

# **Operations in Financial Services: Processes, Technologies, and Risks**

**Other titles in Foundations and Trends® in Technology, Information and Operations Management**

*Designing Effective Supply Chains in Strategic Alignment with Demand Characteristics and Market Requirements*

Mojtaba Mahdavi and Tava Lennon Olsen

ISBN: 978-1-68083-268-6

*Last-mile Supply Network Distribution in Omnichannel Retailing: A Configuration-Based Typology*

Stanley Frederick W. T. Lim, Elliot Rabinovich, Dale S. Rogers, and Timothy M. Laseter

ISBN: 978-1-68083-184-9

*Performance Improvement in Health Care Organizations*

Hummy Song and Anita Tucker

ISBN: 978-1-68083-192-4

*Integrated Modeling for Location Analysis*

Ho-Yin Mak and Zuo-Jun Max Shen

ISBN: 978-1-68083-190-0

# Operations in Financial Services: Processes, Technologies, and Risks

---

**Michael Pinedo**

Stern School of Business, New York University, USA

**Yuqian Xu**

College of Business  
University of Illinois at Urbana-Champaign, USA

**now**

the essence of knowledge

Boston — Delft

# Foundations and Trends<sup>®</sup> in Technology, Information and Operations Management

*Published, sold and distributed by:*

now Publishers Inc.  
PO Box 1024  
Hanover, MA 02339  
United States  
Tel. +1-781-985-4510  
[www.nowpublishers.com](http://www.nowpublishers.com)  
[sales@nowpublishers.com](mailto:sales@nowpublishers.com)

*Outside North America:*

now Publishers Inc.  
PO Box 179  
2600 AD Delft  
The Netherlands  
Tel. +31-6-51115274

The preferred citation for this publication is

M. Pinedo and Y. Xu. *Operations in Financial Services: Processes, Technologies, and Risks*. Foundations and Trends<sup>®</sup> in Technology, Information and Operations Management, vol. 11, no. 3, pp. 223–342, 2017.

ISBN: 978-1-68083-337-9

© 2017 M. Pinedo and Y. Xu

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, mechanical, photocopying, recording or otherwise, without prior written permission of the publishers.

Photocopying. In the USA: This journal is registered at the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923. Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by now Publishers Inc for users registered with the Copyright Clearance Center (CCC). The 'services' for users can be found on the internet at: [www.copyright.com](http://www.copyright.com)

For those organizations that have been granted a photocopy license, a separate system of payment has been arranged. Authorization does not extend to other kinds of copying, such as that for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale. In the rest of the world: Permission to photocopy must be obtained from the copyright owner. Please apply to now Publishers Inc., PO Box 1024, Hanover, MA 02339, USA; Tel. +1 781 871 0245; [www.nowpublishers.com](http://www.nowpublishers.com); [sales@nowpublishers.com](mailto:sales@nowpublishers.com)

now Publishers Inc. has an exclusive license to publish this material worldwide. Permission to use this content must be obtained from the copyright license holder. Please apply to now Publishers, PO Box 179, 2600 AD Delft, The Netherlands, [www.nowpublishers.com](http://www.nowpublishers.com); e-mail: [sales@nowpublishers.com](mailto:sales@nowpublishers.com)

**Foundations and Trends<sup>®</sup> in Technology,  
Information and Operations Management**  
Volume 11, Issue 3, 2017  
**Editorial Board**

**Editor-in-Chief**

**Charles Corbett**

UCLA, Anderson School of Management  
United States

**Editors**

Fernando Bernsteini

*Duke University*

Cheryl Gaimon

*Georgia Institute of Technology*

Uday Karmarkar

*University of California, Los Angeles*

Sunder Kekre

*Carnegie Mellon University*

Panos Kouvelis

*Washington University*

Michael Lapré

*Vanderbilt University*

Karl Ulrich

*University of Pennsylvania*

Luk van Wassenhove

*INSEAD*

## Editorial Scope

### Topics

Foundations and Trends<sup>®</sup> in Technology, Information and Operations Management publishes survey and tutorial articles in the following topics:

- B2B Commerce
- Business Process Engineering and Design
- Business Process Outsourcing
- Capacity Planning
- Competitive Operations
- Contracting in Supply Chains
- E-Commerce and E-Business Models
- Electronic markets, auctions and exchanges
- Enterprise Management Systems
- Facility Location
- Information Chain Structure and Competition
- International Operations
- Marketing/Manufacturing Interfaces
- Multi-location inventory theory
- New Product & Service Design
- Queuing Networks
- Reverse Logistics
- Service Logistics and Product Support
- Supply Chain Management
- Technology Management and Strategy
- Technology, Information and Operations in:
  - Automotive Industries
  - Electronics manufacturing
  - Financial Services
  - Health Care
  - Media and Entertainment
  - Process Industries
  - Retailing
  - Telecommunications

### Information for Librarians

Foundations and Trends<sup>®</sup> in Technology, Information and Operations Management, 2017, Volume 11, 4 issues. ISSN paper version 1571-9545. ISSN online version 1571-9553. Also available as a combined paper and online subscription.

# Contents

---

<b>Preface</b>	<b>2</b>
<b>1 Introduction</b>	<b>5</b>
1.1 Importance of Financial Services . . . . .	6
1.2 Operational Characteristics of Financial Services . . . . .	7
1.3 Process Drivers and Operational Measures . . . . .	12
1.4 Operational Risk Aspects of Financial Services . . . . .	16
<b>2 Operations Management in Financial Services</b>	<b>22</b>
2.1 Product Design and Testing . . . . .	24
2.2 Process Design and Reliability . . . . .	25
2.3 Process Management and Quality Control . . . . .	32
2.4 Analytical Modeling in Process Design and Management . . . . .	37
<b>3 Online and Mobile Financial Services</b>	<b>40</b>
3.1 Channel Operations . . . . .	41
3.2 Customer Behavior . . . . .	43
3.3 Online and Digital Fraud . . . . .	46
<b>4 Operational Risk in Financial Services</b>	<b>50</b>
4.1 Model Risk . . . . .	51
4.2 IT Related Risks and Cyber Security . . . . .	53

4.3	Behavioral Issues - Incentives and Moral Hazard . . . . .	56
4.4	Remoteness Factors . . . . .	61
4.5	Exogenous Events . . . . .	63
<b>5</b>	<b>Data Analytics</b>	<b>66</b>
5.1	Data Gathering and Supervisory Control . . . . .	66
5.2	Multifactor analysis . . . . .	70
5.3	Data Mining and Machine Learning . . . . .	72
5.4	Bank Client Relationship Analytics . . . . .	80
5.5	Workforce Analytics . . . . .	84
<b>6</b>	<b>Conclusions and Directions for Future Research</b>	<b>86</b>
6.1	Current Practice of Operations Management in Finance . .	86
6.2	Future Research Directions . . . . .	87
	<b>References</b>	<b>92</b>



# Operations in Financial Services: Processes, Technologies, and Risks

Michael Pinedo<sup>1</sup> and Yuqian Xu<sup>2</sup>

<sup>1</sup>*Stern School of Business, New York University*

<sup>2</sup>*College of Business, University of Illinois at Urbana-Champaign*

---

## ABSTRACT

This monograph is an attempt to establish a framework for Operations in Financial Services as a research area from an Operations Management perspective. Operations in Financial Services has not developed itself yet as a well-defined research area within the Operations Management community. It has been touched upon by researchers from various different disciplines, including Operations Management, Statistics, Information Technology, Finance, and Marketing. However, each discipline has a different perspective on what the important issues are and the various disciplines are often at odds with one another. This monograph has been written from an Operations Management perspective.

---

## Preface

---

This monograph is an attempt to establish a framework for Operations in Financial Services as a research area from an Operations Management perspective. Operations in Financial Services has not developed itself yet as a well-defined research area within the Operations Management community. It has been touched upon by researchers from various different disciplines, including Operations Management, Statistics, Information Technology, Finance, and Marketing. However, each discipline has a different perspective on what the important issues are and the various disciplines are often at odds with one another. This monograph has been written from an Operations Management perspective. After a lot of discussion with colleagues of ours from the various different research communities, we settled on the current structure and Table of Contents.

In the first section we present an introduction and provide an overview of the monograph. In the second section, we establish links between the current state of the art in relevant areas of Operations Management and Operations Research and three of the more important aspects of operations in financial services, namely (i) financial product design and testing, (ii) process delivery design, and (iii) process delivery management.

The third section focuses on the current issues that are important in the financial services operations area. These issues center primarily on mobile online banking and trading in a global environment. Several

reviewers were of the opinion that if such issues were not discussed, a monograph on Operations in Financial Services would not be of any interest.

