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Overview, Learning Strategies, Applications, and Future Developments

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Contents

Machine Learning in Marketing

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ABSTRACT

The widespread impacts of artificial intelligence (AI) and machine learning (ML) in many segments of society have not yet been felt strongly in the marketing field. Despite such shortfall, ML offers a variety of potential benefits, including the opportunity to apply more robust methods for the generalization of scientific discoveries. Trying to reduce this shortfall, this monograph has four goals. First, to provide marketing with an overview of ML, including a review of its major types (supervised, unsupervised, and reinforcement learning) and algorithms, relevance to marketing, and general workflow. Second, to analyze two potential learning strategies for marketing researchers to learn ML: the bottom-up (that requires a strong background in general math and calculus, statistics, and programming languages) and the top-down (focused on the implementation of ML algorithms to improve explanations and/or predictions given within the domain of the researcher's knowledge). The third goal is to analyze the ML applications published in top-tier marketing and management journals, books, book chapters, as well as recent working papers on a few promising marketing research sub-fields. Finally, the last goal of the monograph is to discuss possible impacts of trends and future developments of ML to the field of marketing.

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Introduction

The widespread impacts of artificial intelligence (AI) and machine learning (ML) in all segments of society have driven researchers to term the present day as the "AI Revolution" (Makridakis, 2017). This AI revolution has sparked multidisciplinary research. In the business world, such processes have been impactful as a significant source of innovation (Huang and Rust, 2018). Despite their relevance, for many marketing researchers and practitioners, terms such as artificial intelligence and machine learning may seem akin to terms of a foreign language (Conick, 2017). This monograph attempts to change this scenario by discussing the central role that AI and, more specifically, ML can play as a research method in the marketing field.

Why should ML be applied to marketing? There are many possible answers to this question rooted both in academic and applied practices of the discipline. For practitioners, for example, ML is disrupting many industries with new business models, products, and services. In academia, the impact appears to equally substantial. For example, the lack of generalization of scientific discoveries is at the center of the so-called "replication crisis," which has affected many of the life and social sciences, including the fields of management and marketing. This crisis has occurred because researchers have found that many of the most important scientific studies are difficult or impossible to replicate or reproduce (see, for example, Camerer *et al.*, 2018). As this monograph will discuss, the fundamental goal of machine learning is to generalize beyond the examples provided by training data, looking for generalizability (Domingos, 2012). Thus, one of the potential contributions of ML to marketing (and to management in general) lies in its robustness for the generation, testing, and generalization of scientific discoveries. With these different academic and practical perspectives in mind, the goal of this monograph is to provide marketing with an overview of ML and to analyze required learning, applications, and future developments involved in applying ML to marketing.

This monograph progresses as follows. The following section provides an overview of ML, including a review of its most relevant types, algorithms, and relevance to marketing. The following section presents a typical ML workflow, followed by a section that proposes two different learning strategies that can be used by management/marketing researchers interested in ML. That section is followed by a descriptive analysis of applications of ML published in top-tier marketing and management journals, books, book chapters, and recent working papers that explore a few of the most promising marketing research sub-fields. The following section discusses how trends and future developments of ML can impact the field of marketing. The last section summarizes the monograph's contributions, limitations, and suggestions for future research.

References

Annalect (2018). "7 ways computer vision helps marketers see better performance". *Annalect*. April 27. https://www.annalect.com/7-ways-computer-vision-helps-marketers-see-better-performance/.

Ansari, A., K. Jedidi, and S. Jagpal (2000). "A hierarchical Bayesian methodology for treating heterogeneity in structural equation models". *Marketing Science*. 19(4): 328–347.

Ansari, A., Y. Li, and J. Z. Zhang (2018). "Probabilistic topic model for hybrid recommender systems: A stochastic variational Bayesian approach". *Marketing Science*. 37(6): 987–1008.

Armbruster, B. and E. Delage (2015). "Decision making under uncertainty when preference information is incomplete". *Management Science*. 61(1): 111–128.

