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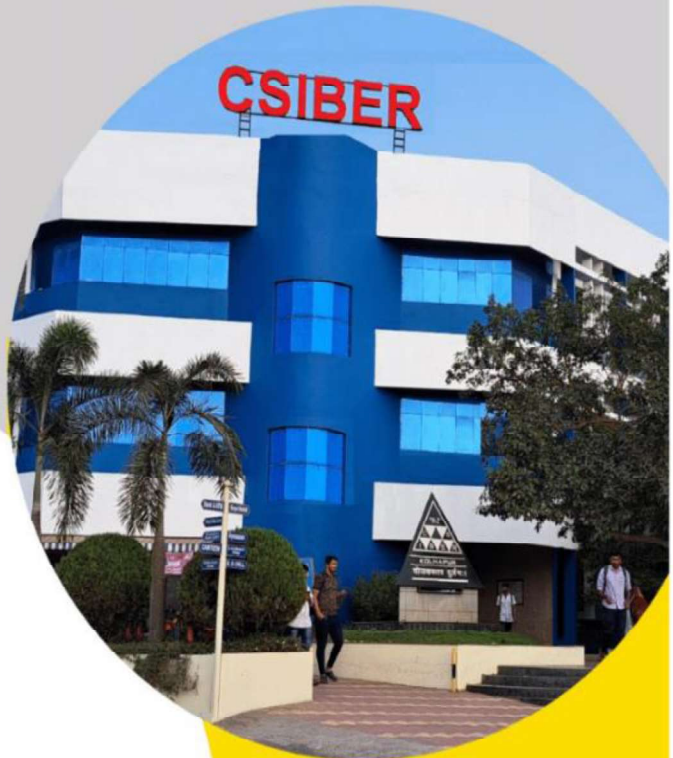
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CONTENTS

Structure Equation modeling for Fake Positive Detection of Advertisement Claims using Machine Learning Tools

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Abstract

Greenwashing, the practice of exaggerating or fabricating environmental claims, has become increasingly prevalent in today's sustainability-driven market. Identifying false positives-legitimate claims mistakenly flagged as deceptive—remains a critical challenge in tackling greenwashing in marketing. A recent study explored the potential of text mining techniques using Python to enhance the accuracy of detecting false positives in greenwashing allegations.

Leveraging Natural Language Processing (NLP) methods such as TF-IDF vectorization, cosine similarity, and classification models, the research analyzed 10,000 greenwashing statements to isolate and identify the most likely false positives. Additionally, visualization tools, including word clouds, conjoint word analysis, and network graphs, were used to uncover connections and patterns among misclassified claims. These techniques provided a comprehensive view of how greenwashing statements are structured and misinterpreted.

The findings demonstrated that the strategic use of Python's text mining capabilities could significantly reduce false positives, improving the reliability of automated greenwashing detection systems. Furthermore, the structural equation model developed in the study offers valuable insights for regulatory bodies, corporations, and consumers. This model serves as a guide to addressing deceptive environmental advertising, fostering greater transparency and accountability in sustainability-focused initiatives.

Keywords: Environmental Advertising, False Positives, Greenwashing, Text Mining, Natural Language Processing (NLP)

Introduction

Environmentalist Jay Westerveld initiated the term greenwashing in 1986 to criticize hotels for promoting towel reuse programs as eco-friendly while ignoring larger environmental issues such as overdevelopment. He observed that these programs were primarily aimed at cutting costs rather than reducing environmental impacts and thus represented a deceptive attempt to appear environmentally responsible (Westerveld, 1986). In addition, greenwashing has extended to describe the practice of companies making exaggerated or misleading statements about their environmental practices to enhance their public image without requiring significant changes to their environmental policies.