The following section discusses operational risk aspects of Financial Services. These topics are just as important as, for example, Total Quality Management (TQM) in micro-electronics manufacturing. Anyone working on TQM in manufacturing knows how important this field is. But it is only lately that people in the finance world have started to realize how important operational risk is. And operational risk in finance has not yet received the research attention that TQM has received in manufacturing.

Since Big Data and Machine Learning have, in many disciplines, become very much in vogue lately, it is more than appropriate to have one section on Data Analytics, which includes Machine Learning. It seems that Data Analytics will have a huge impact on financial operations in the near future and that it will become an important area of academic research.

In the final section we conclude with a discussion on research directions that may become of interest in the future.

We hope that this monograph will turn out to be useful for the operations management community from a teaching as well as from a research perspective. Hopefully, instructors will be able to use this monograph in a course on Service Operations (or maybe even for a more focused course on Operations in Financial Services). For researchers in this area, this monograph may be useful as well since it may provide an overview of the general area and some indication where a particular research problem would fit in within the overall framework.

We are very grateful to the many people who have gone through preliminary drafts of this manuscript and who have provided us with useful feedback. We are especially grateful to Manos Hatzakis (Merrill Lynch) and Suresh Nair (Univ. of Connecticut); several subsections of this monograph have benefited a great deal from ideas presented in the survey paper by Hatzakis *et al.* (2010). Several other colleagues of ours, in academia as well as in industry, have also provided us with many useful comments, namely Stephen Brown (Stern School of Business at

NYU), Marcelo Cruz (Ocwen Financial), Connor Farley (AQR), Stephen Mellas (AQR), Cyrus Mohebbi (Morgan Stanley), Pavel Shevchenko (Macquarie University), and Gary Thompson (Hexagon).

New York, summer 2017

Michael Pinedo  
Yuqian Xu

## References

---

- Alexander, C. 2008. “statistical models of operational loss”. *Handbook of Finance*.
- Alexandre, C. and J. Balsa. 2016. “Integrating Client Profiling in an Anti-money Laundering Multi-agent Based System”. In: *New Advances in Information Systems and Technologies*. AISC Vol. 11, A. Rocha, A. M. Correia, H. Adeli, L. P. Reis, M. Mendonca Teixeira eds., Springer. 931–941.
- Allen, L. and T. G. Bali. 2007. “Cyclicalities in catastrophic and operational risk measurements”. *Journal of Banking & Finance*. 31(4): 1191–1235.
- Allen, L. and A. Saunders. 2004. “Incorporating Systemic Influences Into Risk Measurements: A Survey of the Literature”. *Journal of Financial Services Research*. 26(2): 161–191.
- Alwan, L. C. and H. V. Roberts. 1988. “Time-Series Modeling for Statistical Process Control”. *Journal of Business & Economic Statistics*. 6(1): 87–95.
- Amos, J. P. 2013. “Insider trading detection”. US Patent US20130103561 A1, Assignee: Redkite Financial Markets Limited.
- Anand, K. S., M. F. Pac, and S. Veeraraghavan. 2010. “Quality-Speed Conundrum: Trade-Offs In Customer-Intensive Services”. *Management Science*. 57(1): 40–56.

- Anderson, E. W., C. Fornell, and R. T. Rust. 1997. "Customer Satisfaction, Productivity, and Profitability: Differences between Goods and Services". *Marketing Science*. 16(2): 129–145.
- Angell, L. C. and R. D. Klassen. 1999. "Integrating environmental issues into the mainstream: an agenda for research in operations management". *Journal of Operations Management*. 17(5): 575–598.
- Ascarza, E., S. A. Neslin, O. Netzer, Z. Anderson, P. S. Fader, S. Gupta, B. G. S. Hardie, A. Lemmens, B. Libai, D. Neal, F. Provost, and R. Schrift. 2017. "In Pursuit of Enhanced Customer Retention Management: Review, key issues, and future directions". Columbia Business School Research Papers No. 17-16.
- Babus, S. A., W. Min, B. Ramachandran, and J. Rosenoer. 2007. "Method and apparatus for pre-emptive operational risk management and risk discovery". US Patent US20070208600 A1.
- Bali, T. G. 2007. "A Generalized Extreme Value Approach to Financial Risk Management". *Journal of Money, Credit and Banking*. 39(7): 1613–1649.
- Bank for International Settlements, B. B. S. C. 2009. "Results from the 2008 Loss Data Collection Exercise for Operational Risk".
- Barach, P. and S. D. Small. 2000. "Reporting and Preventing Medical Mishaps: Lessons from Non-Medical Near-Miss Reporting Systems". *British Medical Journal*. 320: 759–763.
- Barlow, R. and F. Proschan. 1975. *Statistical Theory of Reliability and Life Testing - Probability Models*. Holt, Rinehart and Winston, New York.
- Barr, D. G. and K. Cuthbertson. 1991. "Neoclassical Consumer Demand Theory and The Demand for Money". *Economic Journal*. 101(407): 855–876.
- Bartel, A. P. 2004. "Human Resource Management and Organizational Performance: Evidence from Retail Banking". *Industrial and Labor Relations Review*. 57(2): 181–203.
- Barten, A. P. 1977. "The Systems of Consumer Demand Functions: A Review". *Econometrica*. 45(1): 23–51.
- Basel Committee On Banking Supervision. Jan 2001. "Operational Risk".

- Basel Committee on Banking Supervision. Jun 2011b. "Operational risk - Supervisory Guidelines for the advanced Measurement Approaches".
- Basel Committee on Banking Supervision. 2006. "The First Pillar - Minimum Capital Requirements". *BIS consultative document*.
- Basel Committee on Banking Supervision. 2008. "Range of Practices and issues in economic capital modelling". *Bank for International Settlements*. Aug.
- Basel Committee on Banking Supervision. 2011. "Principles for the Sound Management of Operational Risk". BIS consultative document.
- Basel Committee on Banking Supervision, B. f. I. S. 2011. "Operational risk-Supervisory Guidelines for the advanced Measurement Approaches".
- Bazzarello, D., B. Crielaard, F. Piacenza, and A. Soprano. 2006. "Modeling Insurance Mitigation on Operational Risk Capital". *Journal of Operational Risk*. 1(1): 57-65.
- Becker, K. and M. Smidt. 2016. "A risk perspective on human resource management: A review and directions for future research". *Human Resource Management Review*. 26(2): 149-165.
- Beitz, M. and M. Ehrhardt. 2011. "A New Method of Stress Testing Investment Products". *The Risk of Investment Products*. M. CS. Wong (ed.), 225-240.
- Belk, R. W. 1975. "Situational Variables and Consumer Behavior". *Journal of Consumer Research*. 2(3): 157-164.
- Belk, R. W., M. Wallendorf, and J. F. Sherry. 1989. "The Sacred and the Profane in Consumer Behavior: Theodicy on the Odyssey". *Journal of Consumer Research*. 16(1): 1-38.
- Bellotti, T. and J. Crook. 2009. "Credit scoring with macroeconomic variables using survival analysis". *Journal of the Operational Research Society*. 60(12): 1699-1707.
- Ben-Tal, A. and E. Hochman. 1972. "More Bounds on the Expectation of a Convex Function of a Random Variable". *Journal of Applied Probability*. 9(4): 803-812.
- Bergman, B. 1985. "On Reliability Theory and Its Applications". *Scandinavian Journal of Statistics*. 12(1): 1-41.

- Bharath, S. T., S. Dahiya, A. Saunders, and A. Srinivasan. 2007a. "Lending relationships and loan contract terms". *Review of Financial Studies*. 24(4): 1141–1203.
- Bharath, S., S. Dahiya, A. Saunders, and A. Srinivasan. 2007b. "So what do I get? The bank's view of lending relationships". *Journal of Financial Economics*. 85(2): 368–419.
- Bhatia, S., R. Bajaj, and S. Hazari. 2016. "Analysis of credit card fraud detection techniques". *International Journal of Science and Research*. 2(1): 105–106.
- Bhattacharyya, S., S. Jha, K. K. Tharakunnel, and J. C. Westland. 2011. "Data mining for credit card fraud: A comparative study". *Decision Support Systems*. 50(3): 602–613.
- Bish, E. K. and Q. Wang. 2004. "Optimal investment strategies for flexible resources, considering pricing and correlated demands". *Operations Research*. 52(6): 954–964.
- Bish, E. K., X. Zeng, J. Liu, and D. R. Bish. 2012. "Comparative statics analysis of multiproduct newsvendor networks under responsive pricing". *Operations Research*. 60(5): 1111–1124.
- Black, F. and R. Litterman. 1992. "Global Portfolio Optimization". *Financial Analysts Journal*. 48(5): 28–43.
- Boateng, H., D. R. Adam, A. F. Okoe, and T. Anning-Dorson. 2016a. "Assessing the determinants of internet banking adoption intentions: A social cognitive theory perspective". *Computers in Human Behavior*. 65: 468–478.
- Boateng, H., D. R. Adam, A. F. Okoe, and T. Anning-Dorson. 2016b. "Assessing the determinants of internet banking adoption intentions: A social cognitive theory perspective". *Computers in Human Behavior*. 65: 468–478.
- Bocker, K. and C. Kluppelberg. 2010. "Multivariate Models for Operational Risk". *Quantitative Finance*. 10(8): 855–869.
- Boecker, K. and C. Klueppelberg. 2012. "Operational VaR - A Closed Form Approximation". Technical Report.
- Bolton, R. J. and D. J. Hand. 2002. "Statistical fraud detection: A review". *Statistical Science*: 235–249.