Ascarza, E. (2018). "Retention futility: Targeting high-risk customers might be ineffective". *Journal of Marketing Research*. 55(1): 80–98.

Atahan, P. and S. Sarkar (2011). "Accelerated learning of user profiles". *Management Science*. 57(2): 215–239.

Athey, S. and G. Imbens (2016). "Recursive partitioning for heterogeneous causal effects". *Proceedings of the National Academy of Sciences*. 113(27): 7353–7360.

Barocas, S. and H. Hardt (2017). "Fairness in machine learning". In: *Proceeding of the 31st Thirty-First Conference on Neural Information Processing Systems*. Conference on Neural Information Processing Systems. December 4. https://nips.cc/Conferences/2017/Schedule?showEvent=8734.

Barocas, S. and A. Selbst (2016). "Big data's disparate impact". *California Law Review*. 104(3): 1–671.

Bernstein, F., S. Modaresi, and D. Sauré (2019). "A dynamic clustering approach to data-driven assortment personalization". *Management Science*. 65(5): 2095–2115.

Biamonte, J., P. Wittek, N. Pancotti, P. Rebentrost, N. Wiebe, and S. Lloyd (2017). "Quantum machine learning". *Nature*. 549(7671): 195–202.

Bishop, C. M. (2016). *Pattern Recognition and Machine Learning*. New York: Springer.

Blanchard, S. J., D. Aloise, and W. S. DeSarbo (2017). "Extracting summary piles from sorting task data". *Journal of Marketing Research*. 54(3): 398–414.

Blitzstein, J. K. and J. Hwang (2014). *Introduction to Probability*. CRC Press.

Bolukbasi, T., K.-W. Chang, J. Zou, V. Saligrama, and A. Kalai (2016). "Man is to computer programmer as woman is to homemaker? Debiasing word embeddings". *ArXiv: 1607.06520 [Cs, Stat]*. URL: http://arxiv.org/abs/1607.06520.

Braun, M. and A. Bonfrer (2011). "Scalable inference of customer similarities from interactions data using dirichlet processes". *Marketing Science*. 30(3): 513–531.

Braun, M. and P. Damien (2015). "Scalable rejection sampling for Bayesian hierarchical models". *Marketing Science*. 35(3): 427–444.

Brei, V. A., L. Nicolao, M. A. Pasdiora, and R. C. Azambuja (2020). "An integrative model to predict product replacement using deep learning on longitudinal data". *Brazilian Administration Review (BAR)*. 17(2): 1–33.

Breiman, L. (2001). "Random forests". *Machine Learning*. 45(1): 5–32.

Brownlee, J. (2016). “The machine learning mastery method”. *Machine Learning Mastery*. October 9. https://machinelearningmastery.com/machine-learning-mastery-method/.

Camerer, C. F., A. Dreber, F. Holzmeister, T.-H. Ho, J. Huber, M. Johannesson, M. Kirchler, G. Nave, B. A. Nosek, T. Pfeiffer, A. Altmejd, N. Buttrick, T. Chan, Y. Chen, E. Forsell, A. Gampa, E. Heikensten, L. Hummer, T. Imai, . . ., and H. Wu (2018). “Evaluating the replicability of social science experiments in nature and science between 2010 and 2015”. *Nature Human Behaviour*. 2(9): 637–644.

Cavagnaro, D. R., R. Gonzalez, J. I. Myung, and M. A. Pitt (2013). “Optimal decision stimuli for risky choice experiments: An adaptive approach”. *Management Science*. 59(2): 358–375.

Chahal, K. S. and K. Dey (2018). “A survey of modern object detection literature using deep learning”. *ArXiv: 1808.07256 [Cs]*. URL: http://arxiv.org/abs/1808.07256.

Chandukala, S. R., Y. D. Edwards, and G. M. Allenby (2011). “Identifying unmet demand”. *Marketing Science*. 30(1): 61–73.

Chen, Y., R. Iyengar, and G. Iyengar (2017). “Modeling multimodal continuous heterogeneity in conjoint analysis—A sparse learning approach”. *Marketing Science*. 36(1): 140–156.

