



SPRING 2005: Volume 6, Number 2

## Airport Slot Auctions

Research by  
Michael Ball, George L. Donohue, and Karla Hoffman

IN THE ABSENCE OF SLOT CONTROLS, CURRENT POLICIES AT CONGESTED AIRPORTS IMPLICITLY ENCOURAGE AIRLINES TO OVER-SCHEDULE AND THEN CANCEL OR DELAY FLIGHTS. IF AIRLINE A ACTS RESPONSIBLY AND DOES NOT INCREASE ITS SCHEDULE AT A CONGESTED AIRPORT, IT WILL HAVE GIVES A COMPETITOR THE OPPORTUNITY TO SCHEDULE MORE FLIGHTS AT THAT AIRPORT; IF THAT COMPETITOR DECIDES TO INCREASE ITS SCHEDULE, AIRLINE A MAY LOSE MARKET SHARE. TO COMBAT THESE PROBLEMS ADMINISTRATIVE SLOT CONTROLS HAVE BEEN PUT IN PLACE AT CERTAIN AIRPORTS. THESE ADMINISTRATIVE RULES HAVE DISTORTED AIRLINE BEHAVIOR BY ENCOURAGING SLOT HOARDING AND INEFFICIENT USE OF SLOTS. MARKET-BASED APPROACHES TO SLOT ALLOCATION HAVE THE POTENTIAL TO ADDRESSES THESE PROBLEMS IN A MUCH MORE EFFECTIVE MANNER.

In a recent paper, "Auctions for the Safe, Efficient and Equitable Allocation of Airspace System Resources," Michael Ball, Orkand Corporation Professor of Management Science in Smith's department of decision and information technologies, with co-authors George L. Donohue and Karla Hoffman, professors at George Mason University, examine the possibilities of using auctions to allocate national airspace resources and thereby control congestion. The paper describes the possible use of market-based mechanisms for three levels of airspace resource allocation: the sale of long-term leases for airport arrival and departure slots, the exchange of such leases over shorter time frames via a secondary market and the very short term exchange of individual slots on a particular day of operations.

At most U.S. airports, there are no limitations set on the number of flight arrivals and departures scheduled by airlines. However, congestion problems led the FAA to impose slot controls at four high-density rule airports in 1969. The elimination of controls at O'Hare in 2003 led to significant delay increases that were eventually "solved" through a protracted series of negotiations between the FAA and the major airline players. A relaxation of the controls at LaGuardia in 2000-2001 led to intolerable levels of congestion that were resolved by a reduction in the number of slots and a reallocation of certain slots via a lottery.

These experiences clearly demonstrate the need for controls. But the current administrative allocation measures, which essentially provide incumbents infinite-lifetime slots, limit the ability of carriers to expand operations and make it difficult for new entrants to gain access. Ball argues that a market-based allocation system such as auctions would be more efficient, maximizing the benefits to the consumer and the economy by allocating the slots to the airlines that can generate the greatest benefit from their use. The transparency of an auction process also renders it less open to legal challenge.

Airlines have objected to auctions on the grounds that they would impose a new financial burden on airlines at a time when most are in financial distress. Ball argues that careful auction design could choose objectives that encourage new market entries and discourage monopolistic control over markets, rather than maximizing revenue. Auction revenues could be used to offset existing fees paid by the airlines and/or passengers, and any excess revenues could be used to enhance airspace capacity.

Although the FAA "owns" the airspace immediately above the runways and so has the authority to allocate the use of that airspace, any auction must take into

continued on page 4

# Integrated Scheduling of Production and Distribution Operations

Research by  
Zhi-long Chen

WITH INCREASING COMPETITION, COMPANIES IN THE COMPUTER INDUSTRY NORMALLY DELIVER ASSEMBLED AND PACKAGED COMPUTERS TO CUSTOMERS WITHIN TWO TO THREE BUSINESS DAYS. MANY COMPANIES DRIVEN BY DIRECT ORDERS, SUCH AS THOSE IN THE COMPUTER INDUSTRY AND FOOD CATERING SERVICES, PRODUCE AND DELIVER TO CUSTOMERS DIRECTLY WITHOUT HOLDING INTERMEDIATE INVENTORIES. THESE COMPANIES ARE CONFRONTED WITH THE DIFFICULT TASK OF OPTIMIZING BOTH THEIR CUSTOMER SERVICE LEVEL AS WELL AS TOTAL DISTRIBUTION COST.