- Boudreau, J. W. 2004. "Organizational behavior, strategy, performance, and design in management science". *Management Science*. 50(11): 1463–1476.
- Boudreau, J. W., W. Hopp, J. O. McClain, and L. J. Thomas. 2003. "On the interface between operations and human resources management". *Manufacturing and Services Operations Management*. 5(3): 179–202.
- Bowen, D. E. 1986. "Managing Customers as Human Resources in Service Organizations". *Human Resource Management*. 25(3): 371–383.
- Brown, I., L. Edwards, and C. Marsden. 2009. "Information Security and Cybercrime". In: *Law and the Internet, 3rd Edition*. Ed. by L. Edwards and C. Waelde. Hart, Oxford. 671–692.
- Buell, R. W., D. Campbell, and F. X. Frei. 2010. "Are Self-Service Customers Satisfied or Stuck?" *Production and Operations Management*. 19(19): 679–697.
- Buraschi, A. and F. Corielli. 2005. "Risk Management Implications of Time-Inconsistency: Model Updating and Recalibration of No-Arbitrage Models". *Journal of Banking and Finance*. 29(11): 2883–2907.
- Burnham, K. P. and D. R. Anderson. 2002. *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*. Springer-Verlag.
- Buzacott, J. A. and R. Q. Zhang. 2004. "Inventory Management with Asset-Based Financing". *Management Science*. 50(9): 1274–1292.
- Calabrese, A. 2012. "Service Productivity and Service Quality: A Necessary Trade-Off?" *International Journal of Production Economics*. 135(2): 800–812.
- Calomiris, C. and T. Pornrojngkool. 2009. "Relationship banking and the pricing of financial services". *Journal of Financial Services Research*. 35(3): 189–224.
- Cambra-Fierro, J., W. A. Kamakura, I. Melero-Polo, and F. J. Sese. 2016. "Are multichannel customers really more valuable? An analysis of banking services". *International Journal of Research in Marketing*. 33(1): 208–212.

- Campbell, D. E. 2006. *Incentives: Motivation and the Economics of Information (2nd Edition)*. Cambridge, UK: Cambridge University Press.
- Campbell, D. and F. Frei. 2010. "Cost Structure, Customer Profitability, and Retention Implications of Self-Service Distribution Channels: Evidence from Customer Behavior in an Online Banking Channel". *Management Science*. 56(1): 4–24.
- Caspi, A. and P. Gorsky. 2006. "Online deception: Prevalence, motivation, and emotion". *CyberPsychology & Behavior*. 9(1): 54–59.
- Cassenti, D. N., T. D. Kelley, and R. A. Carlson. 2010. "Modeling the Workload-Performance Relationship". *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. 54(19): 1684–1688.
- Castermans, G., D. Martens, T. V. Gestel, B. Hamers, and B. Baensens. 2010. "An Overview and Framework for PD Backtesting and Benchmarking". *The Journal of the Operational Research Society*. 61(3): 359–373.
- Chan, P. K., W. Fan, A. Prodromidis, and S. J. Stolfo. 1999. "Distributed Data Mining in Credit Card Fraud Detection". *IEEE Intelligent Systems*. 14(6): 67–74.
- Chapelle, A., Y. Crama, G. Hübner, and J. P. Peters. 2008. "Practical methods for measuring and managing operational risk in the financial sector: a clinical study". *Journal of Banking and Finance*. 32(6): 1049–1061.
- Chase, R. B. 1978. "Where does the customer fit in a service operation?" *Harvard Business Review*. 56(6): 138–139.
- Chavez-Demoulin, V., P. Embrechts, and J. Neslehova. 2006. "Quantitative models for operational risk: Extremes, dependence and aggregation". *Journal of Banking & Finance*. 30(10): 2635–2658.
- Chen, J., Y. Tao, H. Wang, and T. Chen. 2015. "Big data based fraud risk management at Alibaba". *The Journal of Finance and Data Science*. 1(1): 1–10.
- Chen, Y. and N. D. Singpurwalla. 1997. "Unification of Software Reliability Models by Self-Exciting Point Processes". *Advances in Applied Probability*. 29(2): 337–352.

- Cheng, F., D. Gamarnik, N. Jengte, W. Min, and B. Ramachandran. 2007. "Modeling Operational Risks in Business Processes". *Journal of Operational Risk*. 2(2): 73–99.
- Chernobai, A. S., S. T. Rachev, and F. J. Fabozzi. 2007. *Operational Risk: A Guide to Basel II Capital Requirements, Models, and Analysis*. New York: John Wiley and Sons.
- Chernobai, A., P. Jorion, and F. Yu. 2011. "The determinants of operational risk in US financial institutions". *Journal of Financial and Quantitative Analysis*. 46(6): 1683–1725. Cambridge University Press.
- Chernobai, A., C. Menn, S. Truck, and S. T. Rachev. 2004. "A Note on the Estimation of the Frequency and Severity Distribution of Operational Losses". *Mathematical Scientist*. 30(2): 87–97.
- Chod, J. and N. Rudi. 2005. "Resource flexibility with responsive pricing". *Operations Research*. 53(3): 532–548.
- Choi, S.-K., R. Grandhi, and R. Canfield. 2010. *Reliability-Based Structural Design*. New York: Springer.
- Chong, A. Y., K. Ooi, B. Lin, and B. Tan. 2010. "Online banking adoption: an empirical analysis". *International Journal of Bank Marketing*. 28(4): 267–287.
- Chouhan, R. 2014. "Cyber Crimes: Evolution, Detection and Future Challenges". *IUP Journal of Information Technology*. 10(1): 48–55.
- Clemons, E. K. and M. C. Row. 1992. "Information Technology and Industrial Cooperation: The Changing Economics of Coordination and Ownership". *Journal of Management Information Systems*. 9(2): 9–28.
- Coelho, F. and C. Easingwood. 2003. "Multiple channel structures in financial services: A framework". *Journal of Financial Services Marketing*. 8(1): 22–34.
- Collier, D. A. and S. M. Meyer. 1998. "A service positioning matrix". *International Journal of Operations & Production Management*. 18(12): 1223–1244.
- Collins, H. 2010. "Harmonisation by Example: European Laws against Unfair Commercial Practices". *The Modern Law Review*. 73(1): 89–118.

- Comelli, M., P. Fenies, and N. Tchernev. 2008. "A combined financial and physical flows evaluation for logistic process and tactical production planning: Application in a company supply chain". *International Journal of Production Economics*. 112(1): 77–95.
- Cooper, W. L. 2002. "Asymptotic behavior of an allocation policy for revenue management". *Operations Research*. 50(4): 720–727.
- Cope, E. and A. Labbi. 2008/9. "Operational loss scaling by exposure indicators: evidence from the ORX database". *The Journal of Operational Risk*. 3(4): 25–45.
- Cowing, M. M., M. E. Pate-Cornell, and P. W. Glynn. 2004. "Dynamic Modeling of the Tradeoff between Productivity and Safety in Critical Engineering Systems". *Reliability Engineering and System Safety*. 86: 269–284.
- Cruz, M. 2002. *Modeling, Measuring and Hedging Operational Risk*. New York: John Wiley & Sons.
- Cruz, M., G. W. Peters, and P. V. Shevchenko. 2015. *Fundamental aspects of operational risk and insurance analytics: A handbook of operational risk*. John Wiley & Sons, New York.
- Cruz, M. and M. Pinedo. 2008. "Total Quality Management and Operational Risk in the Service Industry". *Tutorials in Operations Research, INFORMS*. (Chapter 7): 154–169.
- Dahiya, S., M. Puri, and A. Saunders. 2001. "Bank borrowers and loan sales: New evidence on the uniqueness of bank loans". *Journal of Business*. 76(4): 563–582.
- Dahiya, S., A. Saunders, and A. Srinivasan. 2003. "Financial distress and bank lending relationships". *The Journal of Finance*. 58(1): 375–399.
- Das, T. K. 1974. "Administrative Remoteness in Branch Banking". *Economic and Political Weekly*. 9(21): M43–M52.
- Delamaire, L., H. Abdou, and J. Pointon. 2009. "Credit card fraud and detection techniques: A review". *Banks and Bank Systems*. 4(2): 57–68.
- Deloitte. 2013. *Directors, CFOs Share Views on Risk, but Diverge on Time Spent*. URL: <http://deloitte.wsj.com/riskandcompliance/2013/04/16/> (accessed on ).