Cheng, G. and J. Han (2016). “A survey on object detection in optical remote sensing images”. *ISPRS Journal of Photogrammetry and Remote Sensing*. 117: 11–28.

Chica, M. and W. Rand (2017). “Building agent-based decision support systems for word-of-mouth programs: A freemium application”. *Journal of Marketing Research*. 54(5): 752–767.

Chiong, K. X. and M. Shum (2019). “Random projection estimation of discrete-choice models with large choice sets”. *Management Science*. 65(1): 256–271.

Chollet, F. (2017). *Deep Learning with Python*. Manning Publications Company.

Chollet, F. and J. J. Allaire (2018). *Deep Learning with R*. Manning Publications Company.

Chung, J. and V. R. Rao (2012). “A general consumer preference model for experience products: Application to internet recommendation”. *Journal of Marketing Research*. 49(3): 289–305.

Conick, H. (2017). *The Past, Present and Future of AI in Marketing – American Marketing Association*. January 12. https://www.ama.org/marketing-news/the-past-present-and-future-of-ai-in-marketing/.

Cui, D. and D. Curry (2005). "Prediction in marketing using the support vector machine". *Marketing Science*. 24(4): 595–615.

Cui, G., M. L. Wong, and H.-K. Lui (2006). "Machine learning for direct marketing response models: Bayesian networks with evolutionary programming". *Management Science*. 52(4): 597–612.

Currim, I. S., R. J. Meyer, and N. T. Le (1988). "Disaggregate tree-structure modeling of consumer choice data". *Journal of Marketing Research*. 25(3): 253–265.

Cuzzocrea, A. (2014). "Privacy and security of big data: Current challenges and future research perspectives". *Proceedings of the First International Workshop on Privacy and Secuirty of Big Data*: 45–47.

Dancho, M. (2018). TensorFlow for R: Deep Learning with Keras to Predict Customer Churn. URL: https://blogs.rstudio.com/tensorflow/posts/2018-01-11-keras-customer-churn/.

Davis, B. (2017). "10 uses of computer vision in marketing & customer experience". *Econsultancy*. February 3. https://econsultancy.com/10-uses-of-computer-vision-in-marketing-customer-experience/.

De Bruyn, A., J. C. Liechty, E. K. R. E. Huizingh, and G. L. Lilien (2008). "Offering online recommendations with minimum customer input through conjoint-based decision aids". *Marketing Science*. 27(3): 443–460.

De Matos, M. G., P. Ferreira, and M. D. Smith (2018). "The effect of subscription video-on-demand on piracy: Evidence from a household-level randomized experiment". *Management Science*: 5610–5630.

Deisenroth, M. P., A. A. Faisal, and C. S. Ong (2019). *Mathematics for Machine Learning.* Mathematics for Machine Learning. URL: https://mml-book.com/.

Domingos, P. (2012). "A few useful things to know about machine learning". *Communications of the ACM*. 55(10): 78–87.

Dorschel, A. (2019). "Data privacy in machine learning: A technical deep-dive". *Medium*. April 25. https://medium.com/luminovo/data-privacy-in-machine-learning-a-technical-deep-dive-f7f0365b1d60.

Dubé, J.-P. and S. Misra (2019). *Personalized Pricing and Customer Welfare* (SSRN Scholarly Paper ID 2992257). Social Science Research Network.

Dwork, C., F. McSherry, K. Nissim, and A. Smith (2006). "Calibrating noise to sensitivity in private data analysis". *Proceedings of the Third Conference on Theory of Cryptography*: 265–284.

Dzyabura, D. and J. R. Hauser (2011). "Active machine learning for consideration heuristics". *Marketing Science*. 30(5): 801–819.

Dzyabura, D., S. Jagabathula, and E. Muller (2019). "Accounting for discrepancies between online and offline product evaluations". *Marketing Science*. 38(1): 88–106.

