SHAPE-AWARE DEEP LEARNING FOR MODELS OF PRODUCTION

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Abstract. The stochastic frontier model (SFM) is widely employed in the analysis of productivity and efficiency, yet strict parametric forms, such as the Cobb-Douglas and Translog functions, are often assumed for modeling production, leading to potential misspecification issues. While semi- and nonparametric SFMs offer greater flexibility, they face challenges in imposing monotonicity and concavity to maintain their desirable economic interpretation. We develop a framework which enforces the shape restrictions within deep neural networks (DNNs). The stochastic frontier model we develop (DNN-SFM) leverages the flexibility and predictive power of DNNs while preserving key properties of a production function, such as free disposability and diminishing marginal product. Additionally, we demonstrate how to use Shapley values to measure and interpret global and local effects of individual inputs on the production frontier in cases when model parameters to not admit a simple interpretation. The performance of the proposed method is assessed using simulations while a real-world application to rice production in the Philippines illustrates empirical relevance of the proposed method.

Keywords: Deep neural networks, Stochastic frontier models, Shapley values

Mathematics Subject Classifications (2010): 62J05, 62P20, 68T07, 91B38

References

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