- Dillon, R. L. and C. H. Tinsley. 2005. "Interpreting Near-Miss Events". *Engineering Management Journal*. 17(4): 25–29.
- Dillon, R. L. and C. H. Tinsley. 2008. "How Near-Misses Influence Decision-Making under Risk: A Missed Opportunity for Learning". *Management Science*. 54(8): 1425–1440.
- Dismuke, C. and V. Sena. 2001. "Is there a Trade-Off between Quality and Productivity? The Case of Diagnostic Technologies in Portugal". *Annals of Operations Research*. 107: 101–116.
- Diwas, K. and C. Terwiesch. 2012. "An econometric analysis of patient flows in the cardiac intensive care unit". *Manufacturing and Services Operations Management*. 14(1): 50–65.
- Doyle, B., R. Mefford, and N. Tay. 2010. "What Financial Risk Managers Can Learn from Six Sigma Quality Programs". *USF Scholarship Repository, Finance and Economics*: paper 2.
- Drucker, S. and M. Puri. 2005. "On the benefits of concurrent lending and underwriting". *The Journal of Finance*. 60(6): 2763–2799.
- Drucker, S. and M. Puri. 2007. "On loan sales, loan contracting and lending relationships". *Review of Financial Studies*. 22(2): 2835–2872.
- Duda, R. O., P. E. Hart, and D. G. Stork. 2000. *Pattern Classification*. 2nd Edition. New York: John Wiley & sons.
- Duran, R. E. 2013. *Financial Services Technology: Processes, Architecture, and Solutions*. Cengage Learning.
- Easley, D., M. L. de Prado, and M. O'Hara. 2010. "The Microstructure of the 'Flash Crash': Flow Toxicity, Liquidity Crashes and the Probability of Informed Trading". *The Journal of Portfolio Management*. 37(2): 118–128.
- Elsas, R. 2005. "Empirical determinants of relationship lending". *Journal of Financial Economics*. 14(1): 32–57.
- Elsinger, H., A. Lehar, and M. Summer. 2006. "Risk assessment for banking systems". *Management Science*. 52(9): 1301–1314.
- Estrella-Ramon, A., M. Sánchez-Pérez, and G. Swinnen. 2016a. "How customers' offline experience affects the adoption of online banking". *Internet Research*. 26(5): 1072–1092.

- Estrella-Ramon, A., M. Sánchez-Pérez, and G. Swinnen. 2016b. "How customers' offline experience affects the adoption of online banking". *Internet Research*. 26(5): 1072–1092.
- Faroughian, F. F., S. P. Kalafatis, L. Ledden, P. Samoue, and M. H. Tsogas. 2012. "Value and risk in business-to-business e-banking". *Industrial Marketing Management*. 41(1): 68–81.
- Feitelson, G. 2014. *Workload modeling for computer systems performance evaluation*. Cambridge University Press.
- Field, J. M., M. Xue, and L. M. Hitt. 2012. "Learning by customers as co-producers in financial services: an empirical study of the effects of learning channels and customer characteristics". *Operations Management Research*. 5(1-2): 43–56.
- Fitzsimmons, J. A., M. J. Fitzsimmons, and S. Bordoloi. 2013. *Service Management - Operations, Strategy, Information Technology*. McGraw-Hill/Irwin Series Operations and Decision Sciences.
- Fitzsimmons, J. and R. S. Sullivan. 1995. *Service operations management*. McGraw-Hill.
- Fontnouvelle, P., V. DeJesus-Rueff, J. Jordan, and E. Rosengren. 2006. "Capital and Risk: New Evidence on Implications of Large Operational Losses". *Journal of Money, Credit, and Banking*. 38(7): 1819–1846.
- Frachot, A., O. Moudoulaud, and T. Roncalli. 2004. "Loss Distribution Approach in Practice". *The Basel Handbook: A Guide for Financial Practitioners*.
- Frei, F. X. 2006. "Customer-Introduced Variability in Service Operations". *Harvard Business School Background Note 606-063*: March 2006.
- Frei, F. X., R. Kalakota, A. J. Leone, and L. M. Marx. 1999. "Process Variation as a Determinant of Bank Performance: Evidence from the Retail Banking Study". *Management Science*. 45(9): 1210–1220.
- Frick, R. A. 1997. "The Application of Total Quality Management on Service Quality in Banking". *Journal of Performance Management*. 10(3): 3–29.

- Gallagher, B. P., P. J. Case, R. C. Creel, S. Kushner, and R. C. Williams. 2005. "A Taxonomy of Operational Risks". *Technical Report*. CMU/SEI-2005-TN-036, Carnegie Mellon University, Pittsburgh, PA.
- Gan, X., S. P. Sethi, and H. Yan. 2010. "Channel Coordination with a Risk-Neutral Supplier and a Downside-Risk-Averse Retailer". *Production and Operations Management*. 14(1): 80–89.
- Gande, A. and A. Saunders. 2012. "Are banks still special when there is a secondary market for loans?" *The Journal of Finance*. 67(5): 1649–1684.
- Gao, Z. and M. Ye. 2007. "A framework for data mining-based anti-money laundering research". *Journal of Money Laundering Control*. 10(2): 170–179.
- Gardner, M. P. 1985. "Mood States and Consumer Behavior: A Critical Review". *Journal of Consumer Research*. 12(3): 281–300.
- Garleanu, N. and L. H. Pedersen. 2013. "Dynamic Trading with Predictable Returns and Transaction Costs". *Journal of Finance*. 68(6): 2309–2340.
- Geffen, C. A. and S. Rothenberg. 2000. "Suppliers and Environmental Innovation: The Automotive Paint Process". *International Journal of Operations & Production Management*. 20(2): 166–186.
- Gensler, S., P. Leeftang, and B. Skiera. 2012. "Impact of online channel use on customer revenues and costs to serve: Considering product portfolios and self-selection". *International Journal of Research in Marketing*. 29(2): 192–201.
- Ghaffarian, R. 1999. "A Systems Approach for Quality and Reliability of Chip Scale Package Assembly". In: *Proceedings of IEEE Aerospace Conference*.
- Giliberto, M. 1985. "Interest Rate Sensitivity in the Common Stocks of Financial Intermediaries: A Methodological Note". *The Journal of Financial and Quantitative Analysis*. 20(1): 123–126.
- Gorton, G. and G. Pennacchi. 1995. "Banks and loan sales: Marketing non-marketable assets". *Journal of Monetary Economics*. 35(3): 389–411.

- Goyal, S. K. 1985. "Economic order quantity under conditions of permissible delay in payments". *Journal of the Operational Research Society*. 36(4): 335–338.
- Grabowski, M., J. R. W. Merrick, J. R. Harrald, T. A. Mazzuchi, and J. R. V. Dorp. 2000. "Risk Modeling in Distributed Large-Scale Systems". *IEEE Transactions on Systems, Man and Cybernetics Part A - Systems and Humans*. 30: 651–660.
- Grasa, A. A. 1989. *Econometric Model Selection: A New Approach*. Springer.
- Graves, J. A. and B. McDonald. 1989. "Nonnormalities and tests of asset pricing theories". *The Journal of Finance*. 44(4): 889–908.
- Gregoriou, G. N. 2009. *Operational Risk Toward Basel III: Best Practices and Issues in Modeling, Management, and Regulation*. New York: John Wiley and Sons.
- Gross, D. B. and N. S. Souleles. 2002. "An Empirical Analysis of Personal Bankruptcy and Delinquency". *The Review of Financial Studies*. 15(1): 319–347.
- Gunewardena, M., M. Pinedo, and W. R. Egan. 2009. "Method, software program, and system for ranking relative risk of a plurality of transactions". US Patent US7590594 B2, Assignee: Goldman Sachs.
- Gupta, D. and L. Wang. 2009. "A Stochastic Inventory Model with Trade Credit". *Manufacturing & Service Operations Management*. 11(1): 4–18.
- Gupta, S. and K. Dutta. 2011. "Modeling of financial supply chain". *European Journal of Operational Research*. 211(1): 47–56.
- Gutierrez, S. S. M., C. C. Izquierdo, and R. S. J. Cabezudo. 2010. "Product and channel-related risk and involvement in online contexts". *Electronic Commerce Research and Applications*. 9(3): 263–273.
- Hale, G. and J. A. Santos. 2009. "Do banks price their informational monopoly?" *Journal of Financial Economics*. 63(2): 185–206.
- Hanemann, W. M. 1984. "Discrete/Continuous Models of Consumer Demand". *Econometrica*. 52(3): 541–562.
- Harker, P. T. and S. A. Zenios. 2000. *Performance of Financial Institutions - Efficiency, Innovation, Regulation*. Cambridge University Press, Cambridge, U.K.