Dzyabura, D. and H. Yoganarasimhan (2018). "Machine learning and marketing". In: *Handbook of Marketing Analytics*. Edward Elgar Publishing.

El Emam, K., E. Jonker, L. Arbuckle, and B. Malin (2011). "A systematic review of re-identification attacks on health data". *PLoS ONE*. 6(12).

Evgeniou, T., C. Boussios, and G. Zacharia (2005). "Generalized robust conjoint estimation". *Marketing Science*. 24(3): 415–429.

Evgeniou, T., M. Pontil, and O. Toubia (2007). "A convex optimization approach to modeling consumer heterogeneity in conjoint estimation". *Marketing Science*. 26(6): 805–818.

Farias, V. F. and A. A. Li (2019). "Learning preferences with side information". *Management Science*. 65(7): 3131–3149.

Fisher, A., C. Rudin, and F. Dominici (2019). "All models are wrong, but many are useful: Learning a variable's importance by studying an entire class of prediction models simultaneously". *ArXiv: 1801.01489 [Stat]*. URL: http://arxiv.org/abs/1801.01489.

Garbade, D. M. J. (2018). "Clearing the confusion: AI vs. machine learning vs. deep learning differences". *Towards Data Science*. September 14. https://towardsdatascience.com/clearing-the-confusion-ai-vs-machine-learning-vs-deep-learning-differences-fce69b21d5eb.

Gebru, T., J. Krause, Y. Wang, D. Chen, J. Deng, E. L. Aiden, and L. Fei-Fei (2017). "Using deep learning and Google street view to estimate the demographic makeup of neighborhoods across the United States". *Proceedings of the National Academy of Sciences*. 114(50): 13108–13113.

Geer, A. (2018). "How machine learning can help marketers measure multi-touch attribution – American marketing association". February 19. https://www.ama.org/2018/02/19/how-machine-learning-can-help-marketers-measure-multi-touch-attribution/.

Géron, A. (2019). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems*. (2nd edition). O'Reilly Media.

Gilbride, T. J., G. M. Allenby, and J. D. Brazell (2006). "Models for heterogeneous variable selection". *Journal of Marketing Research*. 43(3): 420–430.

Goldberg, D. E. and J. H. Holland (1988). "Genetic algorithms and machine learning". *Machine Learning*. 3(2): 95–99.

Goodfellow, I., Y. Bengio, and A. Courville (2016). *Deep Learning*. Cambridge: MIT Press.

GPPR (2018). "General Data Protection Regulation (GDPR) – Official Legal Text". General Data Protection Regulation (GDPR). URL: https://gdpr-info.eu/.

Grushka-Cockayne, Y., V. R. R. Jose, and K. C. Lichtendahl (2017). "Ensembles of overfit and overconfident forecasts". *Management Science*. 63(4): 1110–1130.

Guelman, L., M. Guillén, and A. M. Pérez-Marín (2015). "Uplift random forests". *Cybernetics and Systems*. 46(3–4): 230–248.

Hauser, J. R., G. L. Urban, G. Liberali, and M. Braun (2009). "Website morphing". *Marketing Science*. 28(2): 202–223.

Hauser, J. R., O. Toubia, T. Evgeniou, R. Befurt, and D. Dzyabura (2010). "Disjunctions of conjunctions, cognitive simplicity, and consideration sets". *Journal of Marketing Research*. 47(3): 485–496.

He, T. (2018). "*Xgboost v0.71.2*. R Documentation". URL: https://www.rdocumentation.org/packages/xgboost/versions/0.71.2.

He, K., X. Zhang, S. Ren, and J. Sun (2015). "Deep residual learning for image recognition". *ArXiv: 1512.03385 [Cs]*. URL: http://arxiv.org/abs/1512.03385.

Hitsch, G. J. and S. Misra (2018). *Heterogeneous Treatment Effects and Optimal Targeting Policy Evaluation* (SSRN Scholarly Paper ID 3111957). Social Science Research Network. DOI: 10.2139/ssrn.3111957.