Zhi-Long Chen, professor of decision and information technologies at the Smith School of Business, with George L. Vairaktarakis, professor of operations at the Weatherhead School of Management at Case Western Reserve University, examined an integrated scheduling model of production and distribution operations. They conclude that in many instances, companies can save on costs and improve customer service by implementing an integrated model instead of a sequential model where production and distribution operations are scheduled sequentially.

When production operations and distribution operations are linked together directly without any intermediate step customer service and cost become the chief concern of these companies. For the study, Chen and Vairaktarakis define customer service level as a function of the times when the jobs are delivered to the customers and the distribution cost as consisting of a fixed charge and a variable cost proportional to the total distance of the route taken by the shipment.

"Generally, the shorter the lead times, the higher the service level. However, to achieve shorter lead times, more delivery shipments may have to be used and this will inevitably result in higher distribution cost," notes Chen. Thus, companies will be forced to decide on how best to optimize the tradeoff between the distribution cost and the customer service level when coordinating their production and distribution operations.

Chen's research model aims to integrate production scheduling for job processing in the processing facility with distribution scheduling and routing for delivery of completed jobs from the processing facility to the customers. Little work has been done on the integration of production and distribution scheduling, although problems associated with these two operations have been extensively studied by other researchers. Past research has typically considered customer service as their objective without accounting for distribution costs or assumed that jobs can be delivered to their customers almost immediately without any transportation delay.

To empirically test their integrated scheduling model, Chen studied two classes of problems that are commonly used in practice: (1) customer service as measured by the average time when the jobs are delivered to the customers; and (2) customer service as measured by the maximum time when the jobs are delivered to the customers. Two machine configurations - single-machine and parallel machine - in the processing facility are considered.

Chen first modeled these two classes of problems as optimization models (or essentially mathematical problems), which comprise of an objective function to be optimized and several constraints such as production capacity and distribution capacity that need to be satisfied. Depending on how difficult the problems were, they proposed a set of algorithms that could enable them to find optimal solutions quickly for easy problems and utilized heuristics (i.e., algorithms which may not produce optimal solutions) for more difficult problems. For each heuristic, Chen analyzed theoretically how good the heuristic was by looking at its worst-case and asymptotic performance. He also conducted computational studies to

**"Generally, the shorter the lead times, the higher the service level. However, to achieve shorter lead times, more delivery shipments may have to be used and this will inevitably result in higher distribution cost."**

evaluate the average performance of the heuristic.

In addition to studying these two classes of problems, Chen examined the potential benefits that could be derived from the proposed integrated model as compared with a standard, sequential model where production and distribution operations are scheduled sequentially and separately. Chen observes that most companies are still using sequential approaches in their supply chain management because they are reasonably easier to implement. On the other hand, using an integrated approach may require the companies to facilitate coordination among their various departments, which can be demanding in practice. This part of the study provides evidence that significant benefits such as cost-saving and customer service improvement can be achieved by integration in many cases.

Chen and Vairaktarakis' work contributes to the current supply chain management literature by creating an integrated model that companies can use to achieve better customer service while reducing their supply chain costs. "I hope our work will be used by supply chain software providers such as SAP and Manugistics to enhance their business models and solution tools. In turn, companies who use supply chain decision support systems from these providers can benefit from the integrated approach," says Chen.

Chen and Vairaktarakis' work will appear in an article to be published in an upcoming issue of the Journal of Management Science.

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## KUDOS

**G. Anandalingam**, Ralph J. Tyser Professor of Management Science, chair of the decision and information technologies department and co-director of the Center for Electronic Markets and Enterprises, and Raghu Raghavan, assistant professor of management science, co-edited a special issue of the Journal of Management Science focused on electronic markets in March 2005.

**Sandor Boyson**, research professor and co-director of the Supply Chain Management Center, was the keynote speaker at both the Greater China Logistics Forum in Taipei in December 2004 and the Annual National E-Logistics Forum sponsored by the Finnish Government.

**Bruce Golden**, France-Merrick Professor of Management Science, was elected to the INFORMS Fellows Selection Committee for a term of three years.