- Harrington, H. J. 1986. "The Productivity and Quality Connection". *IEEE Journal on Selected Areas in Communications*. 4(7): 1009–1014.
- Harrington, S. E. 2009. "The Financial Crisis, Systemic Risk and the Future of Insurance Regulation". *The Journal of Risk and Insurance*. 76(4): 785–819.
- Hartley-Urquhart, W. R. 2000. "Supply chain financing system and method". US6167385.
- Hatzakis, E. D., S. K. Nair, and M. L. Pinedo. 2010. "Operations in Financial Services-An overview". *Production and Operations Management*. 19(6): 633–664.
- Hellmich, M., M. Pinedo, B. Schuck, S. Siddiqui, and A. Uhl. 2014. "Banking Study: The Benefits of Innovative Information Technology in the Banking Industry in turbulent times. An empirical study in Europe and North America". *Business Transformation Academy (BTA)*: Basel, Switzerland.
- Herzberg, A. 2003. "Payments and banking with mobile personal devices". *Communications of the ACM*. 46(5): 53–58.
- Hirano, K. and G. W. Imbens. 2004. "The propensity score with continuous treatments". *Applied Bayesian modeling and causal inference from incomplete-data perspectives*: 73–84.
- Hoffman, D. G. 2002. *Managing Operational Risk*. Canada: John Wiley & Sons.
- Hoffmann, A. and C. Birnbrich. 2012. "The impact of fraud prevention on bank-customer relationships: An empirical investigation in retail banking". *International Journal of bank marketing*. 30(5): 390–407.
- Holmer, M. R. and S. A. Zenios. 1995. "The productivity of financial intermediation and the technology of financial product management". *Operations Research*. 43(6): 970–982.
- Hora, M. and R. D. Klassen. 2013. "Learning from others' misfortune: factors influencing knowledge acquisition to reduce operational risk". *Journal of Operations Management*. 31(1): 52–61.
- Huff, L., C. Fornell, and E. Anderson. 1996. "Quality and Productivity: Contradictory and Complementary". *Quality Management Journal*. 4(1): 22–39.

- Iyer, R. K. and D. J. Rossetti. 1986. "A Measurement-based model for workload dependence of CPU errors". *IEEE Transactions on Computers*. 100(6): 511–519.
- Iyer, R. and M. Puri. 2012. "Understanding bank runs: The importance of depositorbank relationships and networks". *American Economic Review*. 102(4): 1414–1445.
- Jaffee, D. M. and T. Russell. 1997. "Catastrophe Insurance, Capital Markets, and Uninsurable Risks". *The Journal of Risk and Insurance*. 64(2): 205–230.
- Jansen, J. and R. Leukfeldt. 2016. "Phishing and Malware Attacks on Online Banking Customers in the Netherlands: A Qualitative Analysis of Factors Leading to Victimization". *International Journal of Cyber Criminology*. 10(1): 79–91.
- Jarrow, R. A. 2008. "Operational Risk". *Journal of Banking and Finance*. 32(5): 870–879.
- Jarrow, R. A., J. Oxman, and Y. Yildirim. 2010. "The Cost of Operational Risk Loss Insurance". *Review of Derivatives Research*. 13(3): 273–295.
- Kapur, P. K., H. Pham, A. G. Aggarwal, and G. Kaur. 2012. "Two Dimensional Multi-Release Software Reliability Modeling and Optimal Release Planning". *IEEE Transactions on Reliability*. 61(3): 758–768.
- Kapur, P. K., H. Pham, S. Anand, and K. Yadav. 2011. "A Unified Approach for Developing Software Reliability Growth Models in the Presence of Imperfect Debugging and Error Generation". *IEEE Transactions on Reliability*. 60(1): 331–340.
- Karger, D. R., S. Oh, and D. Shah. 2014. "Budget-optimal task allocation for reliable crowdsourcing systems". *Operations Research*. 62(1): 1–24.
- Karsten, F., M. Slikker, and G. J. V. Houtum. 2015. "Resource pooling and cost allocation among independent service providers". *Operations Research*. 62(2): 476–488.
- Kc, D. S. and C. Terwiesch. 2009. "Impact of workload on service time and patient safety: An econometric analysis of hospital operations". *Management Science*. 55(9): 1486–1498.

- Kekre, S., N. Secomandi, E. Sönmez, and K. West. 2009. "OM practice - balancing risk and efficiency at a major commercial bank". *Manufacturing & Service Operations Management*. 11(1): 160–173.
- Kelley, S. W., J. H. Donnelly, Jr., and S. K. Skinner. 1990. "Customer Participation in Service Production and Delivery". *Journal of Retailing*. 66(3): 315–335.
- Kirilenko, A., A. S. Kyle, M. Samadi, and T. Tuzun. 2017. "The Flash Crash: High Frequency Trading in an Electronic Market". *The Journal of Finance*. 72(3): 967–998.
- Klasterin, T. and W. Tsai. 2004. "New Product Introduction: Timing, Design, and Pricing". *Manufacturing and Services Operations Management*. 6(4): 302–320.
- Kleindorfer, P. R. and G. H. Saad. 2010. "Managing Disruption Risks in Supply Chains". *Production and Operations Management*. 14(1): 53–68.
- Koning, H., R. J. Does, and S. Bisgaard. 2008. "Lean Six Sigma in financial services". *International Journal of Six Sigma and Competitive Advantage*. 4(1): 1–17.
- Kopecsni, J. 2010. "Improving Service Performance in Banking using Quality Adjusted Data Envelopment Analysis". *IES Working Paper 10/2010*. Faculty of Social Sciences, Charles University, Prague.
- Kostami, V. and S. Rajagopalan. 2011. "Speed Quality Trade-Offs in a Dynamic Model". Working Paper, Marshall School of Business, University of Southern California.
- Koufaris, M. 2002. "Applying the Technology Acceptance Model and Flow Theory to Online Consumer Behavior". *Information Systems Research*. 13(2): 205–223.
- Kouvelis, P. and W. Zhao. 2012. "Financing the Newsvendor: Supplier vs. Bank, and the Structure of Optimal Trade Credit Contracts". *Operations Research*. 60(3): 566–580.
- Krankel, R., I. Duenyas, and R. Kapuscinski. 2006. "Timing Successive Product Introduction with Demand Diffusion and Stochastic Technology Improvement". *Manufacturing and Services Operations Management*. 8(2): 119–135.

- Krishnan, M. S., V. Ramaswamy, M. C. Meyer, and P. Damien. 1999. "Customer satisfaction for financial services: the role of products, services, and information technology". *Management science*. 45(9): 1194–1209.
- Kuntz, L., R. Mennicken, and S. Scholtes. 2014. "Stress on the ward: Evidence of safety tipping points in hospitals". *Management Science*. 64(1): 754–771.
- Kuo, W. and V. R. Prasad. 2002. "An Annotated Overview of System-Reliability Optimization". *IEEE Transactions on Reliability*. 49(2): 176–187.
- Kushwaha, T. and V. Shankar. 2013. "Are Multichannel Customers Really More Valuable? The Moderating Role of Product Category Characteristics". *Journal of Marketing*. 77(4): 67–85.
- Lancaster, K. J. 1971. *Consumer demand: A new approach*. Columbia University Press.
- Lariviere, B., L. Aksoy, B. Cooil, and T. L. Keiningham. 2011. "Does Satisfaction Matter More If a Multichannel Customer is Also a Multicompany Customer?" *Journal of Service Management*. 22(1): 39–66.
- Leaver, M. and T. W. Reader. 2016. "Human Factors in Financial Trading - An Analysis of Trading Incidents". *Human Factors*. 58(6): 814–832.
- Lee, W.-R., M. G. Beravides, and Y. D. Chiu. 2007. "A Study on the Quality-Productivity Relationship and its Verification in Manufacturing Industries". *Engineering Economist*. 52(2): 117–139.
- Leeson, N. and E. Whitley. 1996. *Rogue Trader: How I Brought Down Barings Bank and Shook the Financial World*. Little Brown and Company.
- Leippold, M. and P. Vanini. 2005. "The quantification of operational risk". *Journal of Risk*. 8(1): 59–85.
- Leon, C. 2009. "Operational Risk Management Using a Fuzzy Logic Inference System". *Borradores de Economia*. 574(5841): 141–153.
- Lewis, M. 2011. *The Big Short: Inside the Doomsday Machine*. W.W. Norton & Company, New York.