Hoff, P. D. (2009). *A First Course in Bayesian Statistical Methods*. Springer Science & Business Media.

Hollenbeck, B. (2018). "Online reputation mechanisms and the decreasing value of chain affiliation". *Journal of Marketing Research*. 55(5): 636–654.

Homburg, C., L. Ehm, and M. Artz (2015). "Measuring and managing consumer sentiment in an online community environment". *Journal of Marketing Research*. 52(5): 629–641.

Hu, M. (Mandy), C. (Ivy) Dang, and P. K. Chintagunta (2019). "Search and learning at a daily deals website". *Marketing Science*. 38(4): 609–642.

Huang, T. (1996). *Computer Vision: Evolution and Promise*. CERN.

Huang, D. and L. Luo (2016). "Consumer preference elicitation of complex products using fuzzy support vector machine active learning". *Marketing Science*. 35(3): 445–464.

Huang, M.-H. and R. T. Rust (2018). "Artificial intelligence in service". *Journal of Service Research*. 21(2): 155–172.

Huang, Z., D. D. Zeng, and H. Chen (2007). "Analyzing consumer-product graphs: Empirical findings and applications in recommender systems". *Management Science*. 53(7): 1146–1164.

Hulstaert, L. (2018). "Interpreting machine learning models". *Towards Data Science*. February 20. https://towardsdatascience.com/interpretability-in-machine-learning-70c30694a05f.

Hutter, F., R. Caruana, R. Bardenet, M. Bilenko, I. Guyon, B. Kégl, and H. Larochelle (2014). *AutoML workshop @ ICML'14*. URL: https://sites.google.com/site/automlwsicml14/.

Jacobs, B. J. D., B. Donkers, and D. Fok (2016). "Model-based purchase predictions for large assortments". *Marketing Science*. 35(3): 389–404.

Jagabathula, S. and P. Rusmevichientong (2019). "The limit of rationality in choice modeling: Formulation, computation, and implications". *Management Science*. 65(5): 2196–2215.

James, G., D. Witten, T. Hastie, and R. Tibshirani (2013). *An Introduction to Statistical Learning: With Applications in R*. Springer-Verlag. URL: http://www.springer.com/us/book/9781461471370.

Jean, N., M. Burke, M. Xie, W. M. Davis, D. B. Lobell, and S. Ermon (2016). "Combining satellite imagery and machine learning to predict poverty". *Science*. 353(6301): 790–794.

Jordan, M. I. and T. M. Mitchell (2015). "Machine learning: Trends, perspectives, and prospects". *Science*. 349(6245): 255–260.

Kaggle (2019). *Datasets*. Datasets | Kaggle. URL: https://www.kaggle.com/datasets.

Kaplan, A. and M. Haenlein (2019). "Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence". *Business Horizons*. 62(1): 15–25.

Kim, M. J. and A. E. B. Lim (2016). "Robust multiarmed bandit problems". *Management Science*. 62(1): 264–285.

Klette, R. (2014). *Concise Computer Vision: An Introduction into Theory and Algorithms*. Springer.

Kuhn, M. and K. Johnson (2013). "Over-Fitting and Model Tuning". In: *Applied Predictive Modeling*. Ed. by M. Kuhn and K. Johnson. New York: Springer. 61–92.

Lee, D., K. Hosanagar, and H. S. Nair (2018). "Advertising content and consumer engagement on social media: Evidence from facebook". *Management Science*. 64(11): 5105–5131.

Lemmens, A. and C. Croux (2006). "Bagging and boosting classification trees to predict churn". *Journal of Marketing Research*. 43(2): 276–286.

Li, Y. and A. Ansari (2014). "A Bayesian semiparametric approach for endogeneity and heterogeneity in choice models". *Management Science*. 60(5): 1161–1179.

Li, N., T. Li, and S. Venkatasubramanian (2007). "t-closeness: Privacy beyond k-anonymity and l-diversity". *2007 IEEE 23rd International Conference on Data Engineering*: 106–115.