**Lawrence A. Gordon**, Ernst & Young Alumni Professor of Managerial Accounting, and Martin Loeb, Deloitte & Touche LLP Faculty Fellow and professor of accounting and information assurance, were invited to be guest editors of a special issue of Information Systems Frontiers on the topic Economic Aspects of Information Security.

A paper coauthored by **Anne Marie Knott**, visiting assistant professor of management and organization, and Wharton PhD student Brian Wu, "Entrepreneurial Risk and Market Entry," received the annual Best Doctoral Paper award from the Small Business Administration's Office of Advocacy. The paper describes entrepreneurs as inherently overconfident, which helps cancel out their sensitivity to risk.

Smith's **marketing department** won best article awards from the Journal of Marketing for two separate articles: **Roland Rust**, David Bruce Smith Chair in Marketing, chair of the marketing department and director of the Center for Excellence in Service, won the MSI/Paul Root Award for the article with the greatest impact on marketing practice, for his article, "Return on Marketing: Using Customer Equity to Focus Marketing Strategy," co-authored by Katherine Lemon & Valarie Zeithaml. **Steve Vargo**, visiting professor of marketing, won the Harold H. Maynard Award for the article with the greatest impact on marketing theory; his paper is entitled "Evolving to a New Dominant Logic for Marketing," and co-authored with Robert Lusch.

Smith's **marketing department** was awarded the 2006 AMA Doctoral Consortium. **Gabriel Biehal**, associate

professor of marketing, **Brian Ratchford**, PepsiCo Chair in Consumer Research and **Roland Rust** will co-chair the Consortium.

**Roland Rust** was named the 2005 winner of the Distinguished Marketing Scholar Award by the Society for Marketing Advances. The award, honoring "exceptional scholarly achievements," will be presented at the annual SMA conference in November.

**Raghu Raghavan**, assistant professor of management science, has been appointed associate editor for the INFORMS Journal on Computing.

**Lemma Senbet**, William E. Mayer Chair in Finance and chair of the finance department, was a speaker at the annual conference of the World Bank in Dakar, Senegal, January 2005. This is the first time that such a meeting was held in Africa. He also participated in the ensuing workshop involving World Bank officials and African economic policy makers.

**M. Susan Taylor**, Dean's Professor of Human Resources, was appointed an International Visiting Research Fellow by AIM, England's Advanced Institute of Management Research, for 2005-2007.

# Distributor Game

Research by  
Thomas Corsi and Sandor Boyson

THE GLOBALIZATION OF SUPPLY CHAINS HAS CREATED NEW CHALLENGES FOR COMPANIES DEALING WITH LONGER TRANSPORTATION TIMES, BIG INVENTORIES, COMPLEX LOGISTICS AND THE HIGH COST OF COORDINATING INFORMATION, GOODS AND MONEY ACROSS THE GLOBE. A NEW WEB-BASED MANAGEMENT GAME AT THE SMITH SCHOOL IS THE FIRST OF A SERIES DEVELOPED TO ADDRESS SUPPLY CHAIN CHALLENGES SUCH AS GLOBALIZATION, THE INCREASING IMPORTANCE OF THE CUSTOMER ROLE AND MASS CUSTOMIZATION.

Supply chain managers today deal with an overwhelming flood of data, more than the manager can actually process. Despite this abundance of data, however, managers often do not have insight into the ripple effects of their decision-making on the supply chain. Thomas Corsi, Michelle E. Smith Professor of Logistics, and Sandor Boyson, research professor, who are co-directors of the Smith School Supply Chain Management Center, developed the Distributor Game, a management game designed to help students engage with supply chain challenges related to globalization and give students a feel for the 24/7 global environment of the supply chain world.

The Distributor Game has been played and tested with MBA students who specialized in supply chain management. "This game is anchored in a next-generation web simulation architecture, with distributed, real-time, multi-player access over the web and with embedded agents whose behaviors can be flexibly programmed. The architecture provides the opportunity to test out complex supply chain interactions and behaviors in ways we have not had the capacity to do before," says Boyson.

The game was tested with 32 Smith School MBA students who had access to a web portal that contained the instructions, content and background information for the game. The web server for this portal was based in Delft, The Netherlands. The players used a graphical interface downloaded from the web portal to control the distributors, enabling the players to always use the latest available graphical user interface without installing new software. No specific game software needed

to be installed on classroom computers.