- Lewis, M. A. 2003. "Cause, Consequence and Control: Towards a Theoretical and Practical Model of Operational Risk". *Journal of Operations Management*. 21(2): 205–224.
- Lewis, W., R. T. W. Jr., and A. Pickren. 2003. "An Empirical Assessment of IT Disaster Risk". *Comm. of the ACM*. 46: 201–206.
- Li, J., J. Feng, D. Wu, and C. Lee. 2012. *Integration of Credit, Market and Operational Risk: A Comparative Analysis of Copula and Variance/Covariance Approach*. Department of Finance and Economics, Rutgers Business School, Rutgers University.
- Li, Y., N. Allan, and J. Evans. 2017. "A Nonlinear Analysis of operational risk events in Australian banks". *Journal of Operational Risk*. 12(1): 1–22.
- Liao, Z. and M. T. Cheung. 2002. "Internet-based E-Banking and consumer attitudes: an empirical study". *Information Management*. 38(5): 299–306.
- Lilien, G. and E. Yoon. 1990. "The Timing of Competitive Market Entry: An Exploratory Study of New Industrial Products". *Management Science*. 36(5): 568–585.
- Lobel, I., J. Patel, G. Vulcano, and J. Zhang. 2014. "Optimizing Product Launches in the Presence of Strategic Consumers". *Working paper*, IOMS Department, Stern School of Business, New York University.
- Longo, C. R. J. and M. A. A. Cox. 2000. "Total Quality Management in the UK Financial Services: Some Findings from a Survey in the Northeast of England". *Total Quality Management*. 11(1): 17–23.
- Lovelock, C. H. and R. F. Young. 1979. "Look to Consumers to Increase Productivity". *Harvard Business Review*. 57(May): 168–178.
- Lowenstein, R. 2001. *When Genius Failed: The Rise and Fall of Long-Term Capital Management*. New York: Random House Trade Paperbacks.
- Luo, X., P. Shevchenko, and J. Donnelly. 2007. "Addressing the Impact of Data Truncation and Parameter Uncertainty on Operational Risk Estimates". *Journal of Operational Risk*. 2(4): 3–26.
- Luss, H. 2012. *Equitable Resource Allocation: Models, Algorithms, and Applications*. New York: John Wiley and Sons.

- Madan, D. and B. Soubra. 1991. "Design and Marketing of Financial Products". *The Review of Financial Studies*. 4(2): 361–384.
- Maes, S., K. Tuyls, B. Vanschoenwinkel, and B. Manderick. 2002. "Credit Card Fraud Detection using Bayesian and Neural Networks". In: *Proceedings of the 1st International NAISO Congress on Neuro Fuzzy Technology*. NAISO. 1681–1684.
- Majnoni, G., S. M. Peria, W. Blaschke, and M. T. Jones. 2001. *Stress testing of financial systems: an overview of issues, methodologies, and FSAP experiences*. International Monetary Fund, Working Paper WP/01/88.
- Markowitz, H. 1952. "Portfolio Selection". *The Journal of Finance*. 7(1): 77–91.
- Martins, C., T. Oliveira, and A. Popovič. 2014. "Understanding the Internet banking adoption: A unified theory of acceptance and use of technology and perceived risk application". *International Journal of Information Management*. 34(1): 1–13.
- McCausland, W. J. 2009. "Random Consumer Demand". *Economica*. 76(301): 89–107.
- McNeil, A. J., R. Frey, and P. Embrechts. 2005. *Quantitative Risk management: Concepts, techniques and tools*. Princeton University Press.
- Meier, H., N. Christofides, and G. Salkin. 2001. "Capital budgeting under uncertainty-an integrated approach using contingent claims analysis and integer programming". *Operations Research*. 49(2): 196–206.
- Melnick, E. L., P. R. Nayyar, M. Pinedo, and S. Seshadri. 2000. *Creating value in financial services: Strategies, operations and technologies*. Springer, New York.
- Menor, L. J. and A. V. Roth. 2008. "New service development competence and performance: An empirical investigation in retail banking". *Production and Operations Management*. 17(3): 267–284.
- Metters, R. D., K. H. King-Metters, M. Pullman, and S. Walton. 2008. *Successful service operations management*. South-Western College Publishing.

- Mignola, G. and R. Ugoccioni. 2006. "Effect of a Data Collection Threshold in the Loss Distribution Approach". *Journal of Operational Risk*. 1(4): 35–47.
- Mills, P. K. and J. H. Morris. 1986. "Clients as Partial Employees of Service Organizations: Role Development in Client Participation". *Academy of Management Review*. 11(4): 726–735.
- Mizgier, K. J., M. Hora, S. M. Wagner, and M. P. Juttner. 2015. "Managing Operational Disruptions through Capital Adequacy and Process Improvement". *European Journal of Operational Research*. 245(1): 320–332.
- Money, R. B. 2004. "Word-of-mouth promotion and switching behavior in Japanese and American business-to-business service clients". *Journal of Business Research*. 57(3): 297–305.
- Moore, T. and N. Christin. 2013. "Beware the middleman: Empirical analysis of Bitcoin-exchange risk". In: *International Conference on Financial Cryptography and Data Security*. Springer. 25–33.
- Mortimer, G., L. Neale, S. F. Hasan, and B. Dunphy. 2015. "Investigating the factors influencing the adoption of m-banking: A cross cultural study". *International Journal of Bank Marketing*. 33(4): 545–570.
- Muermann, A. and U. Oktem. 2002. "The Near-Miss Management of Operational Risk". *Journal of Risk Finance*. 4: 25–36.
- Mukhopadhyaya, K. and B. P. Sinha. 1992. "Reliability Analysis of Networks using Stochastic Modeling". *Information Sciences*. 65: 225–237.
- Nayar, P. and Y. A. Ozcan. 2008. "Data Envelopment Analysis Comparison of Hospital Efficiency and Quality". *Journal of Medical Systems*. 32: 193–199.
- Neil, M., L. Andersen, and D. Hager. 2009. "Modeling Operational Risk for Financial Institutions using Hybrid Dynamic Bayesian Networks". *Journal of Operational Risk*. 4(1): 3–33.
- Neil, M., N. Fenton, and M. Tailor. 2005. "Using Bayesian Networks to Model Expected and Unexpected Operational Losses". *Risk Analysis*. 25(4): 1–10.

- Nelson, J. A. 2007. "Information Security Risk in Financial Institutions". *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*. 1(10): 528–530.
- Neslin, S. A., D. Grewal, R. Leghorn, V. Shankar, M. K. Teerling, J. S. Thomas, and P. C. Verhoef. 2006. "Challenges and opportunities in multichannel customer management". *Journal of Service Research*. 9(2): 95–112.
- Ngai, E. W. T., Y. Hu, Y. H. Wong, Y. Chen, and X. Sun. 2011. "The application of data mining techniques in financial fraud detection: A classification framework and an academic review of literature". *Decision Support Systems*. 50(3): 559–569.
- Nie, J. and X. Hu. 2008. "Mobile banking information security and protection methods". In: *Computer Science and Software Engineering, 2008 International Conference on*. Vol. 3. IEEE. 587–590.
- Pakhchanyan, S. 2016. "Operational Risk Management in Financial Institutions: A Literature Review". *International Journal of Financial Studies*. 4(4): 20. Multidisciplinary Digital Publishing Institute.
- Panjer, H. H. 2006. *Operational Risk: Modeling Analytics*. Wiley & Sons, Inc.
- Parlour, C. and G. Plantin. 2008. "Loan sales and relationship banking". *The Journal of Finance*. 63(3): 1291–1314.
- Parlour, C. and A. Winton. 2013. "Laying off credit risk: Loan sales versus credit default swaps". *Journal of Financial Economics*. 107(1): 25–45.
- Patidar, R. and L. Sharma. 2011. "Credit Card Fraud Detection Using Neural Network". *International Journal of Soft Computing and Engineering*. 1: 32–38.
- Paulssen, M. and M. M. Birk. 2007. "Satisfaction and Repurchase Behavior in a Business-to-business Setting: Investigating the Moderating Effect of Manufacturer, Company and Demographic Characteristics". *Industrial Marketing Management*. 36(7): 983–997.
- Payne, C. 2009. "A Cryptographically-based Operating System Security Model that Protects against Privileged Attackers". *PhD thesis*. Murdoch University, Perth, Australia.
- Peled, D. A. 2011. *Software Reliability Methods*. Springer.



