ANALYSING SIGNIFICANT AUTOMOBILE CARBON DIOXIDE (CO_2) EMISSION FACTORS FOR ECO-FRIENDLY AUTOMOTIVE FRAMEWORKS USING DESCRIPTIVE ANALYTICS AND ARTIFICIAL NEURAL NETWORK (ANN) TECHNOLOGY

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DOCTOR OF PHILOSOPHY
(MARITIME TECHNOLOGY)

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ROZITA BINTI HUSAIN

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2024

ABSTRACT

The automotive industry's role in environmental sustainability has gained significant attention globally, with carbon dioxide (CO2) emissions being a primary concern. This study investigates the factors influencing CO2 emissions in automobiles within the context of eco-friendly frameworks. A comprehensive analysis is conducted using Partial Least Squares Structural Equation Modelling (PLS-SEM) and Artificial Neural Network (ANN) technology to understand the intricate relationships between various automotive factors and their impact on CO2 emissions.

The study identifies critical variables, including engine CC, horsepower, fuel type, track width, weight, aerodynamics, car segment, official euro class, transmission, emotion, knowledge and driving behaviour, hypothesized to influence CO2 emissions. Adopting PLS-SEM, these variables' direct and indirect effects on emissions are examined, providing insights into their relative importance and interdependencies. Moreover, the ANN model is deployed to explore nonlinear relationships and predict CO2 emissions more accurately.

Results indicate that engine efficiency and fuel type significantly affect CO2 emissions, with higher-efficiency engines and alternative fuels demonstrating a considerable reduction in emissions. Additionally, vehicle weight emerges as a crucial determinant, with lighter vehicles exhibiting lower emissions due to enhanced energy efficiency. Moreover, driving behaviour, encompassing factors such as speed patterns

and acceleration rates, influences emissions, emphasizing the importance of eco-conscious driving habits.

Integrating PLS-SEM and ANN technology enables a robust analysis of automotive factors contributing to CO2 emissions, offering valuable insights for eco-friendly automotive frameworks. By understanding these relationships, policymakers, manufacturers, and consumers can make informed decisions to mitigate emissions and promote sustainable transportation solutions. Future research could explore additional variables and refine modelling techniques to further enhance the understanding of CO2 emissions in the automotive sector and facilitate the transition towards a greener mobility landscape.

ABSTRAK

Peranan yang dimainkan oleh industri automotif dalam kelestarian alam sekitar telah mendapat perhatian penting di peringkat global, dengan pelepasan karbon dioksida (CO2) yang tidak terkawalan teleh mengakibatkan kebimbangan seluruh dunia. Kajian ini bertujuan mengenal pasti faktor-faktor yang mempengaruhi pelepasan CO2 oleh automotif dalam konteks rangka kerja mesra alam. Dengan menggunakan teknologi *Partial Least Squares Structural Equation Modeling (PLS-SEM)* dan *Artificial Neural Network (ANN*), analisis dijalankan secara komprehensif untuk memahami hubungkait diantara pelbagai faktor kejuruteraan, bentuk kenderaan dan pemanduan serta kesannya terhadap pelepasan CO2.

Kajian bermula dengan mengenal pasti pembolehubah utama dalaman, termasuk CC enjin, kuasa kuda, jenis bahan api, lebar trek, berat, aerodinamik, segmen kereta, kelas euro rasmi, transmisi dan pembolehubah luaran seperti pengetahuan, emosi dan tingkah laku pemanduan, yang dihipotesiskan boleh mempengaruhi pelepasan CO2. Dengan mengguna pakai PLS-SEM, kesan langsung dan tidak langsung pembolehubah ini terhadap pelepasan CO2 dikaji agar dapat memberikan pandangan tentang kepentingan relatifnya dan saling kebergantungannya. Selain itu, model ANN digunakan untuk meneroka perhubungan tak linear dan meramalkan pelepasan CO2 dengan lebih tepat.

Keputusan menunjukkan bahawa kecekapan enjin dan jenis bahan api memberi kesan ketara kepada pelepasan CO2, dengan kecekapan enjin yang lebih tinggi dan

bahan api alternatif menunjukkan pengurangan yang ketara dalam pelepasan CO2. Selain itu, berat kenderaan muncul sebagai penentu penting, dengan kenderaan yang lebih ringan menunjukkan pelepasan yang lebih rendah disebabkan oleh kecekapan tenaga yang dipertingkatkan. Selain itu, tingkah laku pemanduan, merangkumi faktor seperti corak kelajuan dan kadar pecutan, didapati mempengaruhi pelepasan, menekankan kepentingan tabiat pemanduan yang mementingkan alam sekitar.

Penyepaduan teknologi PLS-SEM dan ANN membolehkan analisis mantap dilakukan bagi mengenal pasti faktor automotif yang menyumbang kepada pelepasan CO2, menawarkan cerapan berharga untuk rangka kerja automotif mesra alam. Dengan memahami hubungan ini, penggubal dasar, pengilang dan pengguna boleh membuat keputusan termaklum untuk mengurangkan pelepasan dan mempromosikan penyelesaian pengangkutan yang mampan. Penyelidikan masa depan boleh meneroka pembolehubah tambahan dan memperhalusi teknik pemodelan untuk meningkatkan lagi pemahaman kami tentang pelepasan CO2 dalam sektor automotif dan memudahkan peralihan ke arah landskap mobiliti yang lebih hijau.

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Rozita Binti Husain

APPROVAL

The Examination Committee has met on **8 March 2024** to conduct the final examination of **Rozita Binti Husain** on his degree thesis entitled **Analysing Significant Automobile Carbon Dioxide (CO2) Emission Factors for Eco-Friendly Automotive Framework Using Descriptive Analytics and Artificial Neural Network (ANN) Technology.**

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LIST OF ABBREVIATIONS

$CapR^2$	-	Coefficient of Determination
AD	-	Automotive Design
AE	-	Automotive Engineering
AF	-	Alternative Fuels
AF	-	Automotive Features
AI	-	Artificial Intelligence
AM	-	Activation Maximisation
AMI	-	Active Mobility Infrastructure
ANN	-	Artificial Neural Network
AP	-	Alternative Propulsion
ARD	-	Automotive Research and Development
ARIMA	-	Auto-Regressive Integrated Moving Average
AVE	-	Average Variance Extracted
AVE	-	Average Variance Extracted
BAU	-	Business-As-Usual Baseline
CA	-	Cronbach's Alpha
CAE	-	Automotive Consumer Awareness and Education
CAFE	-	Corporate Average Fuel Economy
CAS	-	Complex Adaptive Systems
CB-SEM	-	Covariance-Based Sem
CC	-	Car Segment
cc	-	Cubic Centimetre
CCS	-	Carbon Capture and Storage
CFA	-	Confirmatory Factor Analysis
CH4	-	Methane
CI	-	Confidence Intervals
CMB	-	Common Method Bias
CNG	-	Compressed Natural Gas
CNN	-	Convolutional Neural Networks