Li, Z., X. Fang, X. Bai, and O. R. L. Sheng (2017). “Utility-based link recommendation for online social networks”. *Management Science*. 63(6): 1938–1952.

Liu, L. and D. Dzyabura (2016). “Capturing multi-taste preferences: A machine learning approach”. *SSRN Electronic Journal*. DOI: 10.2139/ssrn.2729468.

Liu, J. and O. Toubia (2018). “A semantic approach for estimating consumer content preferences from online search queries”. *Marketing Science*. 37(6): 930–952.

Makridakis, S. (2017). “The forthcoming artificial intelligence (AI) revolution: Its impact on society and firms”. *Futures*. 90: 46–60.

Marsland, S. (2015). *Machine Learning: An Algorithmic Perspective*. (2nd edition). CRC Press.

Martech (2017). “How computer vision may impact the future of marketing”. *MarTech Today*. September 6. https://martechtoday.com/computer-vision-may-impact-future-marketing-203605.

Mathematicalmonk (2019). “Mathematicalmonk”. URL: https://www.youtube.com/channel/UCcAtD_VYwcYwVbTdvArsm7w.

McMahan, B. and D. Ramage (2017). “Federated learning: Collaborative machine learning without centralized training data”. *Google AI Blog*. April 6. http://ai.googleblog.com/2017/04/federated-learning-collaborative.html.

Mishra, V. K., K. Natarajan, D. Padmanabhan, C.-P. Teo, and X. Li (2014). “On theoretical and empirical aspects of marginal distribution choice models”. *Management Science*. 60(6): 1511–1531.

Misra, K., E. M. Schwartz, and J. Abernethy (2019). “Dynamic online pricing with incomplete information using multiarmed bandit experiments”. *Marketing Science*. 38(2): 226–252.

Mitchell, T. M. (1997). *Machine Learning*. McGraw-Hill.

Molnar, C. (2019). “Interpretable machine learning: A guide for making black box models explainable”. URL: https://christophm.github.io/interpretable-ml-book/.

Montjoye, Y.-A. de, L. Radaelli, V. K. Singh, and A. “Sandy” Pentland (2015). “Unique in the shopping mall: On the reidentifiability of credit card metadata”. *Science*. 347(6221): 536–539.

Moon, S. and G. J. Russell (2008). "Predicting product purchase from inferred customer similarity: An autologistic model approach". *Management Science*. 54(1): 71–82.

Munster, G. (2018). "IPhone intent to upgrade survey suggests more predictable demand". *Loup Ventures*. March 12. https://loupventures.com/iphone-intent-to-upgrade-survey-suggests-more-predictable-demand/.

Murphy, K. P. (2012). *Machine Learning: A Probabilistic Perspective*. MIT Press.

Naik, P. A., M. K. Mantrala, and A. G. Sawyer (1998). "Planning media schedules in the presence of dynamic advertising quality". *Marketing Science*. 17(3): 214–235.

Neiswanger, W. (2019). "Intro to modern Bayesian learning and probabilistic programming". *Medium*. January 15. https://medium.com/@Petuum/intro-to-modern-bayesian-learning-and-probabilistic-programming-c61830df5c50.

Neslin, S. A., S. Gupta, W. Kamakura, L. U. Junxiang, and C. H. Mason (2006). "Defection detection: Measuring and understanding the predictive accuracy of customer churn models". *Journal of Marketing Research*. 43(2): 204–211.

O'Leary, D. E. (1998). "Knowledge acquisition from multiple experts: An empirical study". *Management Science*. 44(8): 1049–1058.

Piramuthu, S., H. Ragavan, and M. J. Shaw (1998). "Using feature construction to improve the performance of neural networks". *Management Science*. 44(3): 416–430.

Puranam, D., V. Narayan, and V. Kadiyali (2017). "The effect of calorie posting regulation on consumer opinion: A flexible latent dirichlet allocation model with informative priors". *Marketing Science*. 36(5): 726–746.

Rafieian, O. (2019a). *Optimizing user engagement through adaptive ad sequencing*. Technical report, Working paper. URL: http://staff.washington.edu/rafieian/data/part1.pdf.