- Pennacchi, G. 1988. "Loan sales and the cost of bank capital". *The Journal of Finance*. 43(2): 375–396.
- Pennings, J. M. E. and B. Wansink. 2004. "Channel Contract Behavior: The Role of Risk Attitudes, Risk Perceptions, And Channel Members' Market Structures". *Journal of Business*. 77(4): 697–723.
- Peotta, L., M. D. Holtz, B. M. David, F. G. Deus, and R. T. de Sousa. 2011. "A formal classification of internet banking attacks and vulnerabilities". *International Journal of Computer Science & Information Technology*. 3(1): 186–197.
- Peters, G. W., A. Chapelle, and E. Panayi. 2016. "Opening discussion on banking sector risk exposures and vulnerabilities from virtual currencies: An operational risk perspective". *Journal of Banking Regulation*. 17(4): 239–272.
- Peters, G. W. and P. V. Shevchenko. 2015. *Advances in Heavy Tailed Risk Modeling: A Handbook of Operational Risk*. John Wiley & Sons.
- Peters, G., A. Byrnes, and P. Shevchenko. 2011. "Modeling Insurance Mitigation on Operational Risk Capital". *Insurance: Mathematics and Economics*. 48: 287–303.
- Peterson, S., R. C. Stapleton, and M. G. Subrahmanyam. 2003. "A Multifactor Spot Rate Model for the Pricing of Interest Rate Derivatives". *The Journal of Financial and Quantitative Analysis*. 38(4): 847–880.
- Pham, H. 2010. "System Software Reliability". In: *Springer Series in Reliability Engineering*. Springer.
- Pinedo, M. and I. Walter. 2013. *Global asset management: strategies, risks, processes, and technologies*. Palgrave Macmillan.
- Portanger, E., M. R. Sesit, and A. Galloni. 2002. "Allied Irish Banks Say a Rogue Trader Lost \$750 Million in Unauthorized Deals". *Wall Street Journal*, Feb, 7th. 2014-05-02 17:59:27 +0000.
- Powell, A., S. Savin, and N. Savva. 2012. "Physician workload and hospital reimbursement: Overworked physicians generate less revenue per patient". *Manufacturing and Services Operations Management*. 14(4): 512–528.
- Prasad, V. R. and W. Kuo. 2000. "Reliability Optimization of Coherent Systems". *IEEE Transactions on Reliability*. 49(3): 323–330.

- Puri, M. and J. Rocholl. 2008. "On the importance of retail banking relationships". *Journal of Financial Economics*. 89(2): 253–267.
- Puri, M., J. Rocholl, and S. Steffen. 2010. "The sources of value of relationships. Screening, monitoring and the likelihood of consumer default". *Tech. rep.* Working paper.
- Puri, M., J. Rocholl, and S. Steffen. 2011. "On the importance of prior relationships in bank loans to retail customers". *European Central Bank (ECB) Working Paper Series*: No 1395.
- Puri, M., J. Rocholl, and S. Steffen. 2017. "What Do a Million Observations Have to Say About Loan Defaults? Opening the Black Box of Relationships". *Journal of Financial Intermediation*. 31: 1–15.
- Rauyruen, P. and K. E. Miller. 2007. "Relationship quality as a predictor of B2B customer loyalty". *Journal of Business Research*. 60(1): 21–31.
- Robles-Granda, P. D. and V. Belik. 2010. "A Comparison of Machine learning Classifies Applied to Financial Datasets". In: *Proceedings of the World Congress on Engineering and Computer Science*. Vol. 1.
- Ross, S., R. Westerfield, and J. Jaffe. 2010. *Corporate Finance*. 9th Edition. New York: McGraw-Hill Irwin.
- Roth, A. V. and L. J. Menor. 2003. "Insights into service operations management: a research agenda". *Production and Operations management*. 12(2): 145–164.
- Royset, J. O. and R. Szechtman. 2013. "Optimal budget allocation for sample average approximation". *Operations Research*. 61(3): 762–776.
- Rust, R. T., C. Moorman, and P. R. Dickson. 2002. "Getting Return on Quality: Revenue Expansion, Cost Reduction, or Both?" *Journal of Marketing*. 66(4): 7–24.
- Rust, R. and T. Chung. 2006. "Marketing models of service and relationships". *Marketing Science*. 25(6): 560–580.
- Rust, R. and M. Huang. 2012. "Optimizing Service Productivity". *Journal of Marketing*. 76(2): 47–66.
- Sampson, S. E. and C. M. Froehle. 2006. "Foundations and implications of a proposed unified services theory". *Production and Operations Management*. 15(2): 329–343.

- Samson, D. and M. Terziovski. 1999. "The Relationship between Total Quality Management Practices and Operational Performance". *Journal of Operations Management*. 17: 393–409.
- Sanford, A. D. and I. A. Moosa. 2011. "A Bayesian Network Structure for Operational Risk Modeling in Structured Finance Operations". *Journal of the Operational Research Society*. 63: 431–444.
- Santos, J. and A. Winton. 2008. "Bank loans, bonds, and information monopolies across the business cycle". *The Journal of Finance*. 63(3): 1315–1359.
- Sarmah, S. P., D. Acharya, and S. K. Goyal. 2008. "Coordination of a single-manufacturer/multi-buyer supply chain with credit option". *International Journal of Production Economics*. 111(2): 676–685.
- Scharfman, J. 2008. *Hedge Fund Operational Due Diligence: Understanding the Risks*. New York: Wiley Finance.
- Schenone, C. 2008. "Lending relationships and information rents: Do banks exploit their information advantages?" *Review of Financial Studies*. 23(3): 1149–1199.
- Schmenner, R. W. 1986. "How can service businesses survive and prosper?" *Sloan Management Review (Spring 1986)*. 27(3): 21–32.
- Schneider, A. 2013. "After the storm: Four Innovations Changing Investment Management". In: *Global asset management: strategies, risks, processes, and technologies*. Ed. by M. Pinedo and I. Walter. Palgrave Macmillan. Chap. 6. 107–121.
- Services, K. B. A. 2007. *Survey on Economic Capital Practice and Applications*. IFRI Foundation/CRO Forum.
- Sevcik, K. 1994. "Application scheduling and processor allocation in multiprogrammed parallel processing systems". *Performance Evaluation*. 19(2-3): 107–140.
- Shahrokhi, M. and A. Bernard. 2004. "Risk Assessment/Prevention in Industrial Design Processes". In: *2004 IEEE International Conference on Systems, Man and Cybernetics*. 2592–2598.
- Shao, B. 2005. "Optimal Redundancy Allocation for Information Technology Disaster Recovery in the Network Economy". *IEEE Transactions on Dependable and Secure Computing*. 2: 262–267.

- Sherman, H. D. and J. Zhu. 2006. "Benchmarking with Quality Adjusted DEA (Q-DEA) to Seek Lower-Cost high Quality Service: Evidence from a U.S. Bank Application". *Annals of Operations Research*. 145: 301–319.
- Shevchenko, P. V. 2011. *Modeling Operational Risk Using Bayesian Inference*. Springer.
- Shevchenko, P. and G. Temnov. 2009. "Modeling Operational Risk Data Reported above a Time-varying Threshold". *Journal of Operational Risk*. 4(2): 19–42.
- Shostack, G. L. 1984. "Designing Services that Deliver". *Harvard Business Review*. 62(1): 133–139.
- Sibbertsen, P., G. Stahl, and C. Luedtke. 2008. "Measuring Model Risk". *Journal of Risk Model Validation*. 2(4): 65–81.
- Singapore Monetary Authority, F. S. 2008. "Internet Banking and Technology Risk Management Guidelines".
- Sirgy, M. J. 1982. "Self-Concept in Consumer Behavior: A Critical Review". *Journal of Consumer Research*. 9(3): 287–300.
- Smilowitz, K. and S. Madanat. 2000. "Optimal Inspection and Maintenance Policies for Infrastructure Networks". *Computer-Aided Civil and Infrastructure Engineering*. 15: 5–13.
- Smith, J. S., K. R. Karwan, and R. E. Markland. 2007. "A Note on the Growth of Research in Service Operations Management". *Production and Operations Management*. 16(6): 780–790.
- Sohail, M. S. and B. Shanmugham. 2003. "E-banking and customer preferences in Malaysia: An empirical investigation". *Information Sciences*. 150(3-4): 207–217.
- Sommer, P. and I. Brown. 2011. "Reducing systemic cyber security risk". *OECD Working Paper* No. IFP/WKP/FGS(2011)3. Organisation for Economic Cooperation and Development, Paris, France.
- Souteriou, A. and S. A. Zenios. 1999. "Operations, Quality and Profitability in the Provision of Banking Services". *Management Science*. 45(9): 1221–1238.
- Sparrow, A. 2000. "A Theoretical Framework for Operational Risk Management and Opportunity Realization". *Tech. rep.* Report 00/10, New Zealand Treasury.