The architecture of the game allows multiple game administrators to login at the same time from different computers, each of whom may focus on a different part of the game.

The scenario focused on a demand surge for laptop computers in the Asian region and a diminishing demand for desktop computers. Suppliers in the Asian region were modeled in such a way that they could not meet the increased demand of distributors, causing shift in demand from Asian distributors to suppliers in the U.S.

Players had to manage a variety of operational-level decision-making processes to keep their distributors in an economically healthy state. Players had to deal with business messages including quotes, orders, confirmations, and bills. Shipments and payments were handled by computational algorithms that supported the human players. It is possible to structure the game to focus on setting policies for more advanced agents that handle the business message on their behalf. The game's architecture also supports splitting the decision-making process between multiple players on a team, so that one focuses on inventory and one on sales, for example.

To better reflect the pace of the real-time global supply chain, the simulator allows for continuous play by looping over an eventlist while taking pre-defined steps in between. The controls allow the game operators to slow down or speed up a game, helping to emphasize and control the attention and focus of the players. The simulator is part of the DSOL suite, a set of Java-based simulation libraries.

A game may last several weeks or even over the course of a semester, where players can make decisions to manage companies at different times and from different locations. Continuous time advance, rather than turn-based play, allows players to interact with the game over a long period of time.

"The game is also used as a tool for research in areas like shared information in

**"The Distributor Game is a management game designed to help students engage with supply chain challenges related to globalization and give students a feel for the 24/7 global environment of the supply chain world."**

supply chains, where we find that the more shared information, the more efficient the supply chain," said Corsi.

Further research will focus on software services to make game instantiation easier and to further support development and use of simulation-based supply chain management games.

The Distributor Game was jointly developed by the Robert H. Smith School of Business and the Delft University of Technology, Delft, The Netherlands. "Training for Today's Supply Chains: An Introduction to the Distributor Game" was co-authored by Thomas Corsi, Sandor Boyson, Stijn-Pieter A. van Houten, lecturer of faculty and technology, policy and management, Delft University of Technology, and Alexander Verbraeck, Chair, Systems Engineering Section, Delft University of Technology, and presented at the 2005 Winter Simulation Conference in Orlando, Florida.

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## KNOWLEDGE SHARING

### Conferences and Symposia

#### Statistical Challenges in E-Commerce May 22-23, 2005

This interdisciplinary symposium featured workshops which identified problems and research questions related to empirical research in electronic commerce by bringing together researchers from information systems, statistics and related fields to help better understand how these various lines of work connect to one another and how, together, they can contribute to the modernization and enhancement of empirical research methods for electronic commerce and our digital society at large.

■ Sponsored by the Center for Electric Markets and Enterprises and the University of Maryland Statistics Consortium.

#### Financial Information Systems and Cybersecurity: A Public Policy Perspective May 26, 2005

Information security is a subject of increasing interest in a world where business is driven by data. The Forum on Financial Information Systems and Cybersecurity featured discussions by academicians and subject matter experts from around the world.

■ Co-Coordinator: Lawrence A. Gordon, and Martin P. Loeb, University of Maryland, Robert H. Smith School of Business, and William Lucyshyn, University of Maryland, School of Public Policy

#### Imagining Tomorrow's Internet: The Convergence of Digital and Social Networks Smith's Fifth Annual Netcentricity Conference April 29, 2005

Smith's Fifth Annual Netcentricity Conference featured thought leaders

and cutting-edge research at the intersection of digital and social networks. Speakers included executives and researchers from Amazon.com, the Institute for Social and Economic Research and Policy at Columbia University, the Weatherhead School of Management at Case University, Health A to Z, and Washington Technology Partners, among others. The program featured panels on virtual communities in health care, open source networks, and global coordination of digital and social networks.

■ Sponsored by the Center for Electronic Markets and Enterprises, Robert H. Smith School of Business.  
■ See highlights from the 2005 Netcentricity Conference on our Web site at [www.rhsmith.umd.edu/netconference](http://www.rhsmith.umd.edu/netconference).

