

# **Bias and Fairness in Information Retrieval Algorithms on E-commerce Platforms**

**Abstract of the thesis to be submitted in partial fulfillment  
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by

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## Abstract

E-commerce platforms / marketplaces (e.g., Amazon, Walmart, Flipkart, Alibaba) have redefined the fabric of shopping across the globe. Customers and producers and / or sellers are the primary stakeholders of such marketplaces along with the platform organization itself. A number of information retrieval (IR) algorithms, e.g., recommendation, and search algorithms mediate the interaction between customers and producers in these marketplaces. Traditionally, these IR algorithms are keyed to relevance aimed at increasing customer engagement and satisfaction. However, after a period of expedited growth, currently researchers, policymakers are recognizing several inadvertent consequences of these algorithms toward different stakeholders such as producers on the marketplace. A primary reason for such consequences stem from the underlying ranking and scoring mechanisms in IR algorithms. While these algorithms may implicitly induce several biases due to such mechanisms, these effects can be further compounded by the way products are presented in the recommendation carousel or search engine result pages etc.

These concerns are even more worrying nowadays than they were before due to recent vertical integration of platforms in other facets of the marketplace. For example, manufacturing and selling of private label products; providing fulfillment services to sellers etc. Such involvements have resulted in the evolution of multiple special relationships among different stakeholders and the platform organization. A number of recent media articles, through anecdotal evidences, have pointed to e-commerce platforms rigging their algorithms and product placements to promote their in-house private label products. Therefore, these special relationships have the potential to undermine the competition and fairness of the marketplace and thus may have serious ramification on all the stakeholders associated.

The aforementioned concerns are strictly limited to traditional mediums where e-commerce platforms serve a number of options through search results and recommendations on product detail pages. However, online shopping is not merely limited to desktop or mobile apps nowadays. With the invention of voice assistants (VAs) (e.g., Alexa) and smart speakers (e.g. Echo dot), a few voice commands are all that is needed to purchase products online. In such interactions, the details of a single product is spelt out and the same is added to cart by VAs. Hence, the number of options to explore / choices to make has further reduced in the context of conversational e-commerce search. In other words, customers are ceding their autonomy to digital systems and their decision making algorithms. Such reduced autonomy of customers further warrants more responsible action and response from the VAs.

Motivated by these different issues and nuances, this thesis develops audit mechanisms to succinctly quantify biases in online e-commerce platforms and proposes probable mitigation strategies. Specifically, we make the following contributions:

**Framework for quantifying bias (if any) induced due to related item recommendation algorithms:** We propose a network centric framework to instantiate related item recommendations on Amazon e-commerce marketplace. Through a diverse set of bias quantification measures, in this work, we study the preferential treatment toward Amazon private label products in its related item recommendation.

**FaiRIR: fair related item recommendation algorithms:** We showcase that standard related item recommendation algorithms may beget exposure bias toward producers implicitly. To mitigate such bias and achieve individual fairness, we propose a novel suite of algorithms: **FaiRIR**, which intervenes at different stages of the related item recommendation pipeline to generate fair recommendations.

**Fairness and interpretability issues in conversational e-commerce search through Alexa:**

We investigate the responses and actions of Alexa voice assistant to different e-commerce search queries. Through empirical investigation and user survey, we establish that there is a significant gap between the customers' interpretation and Alexa's explanation of its responses. Further, we also quantify the potential unfairness in the action (product selection) done by Alexa toward different stakeholders of the marketplace.

In summary, this thesis is an attempt to uncover and mitigate certain inadvertent consequences (toward different stakeholders) of algorithms deployed on e-commerce marketplaces with the aim of making the marketplace a level playing field for all stakeholders. The findings of this dissertation can be of interest to not only the primary stakeholders of e-commerce platforms, but also to algorithm designers and policy makers alike.

**Keywords:** e-commerce marketplace, platform, information retrieval, search, recommendation, conversational search, voice assistant, private label product, exposure bias, fairness, interpretability.

## Publications from the thesis

1. **A. Dash**, A. Chakraborty, S. Ghosh, A. Mukherjee, K. P. Gummadi, *FaiRIR: Mitigating Exposure Bias from Related Item Recommendations in Two-Sided Platforms*, IEEE Transactions on Computational Social Systems (IEEE TCSS), April, 2022.
2. **A. Dash**, A. Chakraborty, S. Ghosh, A. Mukherjee, K. P. Gummadi, *Alexa, in you, I trust! Fairness and Interpretability Issues in E-commerce Search through Smart Speakers*, In Proceedings of The ACM Web Conference (WWW), April, 2022.
3. **A. Dash**, A. Chakraborty, S. Ghosh, A. Mukherjee, K. P. Gummadi, *When the Umpire is also a Player: Bias in Private Label Product Recommendations on E-commerce Marketplaces*, In Proceedings of the ACM Conference on Fairness, Accountability, and Transparency, (ACM FAccT), March, 2021.
4. **A. Dash**, A Mukherjee, S. Ghosh, *A Network-centric Framework for Auditing Recommendation Systems*, In Proceedings of the IEEE International Conference on Computer Communications (IEEE INFOCOM), April, 2019.

## All Publications

1. **A. Dash**, A. Chakraborty, S. Ghosh, A. Mukherjee, K. P. Gummadi, *FaiRIR: Mitigating Exposure Bias from Related Item Recommendations in Two-Sided Platforms*, IEEE Transactions on Computational Social Systems (IEEE TCSS), April, 2022.
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3. S. D. Jaiswal, K Duggirala, **A. Dash**, A. Mukherjee, *Two-Face: Adversarial Audit of Commercial Face Recognition Systems*, To be published in Proceedings of the International Conference On Web and Social Media (AAAI ICWSM), June, 2022.
4. **A. Dash**, A. Chakraborty, S. Ghosh, A. Mukherjee, K. P. Gummadi, *When the Umpire is also a Player: Bias in Private Label Product Recommendations on E-commerce Marketplaces*, In Proceedings of the ACM Conference on Fairness, Accountability, and Transparency, (ACM FAccT), March, 2021.
5. A. Shandilya, **A. Dash**, A. Chakraborty, K. Ghosh and S. Ghosh, *Fairness for Whom? Understanding the Reader's Perception of Fairness in Text Summarization*, International Workshop on Fair and Interpretable Learning Algorithms (FILA 2020), In conjunction with IEEE BigData, December, 2020.
6. **A. Dash**, A Shandilya, A. Biswas, K. Ghosh, S. Ghosh, A. Chakraborty, *Summarizing User-generated Textual Content: Motivation and Methods for Fairness in Algorithmic Summaries*, In Proceedings of the ACM on Human-Computer Interaction, vol. 3, No. CSCW, Article 172, November 2019.
7. **A. Dash**, A Mukherjee, S. Ghosh, *A Network-centric Framework for Auditing Recommendation Systems*, In Proceedings of the IEEE International Conference on Computer Communications (IEEE INFOCOM), April, 2019.