Digital Automation for Scope 3 Emissions Reporting of Complex Value Chains: A Machine Learning Based Approach

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Abstract

Scope 3 emissions typically account for the largest share of an organisation's emissions portfolio, covering indirect emissions across the upstream and downstream value chain activities. These emissions have become a central concern for organisations as emerging regulatory and government disclosure standards started moving from voluntary to mandatory reporting. However, measuring and reporting these emissions is difficult because it requires collecting and harmonising data across thousands of upstream and downstream suppliers. Consequently, many organisations use spend-based methods by linking general ledger expenditure records to emission factors as a proxy. This approach presents its own challenges, as mapping financial transactions to the appropriate Scope 3 categories and emission factors are often manual, time-consuming, and labour-intensive. This study introduces a machine learning-based approach to overcome these challenges by empirically evaluating four models, including both traditional and deep learning models, for classifying financial transaction data into EEIO categories. The authors employed a real-world

dataset from an Australian higher education institution. Using a real-world dataset, the study identified complexities in realistic operational datasets, including class imbalance, semantic interdependence, and high dimensionality. Selected traditional SVM and XGBoost, together with DistilRoBERTa-base and BiLSTM deep-learning models, were accordingly adapted and implemented to address these real-world dataset issues. The results indicate that both conventional and deep learning models perform well under different hyperparameters when the identified dataset complexities are taken into account. Deep learning models outperform conventional classifiers, achieving up to 95% accuracy and offering greater accuracy and reproducibility when organisations have sufficient technical capacity, budget, and other resources. By contrast, traditional models deliver commendable performance of up to 84%, underscoring their suitability for organisations with lower technical readiness and fewer resources. Hence, this study advances automated Scope 3 emissions accounting through the application of machine learning, thereby streamlining disclosure workflows and supporting organisational progress toward net-zero targets.

Keywords
Scope 3 emissions, machine learning, emissions accounting, climate change.

Biographies
Ishara Mudiyansege is currently a PhD candidate at the Faculty of Business and Law, School of Business, University of Wollongong, Australia. She received her B.Sc. (Honours) in Management and Information Technology from the University of Kelaniya, Sri Lanka, with a first class, specialising in Business Systems Engineering. Her PhD research project related to climate change impacts and adoption within the realm of complex service supply chains. She is an active researcher in the field of supply chain and logistics and has published several research papers. Her research interests include sustainable supply chains, digital technology adoption, Scope 3 emissions, optimisation and logistics.

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Dr Clayton McDowell is the Associate Director of Sustainability at the University of Wollongong (UOW), leading initiatives in energy, water, and biodiversity to achieve UOW's 2030 carbon neutrality goal. Previously, he was a Research Associate at the Sustainable Buildings Research Centre, where he managed the ARENA- and AIRAH-funded Innovation Hub for Affordable Heating and Cooling (i-Hub). This initiative created living laboratories in education and aged care facilities to trial new technologies. Clayton holds a PhD, a Bachelor's, and a Master's in Mechanical Engineering from UOW. His doctoral research examined energy use and thermal environments in low-income elderly housing to inform energy efficiency policies. Motivated by this work, he managed Team UOW's award-winning Desert Rose House for the Solar Decathlon Middle East 2018, focused on dementia-friendly, sustainable living. The project earned global and national recognition, including Engineers Australia's Excellence Award. A member of Engineers Australia, Clayton is passionate about sustainable building design, energy efficiency, and thermal comfort.

Dr Anura De Zoysa is an Associate Professor in the School of Business at the University of Wollongong (UOW), where he has taught since 2001 after completing his PhD in Accounting. Before joining UOW, he spent eight years in Japan researching cost management and management accounting in manufacturing, gaining unique expertise in

Japanese systems such as Genka Kikaku, Just-in-Time, and Kaizen. His research and teaching span cost management, corporate governance, CSR, sustainability, small business management, and accounting education. Anura has over 30 years of teaching experience in Sri Lanka, Japan, and Australia, with more than 90 publications and 1,700 citations, and his work on UOW's Research Online has attracted 82,000+ downloads worldwide. He has successfully supervised 17 higher degree research students and is a CPA, CMA, and FCA-qualified accountant with professional auditing and taxation experience. Recognised for excellence, he received UOW's OCTAL award (2019) and a Vice Chancellor's Award for Research Supervision.