In the 1970s, Greenwashing became a major influence on the corporate social responsibility (CSR) movement. At this time, environmental concerns were becoming more frequent, and companies faced difficulties from both governments and the public to adopt more sustainable practices. However, many firms chose to market themselves as environmentally friendly without making significant improvements, leading to the early stages of greenwashing (Pearce, 1976). The 1990s saw a rise in greenwashing practices as environmental awareness grew among consumers. One significant event was the 1992 Rio Earth Summit, which encouraged many corporations to incorporate sustainability into their business strategies. Nevertheless, many of these efforts were superficial, focusing more on marketing than substantive change (United Nations Conference on Environment and Development, 1992).BP's "Beyond Petroleum" campaign in the early 2000s pursued to rebrand the company as environmentally conscious, yet the firm continued to rely heavily on fossil fuel production (Hamilton, 2010). Similarly, Volkswagen's 2015 emissions scandal lime lighted how companies could falsely advertise their products as green, as in this case, claimed that their diesel cars met environmental standards when they had in fact manipulated emissions tests (Hotten, 2015).

The emergence of green consumption has further led to the spread of greenwashing. With the increasing demand for eco-friendly products, companies have recognized the market value of being sustainable. Many have commissioned deceptive tactics, such as using vague terms like "natural" or "eco-friendly," without backing these claims with supportable data (TerraChoice, 2010). These tactics not only mislead consumers but also undermined genuine efforts to promote sustainability. In response to growing concerns about greenwashing, regulatory bodies and certification systems have emerged to ensure companies are more accountable. An instance was the inception of ISO 14001 certification that provided a framework for organizations to meet environmental management standards (Parguel, Benoît-Moreau, & Larceneux, 2011). In addition, independent organizations such as Green Seal and Energy Star have introduced certification labels to assist consumers in

recognizing genuinely sustainable products. Despite these efforts, greenwashing persists, exhibiting the ongoing tension between corporate profit motives and environmental responsibility.

Definitions

" Greenwashing is often defined as the process of making false or misleading claims about the positive environmental impacts of a product, service, or company. This includes overstating the eco-friendliness of goods or services, offering the misleading impression that a corporation is more ecologically responsible than it actually represents. Greenwashing takes place when companies broadcast positive information regarding their environmental performance while operating differently behind their doors."

- Delmas
, M. A., & Burbano, V. C. (2011).

"Greenwashing entails selective disclosure, where companies highlight ecologically conscious facets of their operations or products while negating or hiding negative environmental practices. Greenwashing can be understood as a method that includes advertising or publicizing selective environmentally friendly actions without addressing the more significant environmental impacts."

- Lyon, T. P., & Maxwell, J. W. (2011).

"Greenwashing can also be defined as a deliberate corporate strategy to improve reputation and gain market advantage by presenting a false image of environmental responsibility. Greenwashing is commonly adopted by corporations to attract environmentally conscientious customers and investors without making meaningful changes to their real operations."

- Marquis, C., Toffel, M. W., & Zhou, Y. (2016).

"Greenwashing may also apply to specific promotional strategies that deceive consumers into perceiving a product is more environmentally friendly than it is. Greenwashing is the application of deceptive communication strategies to falsely elevate the perception of a company's ecological responsibility."

- Parguel, B., Benoît-Moreau, F., & Larceneux, F. (2011).

The study encompasses a comprehensive review of historic literature, focusing on the meaning, history, and prior research on false positives, as detailed in Section 2. The research objectives are outlined in Section 3, providing clarity on the scope and goals of the study. Section 4 elaborates on the research methods employed to examine false positives, emphasizing the methodologies utilized to ensure a robust investigation. The analysis and discussion of the findings are presented in Section 5, offering critical insights into the study's results. A summary of results is provided in Section 6, encapsulating the key outcomes and their implications. Finally, Section 7 discusses the study's conclusions, while Section 8 explores directions for future research, proposing advancements to address identified gaps and challenges.