Rafieian, O. (2019b). "*Revenue-Optimal Dynamic Auctions for Adaptive Ad Sequencing*". URL: https://staff.washington.edu/rafieian/data/part2.pdf.

Rafieian, O. and H. Yoganarasimhan (2020). *Targeting and Privacy in Mobile Advertising* (SSRN Scholarly Paper ID 3163806). Social Science Research Network. DOI: 10.2139/ssrn.3163806.

Rao, V. R. (2014). *Applied Conjoint Analysis*. Springer.

Ribeiro, M. T., S. Singh, and C. Guestrin (2016). "Why should I trust you?: Explaining the predictions of any classifier". In: *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*. 1135–1144.

Russell, S. and P. Norvig (2016). *Artificial Intelligence: A Modern Approach*. CreateSpace Independent Publishing Platform.

Ryzhov, I. O., B. Han, and J. Bradić (2016). "Cultivating disaster donors using data analytics". *Management Science*. 62(3): 849–866.

Samarati, P. and L. Sweeney (1998). *Protecting Privacy When Disclosing Information: K-Anonymity and Its Enforcement Through Generalization and Suppression.*

Sambasivan, R., S. Das, and S. K. Sahu (2018). "A Bayesian perspective of statistical machine learning for big data". *ArXiv: 1811.04788 [Cs, Stat]*. URL: http://arxiv.org/abs/1811.04788.

Schwartz, E. M., E. T. Bradlow, and P. S. Fader (2017). "Customer acquisition via display advertising using multi-armed bandit experiments". *Marketing Science*. 36(4): 500–522.

Schweidel, D. A., Y.-H. Park, and Z. Jamal (2014). "A multiactivity latent attrition model for customer base analysis". *Marketing Science*. 33(2): 273–286.

Shapley, L. S. (1953). "A value for n-person games". *Contributions to the Theory of Games*. 2(28): 307–317.

Shmueli, G. (2010). "To explain or to predict?" *Statistical Science*. 25(3): 289–310.

Sonnier, G. P., L. McAlister, and O. J. Rutz (2011). "A dynamic model of the effect of online communications on firm sales". *Marketing Science*. 30(4): 702–716.

Sprigg, J., K. Becker, and A. Cosmas (2014). "Estimating individual promotional campaign impacts through Bayesian inference". *Journal of Consumer Marketing*. 31(6/7): 541–552.

Sun, B. (2006). "Technology innovation and implications for customer relationship management". *Marketing Science*. 25(6): 594–597.

Sutton, R. S. and A. G. Barto (2018). *Reinforcement Learning: An Introduction*. MIT Press.

Tam, K. Y. and M. Y. Kiang (1992). "Managerial applications of neural networks: The case of bank failure predictions". *Management Science*. 38(7): 926–947.

Tillmanns, S., F. Ter Hofstede, M. Krafft, and O. Goetz (2017). "How to separate the wheat from the chaff: Improved variable selection for new customer acquisition". *Journal of Marketing*. 81(2): 99–113.

Tirenni, G., A. Labbi, C. Berrospi, A. Elisseeff, T. Bhose, K. Pauro, and S. Pöyhönen (2007). "Customer equity and lifetime management (CELM) finnair case study". *Marketing Science*. 26(4): 553–565.

Toubia, O. and L. Florès (2007). "Adaptive idea screening using consumers". *Marketing Science*. 26(3): 342–360.

Toubia, O. and O. Netzer (2017). "Idea generation, creativity, and prototypicality". *Marketing Science*. 36(1): 1–20.

Toubia, O., E. Johnson, T. Evgeniou, and P. Delquié (2013). "Dynamic experiments for estimating preferences: An adaptive method of eliciting time and risk parameters". *Management Science*. 59(3): 613–640.

Toubia, O., G. Iyengar, R. Bunnell, and A. Lemaire (2019). "Extracting features of entertainment products: A guided latent dirichlet allocation approach informed by the psychology of media consumption". *Journal of Marketing Research*. 56(1): 18–36.