#### Entrepreneurship Within and Across Borders April 22-23, 2005

The first Smith Entrepreneurship Research Conference, "Entrepreneurship Within and Across Borders," brought together some of the world's leading scholars in the field of entrepreneurship to share their research, ideas and thoughts on topics such as entrepreneurial cognitions and behavior, learning and entrepreneurship, entrepreneurial ecosystems, new venture business models and entrepreneurship in a global context.

■ Sponsored by the United States Department of Education and the Robert H. Smith School of Business.  
■ Conference co-chairs: Anil Gupta and Violina Rindova, University of Maryland, Robert H. Smith School of Business.  
■ See highlights from this conference, including streaming video and presentations, at [www.rhsmith.umd.edu/entrepconf](http://www.rhsmith.umd.edu/entrepconf).

**Supply Chain Management**

An integrated model for scheduling production and distribution can result in cost savings and improved customer service for companies driven by direct orders.

**RESEARCH BY**  
*Zhi-long Chen*

**Strategic Games**

The Distributor Game uses web-enabled supports training and learning for today's supply chains.

**RESEARCH BY**  
*Thomas Corsi and Sandor Boyson*

**Transportation**

Market-driven mechanisms like auctions may be a more effective way to allocate airport slots than administrative processes.

**RESEARCH BY**  
*Michael Ball*



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**Airport Slot Auctions**  
continued from page 1

account the physical necessities—gates, baggage terminals—which are owned by the airport and which often have been developed at the expense of a particular airline. The distribution of aircraft types using the slots also impacts the capacity of the system, so the number of arrival slots to be auctioned may vary depending on the type of aircraft that would use them. Thus, when determining winners, the auctioneer must assure that the physical limitations of the airport are considered when choosing a feasible allocation set. Property rights must also be carefully specified in an auction—specifically, what it means to own a slot must be clarified. This question can be challenging when one considers the variety of disruptions that can occur on a given day within the national airspace system.

Ball recommends a transition period that moves the airline industry from an administrative process to a market-clearing process, starting with the nation's most congested airports, like LaGuardia, during its most congested time periods. The implicit property rights of incumbents could be taken into account through a system of vouchers or through an allocation of limited term leases during a transition period.

Although it might be appropriate to reduce flight operations to reduce delays, the number of passengers serviced during these time periods may remain the same or even increase, because airlines will choose to use larger aircraft with a greater number of seats. Flights for which there is less demand will likely move to alternate time periods where it makes sense to have smaller planes in service.

Ball and Hoffman are now leading a large project funded by the FAA and the U.S. Department of Transportation to explore the use of market mechanisms for slot allocation at LaGuardia, sponsored by NEXTOR, the National Center of Excellence for Aviation Operations Research, which Ball co-directs. Two strategic simulations have been performed comparing administrative actions, congestion pricing and slot auctions, the first in November 2004 and the second in February 2005. Representatives of the federal government, various airport authorities and the airline industry participated in both simulations.

"Auctions for the Safe, Efficient and Equitable Allocation of Airspace System Resources" was co-authored by Michael Ball, George L. Donohue, and Karla Hoffman. Continued research, including further strategic simulations, are planned.

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**NEW CENTER OPENS AT SMITH**

The Robert H. Smith School of Business has established the Center for Health Information and Decision Systems (CHIDS), a research and development center focusing on the use of advanced information technologies in the health care system's business processes and management systems.

CHIDS is a collaborative effort drawing on the expertise of the Decision and Information Technologies (D&IT) department at the Smith School, the University of Maryland Medical Center, University Hospital, and other resources in the University of Maryland network. CHIDS will work to improve the delivery of health care with researched solutions that impact safety, quality, access, efficiency, and return on investment.

"The potential savings and other benefits of fully moving the health care industry into the digital age are substantial but so are the challenges," said Howard Frank, dean of the Robert H.

Smith School of Business. "The Smith School's Center for Health Information and Decision Systems comes at a critical time and answers significant gaps in current health information technology education and research."

The primary purpose of CHIDS is to encourage and sponsor research related to health care IT. The center will also:

- Offering cutting edge education and opportunities for Smith School students to solve real-world problems related to the development, implementation or use of technology and analytical tools in a health care setting;
- Hosting industry meetings, seminars and forums to encourage knowledge exchange on the most important issues facing the industry with the recent adoption of IT into business processes;
- Disseminating knowledge and best practices through white papers, journals and publications.