Literature Review

The term **advertisement** has seen substantial evolution, encompassing art, culture, and human behavior. O'Barr (2006) described advertisements as interpretive tools, enabling the study of diverse mediums, such as religious texts, novels, and films, focusing on the role of visual imagery. Broadbent (2000) further emphasized the behavioral impact of advertisements, linking customer-centered narratives to brand objectives. He highlighted how advertising builds brand personalities, simplifying consumer choices. Since Krugman's (1972) conceptualization of advertising engagement, which originally focused on interest and attention, the concept has expanded to include emotional, intellectual, and brand-level involvement. High engagement fosters stronger memory, credibility, and purchase intentions (Muehling et al., 1993). Soar (2000) advocated incorporating cultural studies to explore subjective elements of commercial culture, while Forceville (1994) examined the use of visual metaphors in advertisements, emphasizing their cognitive underpinnings. Historical advertising research revealed nuanced portrayals, such as Lerner and Kalof's (1999) study on animal depictions in commercials, uncovering sociological connections to gender and race. Meanwhile, MacInnis et al. (2002) analyzed advertising weight in mature product categories, discovering that creative elements, rather than media spending, influenced sales.

Commerce in ancient civilizations relied on strategies such as visual notices and interactive promotion (O'Barr, 2010). Over time, regulatory frameworks shaped advertising. The Federal Trade Commission (FTC), established in 1914, regulated deceptive marketing. Historical research by Starcevic (2015) traced branding's origins to ancient societies, highlighting its role in societal advancement. Works like *Fables of Abundance* (Lears) and *Where the Suckers Moon* (Rothenberg) challenged traditional advertising studies,

linking campaigns to societal perceptions (Bogart, 1995).The rise of advertising in 19th-century European cities, as explored by Wischermann (2019), was propelled by technological and societal changes. Later, Phillips and McQuarrie (2002) identified evolving rhetorical styles in U.S. advertisements, reflecting shifting consumer-marketer dynamics. Nostalgic advertising, such as fading downtown murals, illustrates historical and cultural transitions, underscoring the persistence of advertising as a cultural artifact (Lears, 1984).

Greenwashing, the practice of exaggerating environmental claims, has become pervasive. De Freitas Netto et al. (2020) categorized greenwashing into firm- and product-level typologies, while Parguel et al. (2015) revealed the misleading power of nature-evoking cues in advertising. Empirical studies, such as Baum's (2012) analysis of 247 advertisements, highlighted the prevalence of greenwashing, emphasizing stricter regulatory needs. Gephart et al. (2011) documented a surge in "green" claims over decades, calling for robust FTC guidelines to combat deceptive practices. Online advertising's dual role in economic value generation and cultural influence is evident in its reach and risks. Zarras (2014) explored online user safety, identifying systemic vulnerabilities in ad exchanges. Similarly, Ford et al. (2009) addressed malicious activity in dynamic web content through automated Flash content analysis, achieving high reliability. Poornachandran et al. (2016) highlighted malvertising challenges, offering innovative detection solutions.

Online advertisements can also be subject to criminal exploitation. Li and Zhang (2012) introduced MadTracer, a detection system that outperformed industry benchmarks in identifying malvertising. Additionally, Yih et al. (2006) proposed spam filters with enhanced false-positive mitigation. Häger and Landergren (2010) and Sculley et al. (2011) expanded fraud detection methodologies, leveraging machine learning and layered approaches to ensure classification reliability. Advertising research also delves into audience understanding. Ali et al. (2008) studied children's recognition of advertisements across mediums, emphasizing the role of media literacy in shaping consumer awareness. Beyond fraud detection, advertising remains a critical lens for analyzing consumer behavior, regulatory policies, and societal narratives.

The above discussion on research literature provides valuable insights into the evolution, growth, mechanisms, and limitations of the greenwashing phenomenon. However, the findings suggest the need for advanced modeling algorithms capable of capturing random combinations of key linguistic segments—adjectives, verbs, products, claims, and actions—that frequently appear in advertisements. These generated combinations could then be analyzed through similarity checks to determine the occurrence and frequency of false positives in greenwashing detection.

