consuming step of drug discovery, accounting for roughly 40 per cent of the total cost, and at least 50 per cent of the total time. In order to overcome one of the bottlenecks of clinical trials, the slow patient recruitment, many companies are increasingly going global in search of patients, leading to a new challenge in clinical supply management because of the complex global network of trial sites, random patient recruitments, a high requirement on drug availability at sites, and restrictive FDA regulations on the supply of the trial drugs. In an attempt to address this challenge, companies typically produce up to twice the amount of drugs required as a planned overage, and hold most of the inventory at trial sites to meet the requirements of patients, leading to a significant waste of precious materials.

In response, Zhao's group has constructed a new class of mathematical inventory model for clinical trial supply chains. The model calculates the optimal production quantity prior to the trial as well as where to place the inventory during the trial, to improve cost efficiency and increase drug availability. In contrast to the current practice, the model suggests holding only sufficient stock at sites to satisfy demand before the replenishment arrives, and holding a majority of inventory at depots and central warehouses so that it can be used to satisfy demand from different sites. "Testing the model on practice-based examples, we showed that the required inventory coverage can be reduced from the current 100-200 per cent to around 20-30 per cent, with improved drug availability at sites," Zhao enthuses.

> With outsourced work now accounting for 50 per cent or more of the revenue for projects in many industries, supply chain management has never been so important

NOVEL SOLUTIONS

With outsourced work now accounting for 50 per cent or more of the revenue for projects in many industries, supply chain management has never been so important. Zhao's research is integrating supply chain planning and project management into a solution for companies that streamlines material supplies with project activity planning, and leads to both reduced system-wide cost and project durations. The models, planning tools and insights his group is developing will help firms to coordinate project and material supply chain decisions in situations of uncertainty and will have applications in manufacturing, construction and product development.