- Spohrer, J. and P. P. Maglio. 2008. "The emergence of service science: Toward systematic service innovations to accelerate co-creation of value". *Production and Operations Management*. 17(3): 238–246.
- Srinivasan, A. 2014. "Long Run Relationships in Banking". *Foundations & Trends in Finance*. 8(2): 55–143.
- Srivastava, A., S. S. Kundu, and A. Majumdar. 2008. "Credit card Fraud Detection Using Hidden Markov Model". *IEEE Transactions on Dependable and Secure Computing*. 5(1): 37–47.
- Stemmler, L. 2002. *The Role of Finance in Supply Chain Management*. Physica-Verlag.
- Stoneburner, G., A. Goguen, and A. Feringa. 2002. "Risk Management Guide for Information Technology Systems " Recommendations of the National Institute of Standards and Technology". *Tech. rep.* NIST Special Publication 800-30. National Institute of Standards and Technology, Gaithersburg, Md.
- Supatgiat, C. and L. Heusler. 2006. "Cause-to-Effect Operational-Risk Quantification and Management". *Risk Management*. 8(1): 16–42.
- Takieddine, S. and J. Sun. 2015. "Internet banking diffusion: A country-level analysis". *Electronic Commerce Research and Applications*. 14(5): 361–371.
- Tamersoy, A., B. Xie, S. L. Lenkey, B. R. Routledge, D. H. Chau, and S. B. Navathe. 2013. "Inside insider trading: Patterns & discoveries from a large scale exploratory analysis". In: *Proceedings of the 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining*. ACM. 797–804.
- Tan, T. F. and S. Netessine. 2014. "When does the devil make work? An empirical study of the impact of workload on worker productivity". *Management Science*. 60(6): 1574–1593.
- Taplin, R. 2016. *Managing Cyber Risk in the Financial Sector: Lessons from Asia, Europe and the USA*. Routledge.
- Thomas, P., D. Teneketzis, and J. K. Mackie-Mason. 2002. "A market-based approach to optimal resource allocation in integrated-services connection-oriented networks". *Operations Research*. 50(4): 603–616.

- Tinsley, C. H., R. L. Dillon, and M. A. Cronin. 2012. "How Near-Miss Events Amplify or Attenuate Risky Decision Making". *Management Science*. 58(9): 1596–1613.
- Tinsley, C. H., R. L. Dillon, and P. M. Madsen. 2011. "How to Avoid a Catastrophe". *Harvard Business Review*. Apr.: 90–96.
- Tomlin, B. and Y. Wang. 2008. "Pricing and Operational Recourse in Coproduction Systems". *Management Science*. 54(3): 522–537.
- Tsai, C. Y. 2011. "On delineating supply chain cash flow under collection risk". *International Journal of Production Economics*. 129(1): 186–194.
- Tsompanakis, Y., N. D. Lagaros, and M. Papadrakakis, eds. 2012. *Structural Design Optimization Considering Uncertainties*. Taylor and Francis.
- Valetkevitch, C. and C. Mikolajczak. 2012. *Error by Knight Capital rips through stock market*. Reuters, Business News, August 1st, 2012.
- Van Mieghem, J. A. 2003. "Capacity Management, Investment, and Hedging: Review and Recent Developments". *Manufacturing and Services Operations Management*. 5(4): 269–302.
- Van Mieghem, J. A. and M. Dada. 1999. "Price versus production postponement: capacity and competition". *Management Science*. 45(12): 1639–1649.
- Vasek, M. and T. Moore. 2015. "There's No Free Lunch, Even Using Bitcoin: Tracking the Popularity and Profits of Virtual Currency Scams". In: *International Conference on Financial Cryptography and Data Security*. Springer. 44–61.
- Veinott, A. F. 2005. "MS&E 361 Supply-Chain Optimization". Stanford University.
- Vickery, S. K., J. Jayaram, C. Droge, and R. Calantone. 2003. "The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships". *Journal of Operations Management*. 21(5): 523–539.
- Voss, C., A. V. Roth, and R. B. Chase. 2008. "Experience, service operations strategy, and services as destinations: foundations and exploratory investigation". *Production and Operations Management*. 17(3): 247–266.

- Wales, T. J. and A. D. Woodland. 1983. "Estimation of consumer demand systems with binding non-negativity constraints". *Journal of Econometrics*. 21(3): 263–285.
- Wang, K. Q. 2005. "Multifactor Evaluation of Style Rotation". *The Journal of Financial and Quantitative Analysis*. 40(2): 349–372.
- Wei, W., J. Li, L. Cao, Y. Ou, and J. Chen. 2013. "Effective detection of sophisticated online banking fraud on extremely imbalanced data". *World Wide Web*. 16(4): 449–475.
- Westlund, A. H. and M. Lothgren. 2001. "The Interactions between Quality, Productivity and Economic Performance: The Case of Swedish Pharmacies". *Journal of Total Quality Management*. 12: 385–396.
- Wiese, B. and C. Omlin. 2009. "Credit card transactions, fraud detection, and machine learning: Modelling time with LSTM recurrent neural networks". In: *Innovations in neural information paradigms and applications*. Springer. 231–268.
- Wu, M., C. Jayawardhena, and R. Hamilton. 2014. "A comprehensive examination of internet banking user behaviour: evidence from customers yet to adopt, currently using and stopped using". *Journal of Marketing Management*. 30(9-10): 1006–1038.
- Wulf, K. D., J. C. Hoekstra, and H. R. Commandeur. 2000. "The Opening and Reading Behavior of Business-to-Business Direct Mail". *Industrial Marketing Management*. 29(2): 133–145.
- Xiao, B., Y. Chen, Y. Xu, and X. Li. 2017. "Compliance risk and operational risk management in financial service industry based on BPR: theory and application". *Journal of Management Sciences in China (in Chinese)*: forthcoming.
- Xu, G., B. Dan, X. Zhang, and C. Liu. 2014. "Coordinating a dual-channel supply chain with risk-averse under a two-way revenue sharing contract". *International Journal of Production Economics*. 147(1): 171–179.
- Xu, Y., M. Pinedo, and M. Xue. 2017a. "Operational Risk in Financial Services: A New Research Area in Operations Management". *Production and Operations Management*. 26(3): 426–445.

- Xu, Y., J. Zhang, and M. Pinedo. forthcoming. "Budget Allocation Strategies to Minimize Operational Risk Losses in Financial Institutions". *Probability in the Engineering and Informational Sciences*.
- Xu, Y., L. Zhu, and M. Pinedo. 2017b. "Operational Risk Management: Coordinating Capital Investment and Firm Value". IOMS Department, Stern School of Business, New York University, New York, Working Paper.
- Xue, M. and J. M. Field. 2008. "Service co-production with information stickiness and incomplete contracts: implications for consulting service design". *Production and Operations Management*. 17(3): 357–372.
- Xue, M. and P. T. Harker. 2002. "Customer efficiency: concept and its impact on e-business management". *Journal of Service Research*. 4(4): 253–267.
- Xue, M., G. R. Heim, and P. T. Harker. 2005. "Consumer and co-producer roles in e-service: analyzing efficiency and effectiveness of e-service designs". *International Journal of Electronic Business*. 3(2): 174–197.
- Xue, M., L. M. Hitt, and P. Chen. 2011. "The determinants and outcome of Internet banking adoption". *Management Science*. 57(2): 291–307.
- Xue, M., L. M. Hitt, and P. T. Harker. 2007. "Customer efficiency, channel usage and firm performance in retail banking". *Manufacturing & Service Operations Management*. 9(4): 535–558.
- Yao, X., E. Fernandez-Gaucherand, M. C. Fu, and S. I. Marcus. 2004. "Optimal Preventive Maintenance Scheduling in Semiconductor Manufacturing". *IEEE Transactions on Semiconductor Manufacturing*. 17(3): 345–356.
- Zareapoor, M., K. R. Seeja, and A. M. Alam. 2012. "Analysis of Credit Card Fraud Detection Techniques Based on Certain Design Criteria". *International Journal of Computer Applications*. 52(3): 35–42.
- Zenios, S. A. 1996. *Financial Optimization*. U.K: Cambridge University Press.



- Zhang, Z., J. J. Salerno, and P. S. Yu. 2003. "Applying data mining in investigating money laundering crimes". In: *Proceedings of the ninth ACM SIGKDD international conference on Knowledge discovery and data mining*. ACM. 747–752.
- Zuo, Y. and E. Kita. 2012. "Up/Down Analysis of Stock Index by Using Bayesian Network". *Engineering Management Research*. 1(2): 46–53.