In response to this gap, this research paper proposes a two-stage functional model.

a. **Statement Generation**: The model systematically generates random statements by combining segments such as adjectives, verbs, products, claims, and actions, simulating the structure of potential greenwashing advertisements.
b. **Text Mining and Analysis**: These statements are then subjected to text mining techniques to isolate the top ten false-positive words and statements, helping to identify patterns and improve detection accuracy.
c. **Structure Equation Model** : Exploratory factor analysis and Path analysis needs to be ascertained for creating a standard sustainable model.

Research Objectives
The research objectives had clear objectives that included:
a. To generate 10,000 statements from random combinations using segments of adjectives, verbs, products, claims and actions.
b. To Identify false positive statements that represents false claims from the pool of 10,000 statements.
c. To create a standard Structure Equation Model to standardize the two-stage process of generation of false positive claims.

Research Methods
The study includes creating a pool of segments of English sentence vocabulary (adjectives, verbs, products, claims and actions). This pool of words has been randomly combined using machine learning method using Python version 3.0 (open-access) to generate ten thousand statements (text file). This text file was fetched to text mining python codes to generate word cloud, perform conjoint word analysis and network graph was generated to identify the most likely false positive advertisement claims. SEM diagram (https://semdiag.psychstat.org/) free tool was used to construct SEM (Structure Equation Modeling).(Yujiao Mai, Ziqian Xu, Zhiyong Zhang, Ke-Hai Yuan,2022).

Analysis and Discussion
The process of analysis included :
Creating pool of segments that include :
adjectives = ["eco-friendly", "natural", "sustainable", "green", "biodegradable", "carbon- neutral", "organic"]
verbs = ["reduce", "save", "protect", "improve", "preserve", "enhance", "clean"]
products = ["packaging", "materials", "bottles", "clothing", "detergent", "energy", "shampoo", "furniture"]
claims = ["100% recyclable", "certified green", "powered by nature", "ethically sourced", "environmentally friendly"]
actions = ["buy", "choose", "use", "switch to", "support", "invest in"]

Text mining for vague terms (words and statements) in text file

Top 10 most common words in false positive greenwashing statements:		Top 10 False Positives:	RANK
Word	**Count**		
environment:	8935	ethically sourced! Choose our natural materials to save the environment.	1
green	3444	ethically sourced! Support our organic bottles to preserve the environment.	2
friendly	2871	100% recyclable! Use our biodegradable bottles to improve the environment.	3
100	2029	ethically sourced! Use our organic energy to enhance the environment.	4
recyclable	2029	powered by nature! Invest in our sustainable bottles to save the environment.	5
environmentally	2022	certified green! Support our eco-friendly detergent to enhance the environment.	6
certified	1981	environmentally friendly! Buy our biodegradable energy to reduce the environment.	7
Buy	1518	100% recyclable! Choose our eco-friendly bottles to enhance the environment.	8
organic	1509	powered by nature! Buy our sustainable clothing to save the environment.	9
Use	1506	ethically sourced! Support our natural detergent to clean the environment.	10

Figure 1 Top 10 common words in false positives (words and statements)
(Source : Author)

Words such as 'environment', 'green','friendly','100', 'recyclable', 'environmentally', 'certified',' buy', 'organic' and 'use' were the ten false positive words derived from the text mining results. The randomly generated statements mainly comprised of , 'ethically sourced! Choose our natural materials to save the environment' and ' ethically sourced! Support our organic bottles to preserve the environment' were ranked as top false positive claims that can be highlighted by advertising companies (See Figure 1).

