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# A Benchmarking Model Using Constrained Deep Learning

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## Abstract

[Abstract Only] This work presents a novel approach for accurate and theoretically grounded efficiency analysis in dynamic econometric environments, addressing the long-standing trade-off between computational tractability and economic interpretability. Multidirectional Efficiency Analysis (MEA) offers a rigorous framework for evaluating efficiency by jointly assessing potential improvements across inputs, desirable outputs, and undesirable outputs.
However, its computational demands—requiring the solution of multiple linear programming problems for each decision-making unit (DMU)—limit its scalability in large or real-time econometric settings. To overcome this barrier, we introduce the Advanced Monotonic Neural Network (AMNN), a constrained learning architecture designed to approximate MEA outcomes while preserving its core theoretical properties: boundedness, monotonicity, and convexity. By embedding these economic constraints directly into the model's structure and loss functions, the AMNN produces predictions that are both computationally efficient and economically consistent. Empirical evaluations on simulated and real-world econometric data demonstrate that the AMNN achieves high predictive accuracy while maintaining complete adherence to theoretical constraints—unlike conventional machine learning models. This approach opens new possibilities for real-time, interpretable efficiency analysis in applied econometrics.

**Keywords:** Econometrics, Efficiency, Benchmarking, Deep Learning