Toubia, O., D. I. Simester, J. R. Hauser, and E. Dahan (2003). "Fast polyhedral adaptive conjoint estimation". *Marketing Science*. 22(3): 273–303.

Trevor, H., T. Robert, and J. H. Friedman (2009). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*. New York, NY: Springer.

Trusov, M., L. Ma, and Z. Jamal (2016). "Crumbs of the cookie: User profiling in customer-base analysis and behavioral targeting". *Marketing Science*. 35(3): 405–426.

Turing, A. M. (1950). "Computing machinery and intelligence". *Mind*. LIX(236): 433–460.

Urban, G. L., G. (Gui) Liberali, E. MacDonald, R. Bordley, and J. R. Hauser (2014). "Morphing banner advertising". *Marketing Science*. 33(1): 27–46.

Van Roy, B. and Y. Xiang (2010). "Manipulation robustness of collaborative filtering". *Management Science*. 56(11): 1911–1929.

Vepakomma, P., O. Gupta, T. Swedish, and R. Raskar (2018). "Split learning for health: Distributed deep learning without sharing raw patient data". *ArXiv: 1812.00564 [Cs, Stat]*. URL: http://arxiv.org/abs/1812.00564.

Verma, S. and J. Rubin (2018). "Fairness definitions explained". *Proceedings of the International Workshop on Software Fairness*: 1–7. DOI: 10.1145/3194770.3194776.

Viger, F. and M. Latapy (2005). "Efficient and simple generation of random simple connected graphs with prescribed degree sequence". In: *Computing and Combinatorics*. Ed. by L. Wang. Springer. 440–449.

Wager, S. and S. Athey (2018). "Estimation and inference of heterogeneous treatment effects using random forests". *Journal of the American Statistical Association*. 113(523): 1228–1242.

Wang, S. (1995). "The unpredictability of standard back propagation neural networks in classification applications". *Management Science*. 41(3): 555–560.

Wang, J., A. Aribarg, and Y. F. Atchade (2013). "Modeling choice interdependence in a social network". *Marketing Science*. 32(6): 977–997.

Wang, W., J. Xu, and M. Wang (2018). "Effects of recommendation neutrality and sponsorship disclosure on trust vs. Distrust in online recommendation agents: Moderating role of explanations for organic recommendations". *Management Science*. 64(11): 5198–5219.

Xia, F., R. Chatterjee, and J. H. May (2019). "Using conditional restricted boltzmann machines to model complex consumer shopping patterns". *Marketing Science*. 38(4): 711–727.

Xiao, L. and M. Ding (2014). "Just the faces: Exploring the effects of facial features in print advertising". *Marketing Science*. 33(3): 338–352.

Xu, K., H. Yue, L. Guo, Y. Guo, and Y. Fang (2015). "Privacy-preserving machine learning algorithms for big data systems". *2015 IEEE 35th International Conference on Distributed Computing Systems*: 318–327.

Yadav, A. (2018). "AutoML can be the next game-changing technology in 2018 for marketing operations". *Forbes*. March 9. https://www.forbes.com/sites/forbestechcouncil/2018/03/09/automl-can-be-the-next-game-changing-technology-in-2018-for-marketing-operations/.

Yoganarasimhan, H. (2020). "Search personalization using machine learning". *Management Science*. 66(3): 1045–1070.

Yoganarasimhan, H., E. Barzegary, and A. Pani (2019). "Design and evaluation of personalized targeting policies: Application to free trials". URL: https://faculty.washington.edu/hemay/Free_Trial.pdf.

Zhong, Z. (2019). "A tutorial on fairness in machine learning". *Medium*. July 27. https://towardsdatascience.com/a-tutorial-on-fairness-in-machine-learning-3ff8ba1040cb.

Zinkevich, M. (2019). "Rules of machine learning: Best practices for ML engineering". *Google Developers*. URL: https://developers.google.com/machine-learning/guides/rules-of-ml/.