Word chart for 'FALSE- POSITIVE" words

Figure 2 Word Chart for top 10 false positive ad claims
(Source : Author)

Visual representation indicates highlighted words, such as ' environmental,' environmental', 'recycled' , 'certified' and ' green' as some of the most prominent words (See Figure 2).
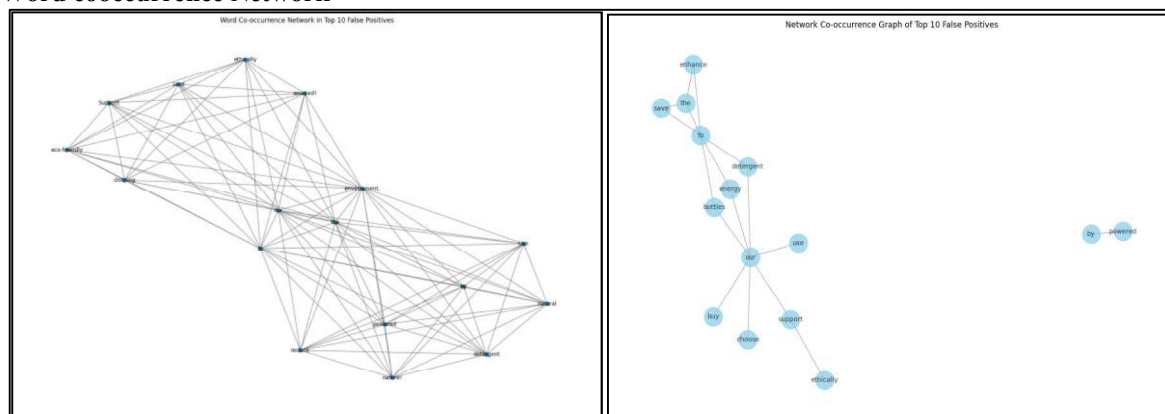
Word cooccurrence Network

Figure 3. Word cooccurrence Network and Graph for top 10 false positive ad claims
(Source : Author)

This code creates a network graph where each node represents a word, and each edge represents a co-occurrence of words in the same statement. The weight of the edges indicates how frequently the word pairs appear together. While ' OUR' word was connected to ' buy', 'choose' , 'use' and 'support', it was also visually seen to be connected to 'bottle', 'energy', ' detergent' respectively. 'TO' word also seemed to be connected to 'save', ' the' and ' enhance' words respectively (See Figure 3).

Metric testing
Table 1 Table of dependencies for structural equation model

SI. NO.	Independent variables	Dependent variable	R-squared value	Meaning
1	ADJECTIVE, VERB, PRODUCTS, CLAIMS, ACTION	STATEMENT POOL	0.89	89% of the variability in the dependent variable can be explained by the independent variables
2	Word cloud, Conjoint analysis, network graph	Fake word 1	0.81	81% of the variability in the dependent variable can be explained by the independent variables
3	Word cloud, Conjoint analysis, network graph	Fake word 2	0.79	79% of the variability in the dependent variable can be explained by the independent variables
4	Word cloud, Conjoint analysis, network graph	Fake word 3	0.78	78% of the variability in the dependent variable can be explained by the independent variables
	NET RESULT			Very strong structural equation model

Results
- Pool of Words are the common English vocabulary words that identifies the common adjectives, verbs, product, claims and actions words together constitutes a false positive statement (**Inputs**).

- Words such as 'environment', 'green','friendly','100' depicts the false positive words that may occur frequently in fake positive claims asserted by advertisement slogans (**see Figure 1 and Figure 2**).

- Network graph generated using text mining revealed keywords i.e. ' **OUR'** was connected to ' buy', 'choose' , 'use' and 'support' on one side, and connected to 'bottle', 'energy', ' detergent' on the other side of the network graph.(**Outputs**) (see **Figure 3**).

Based on the above results, A structure equation model has been proposed where adjectives, verb, products, claims, actions are observed ,independent or exogenous variables that generate statement pool (latent variable or endogenous variable). Statement pool is a mediator variable and word cloud, conjoint analysis, network graph are also mediator variables. Word cloud, Conjoint analysis and Network Graph are also latent variables that

depend on statement pool. Fake words (FW1, FW2, FW3) have emerged from word clouds, conjoint analysis and network graph. e1,e2,e3,e4,e5,e6,e7 are errors with respect to Statement pool, Word cloud, Conjoint analysis and Network Graph. The Structure Equation model or diagram (Figure 5) is based on exploratory factor analysis. Formative Construct reflective construct and path analysis from adjective, verb, products, claims, actions lead to detection of fake words in advertising world.
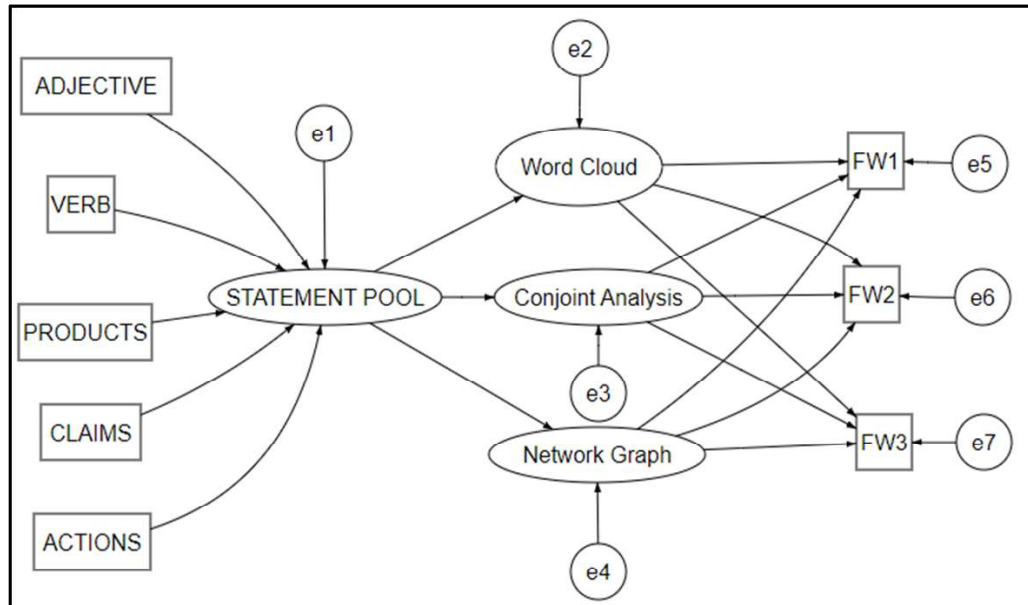
Figure 4. Structure Equation Modeling for Fake detection mechanism using machine learning tool
(Source : Author)

Mathematically, the structure equation model for fake positives can be represented as (See Figure 4) :

Exogenous Variables to Endogenous Variables:

$$S = a_1A + a_2V + a_3P + a_4C + a_5AC + e1$$

Mediator Variables

$$WC = \beta_1S + e2$$
$$CA = \beta_2S + e3$$
$$NG = \beta_3S + e4$$

Fake Words from Mediator Variables

$$FW1 = \beta_4WC + e5$$
$$FW2 = \beta_5CA + e6$$
$$FW3 = \beta_6NG + e7$$

where,

S represents Statement pool
A represents Adjectives
V represents Verb
P represents Products
C represents Claims
AC represents Actions
WC represents Word Cloud
CA represents Conjoint Analysis
NG represents Network graph
$FW1, FW2, FW3$ are three fake words
$\beta_1\ to\ \beta_7$ are coefficients of corelation between dependent and independent variables
e1to e7 are errors during formative construct and refractive construct

Conclusion:

From the above text mining analysis using python 3.0, we can infer that word pool (adjectives, Verbs,Products,Claims,Actions) can be used to generate thousand of statements. These statements can be text mined to generate word cloud, conduct conjoint word analysis and network graph. This analysis shall generate a list of fake words which can be further aggregated to generate a list of fake statements (for advertising claims as per the above analysis and discussion). A very strong variable dependency indicates that the model can be very effective in predicting fake positives for advertising claims (See Table 1 and figure 4).

Future Work:

In future, this model can be further tested on other pool of words form other significant domains such as marketing , finance, human resources and other areas. The list of fake positive words and statements in other domains can be easily ascertained. This proposed Two staged Fake statement detection model can prove to be great tool for qualitative analysis in case of large samples (actual or randomly generated).

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