Research Article

Evaluating the Fairness of Michelin Star Ratings as Indicators of Restaurants' ESG Performance and Sustainable Culinary Quality

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ABSTRACT

This study quantitatively analyzes how fairly the Michelin Guide's star ratings reflect restaurants' ESG (Environmental, Social, and Governance) management and sustainable gastronomy quality. Using open access data, the research statistically examines the relationships between Michelin stars and Green Stars (sustainability certification), as well as the effects of various factors such as price, region, descriptions, facilities, and menus. The results show that restaurants with the Green Star certification are more likely to receive higher star ratings. Still, this tendency is mainly concentrated among high-end restaurants, and there is significant inequality across regions and price levels. While eco-friendly keywords, facilities, and menu items are effective in earning the Green Star, they have a limited impact on star ratings. Although Michelin still holds considerable authority, the study concludes that true fairness requires the official expansion of ESG criteria and improvements in the transparency and balance of the evaluation system.

Keywords: Michelin Guide; ESG Management; Sustainability; Fairness of Evaluation; Data Analysis

INTRODUCTION

In the contemporary global era, unprecedented ease of access to cuisines from every corner of the world—coupled with rising disposable income—has heightened public interest in gastronomy. As diverse food cultures are disseminated through travel and media, consumers actively seek novel culinary experiences and, in doing so, naturally turn their attention to authoritative restaurant rankings such as the Michelin Guide. Now firmly established as a leading indicator of worldwide dining trends, the Michelin Guide exerts considerable influence over the entire food-service sector.

Concurrently, the restaurant industry has witnessed a marked surge in expectations surrounding ESG (environmental, social, and governance) management and sustainability. Today, diners and professionals alike evaluate establishments not only on flavor and service, but also on the ethical sourcing of ingredients, environmentally responsible operations, and contributions to local communities. Reflecting this shift, the Michelin Guide introduced the "Green Star" distinction around 2020 to commend restaurants that demonstrate exemplary commitment to sustainable practices—evidence that eco-friendly and ethical management have become salient issues in haute cuisine.

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Nevertheless, critics contend that Michelin's traditional assessment framework fails to capture fully these emerging values. Star ratings have historically been grounded in classical culinary criteria—ingredient quality, technical skill, harmony of flavors, value for money, and consistency. Elements such as environmental stewardship and social responsibility are conspicuously absent from the formal rubric. Consequently, even three-star restaurants often do not actively publicize sustainability initiatives. Indeed, one recent study found that fewer than half of Michelin's three-star establishments mention practices such as local sourcing on their websites, suggesting that Michelin's evaluation system remains anchored in conventional gastronomic metrics and is slow to mainstream modern sustainability concerns.

Against this backdrop, it is natural for students aspiring to enter the food industry to question whether Michelin's prestigious rating system keeps pace with societal change and maintains fairness. Should Michelin continue to neglect sustainability and corporate responsibility, it may offer the next generation of restaurateurs—and the industry as a whole—misleading signals about what merits recognition. Hence, an objective examination of the extent to which Michelin stars reflect ESG performance and sustainable culinary quality is urgently required.

Motivated by this need, the present researcher proposes to assess the fairness of Michelin evaluations from a fresh perspective, employing quantitative methodologies such as coding and data analytics. Rather than relying on traditional expert opinion or conjecture, this study aims to establish objective and reliable criteria through data-driven analysis, thereby contributing a rigorous foundation for understanding the Michelin Guide's alignment with contemporary values.

This study aims to achieve the following four objectives. Using data-driven methods, this paper first examines whether Michelin stars fairly reflect ESG practices and sustainable culinary quality. Then, it determines how contextual factors—price, geography, and narrative descriptions—shape this relationship. Third, regression and classification models are developed to quantify the independent contribution of ESG-related signals in relation to traditional predictors. Finally, the empirical evidence is translated into concrete, system-level recommendations for incorporating ESG into rating decisions transparently and equitably.

LITERATURE REVIEW

The Michelin Guide originated in 1900, when the French tire manufacturer Michelin published a handbook to help motorists locate lodging and dining options. A single-star rating was introduced in 1926, and by 1931, the now-familiar three-tier system had been codified. The stars carry graded meanings: one star denotes "high-quality cooking, worth a stop"; two stars signify "excellent cooking, worth a detour"; and three stars indicate "exceptional cuisine, worth a special journey." Evaluations are conducted anonymously, with inspectors applying classical criteria including quality of ingredients, culinary technique, harmony of flavors, value for money, and consistency (1). Although ancillary distinctions such as the Bib Gourmand and, more recently, the Green Star have been added, the core star system has long remained anchored in taste and traditional culinary craftsmanship.

In the 21st century, gastronomy has expanded beyond the pursuit of taste to embrace social responsibility and sustainability. Diners now value not only flavor and service but also environmentally friendly ingredients, community engagement, and ethical business practices. Global rating bodies have begun to account for ESG considerations, and in 2020 the Michelin Guide launched the Green Star to honor restaurants that exemplify "sustainable gastronomy" (2). This move signals Michelin's intent to incorporate environmental stewardship and social responsibility alongside culinary excellence.

Despite its global prestige, the Michelin Guide faces sustained criticism. First, its heavy reliance on traditional culinary metrics leaves sustainability and social responsibility underrepresented. Second, unequal accessibility—stemming from inspectors' geographic coverage, restaurant location, price range, and financial resources—can bias star allocations. Critics argue that the system structurally favors high-end, capital-intensive establishments, making it difficult for small or lower-priced venues to earn stars even when they exhibit comparable ecological and social commitment. Regional disparities in inspection capacity further exacerbate imbalances, prompting calls for greater fairness and transparency.

An expanding body of scholarship now examines the interplay between Michelin recognition and restaurant sustainability. Studies have quantified the impact of star status on revenues, reputation, and survival rates, while also examining correlations among star ratings,

ESG practices, and Green Star accreditation (3). In Korea, research frequently explores how Michelin listings influence regional food cultures and eco-friendly management, as well as shifts in consumer perception. Internationally, numerous quantitative analyses centered on Europe, the United States, and Japan investigate whether ESG initiatives predict star attainment or revenue growth (4). Recent work employs text mining, natural-language processing (NLP), and machine learning to probe the Michelin–sustainability nexus with greater precision (5).

To modernize culinary appraisal, researchers increasingly move beyond expert-only judgements toward data-centric methods. Web-scraping, data mining, machine learning, and NLP now leverage open datasets from platforms such as Kaggle, Google Maps, and Yelp, integrating ratings, star levels, ESG keyword frequencies, consumer reviews, and photographic evidence. Projects draw on text-mining analyses of eco-friendly or local-sourcing references, cluster and regression models to estimate star determinants, and deep-learning image classifiers—demonstrating that data-driven frameworks can surpass traditional Michelin assessments in objectivity, scalability, and real-time applicability and may emerge as a new standard for gastronomic evaluation.

Active policy discourse seeks to enhance the fairness and social value of Michelin assessments. Key recommendations include formally expanding the weight of ESG metrics in star decisions, increasing transparency in evaluation criteria, and leveling opportunities for low-cost or small-scale restaurants. Scholars propose forging stronger links between the Green Star and the star hierarchy measures to reduce regional and price-band disparities as well as multi-layered reward structures for eco-conscious and ethical management (6). Hybrid systems combining on-site inspections with data analytics, greater consumer and community participation, and the integration of sustainability certifications into star criteria are advanced as forward-looking approaches to bolster credibility, societal impact, and the sustainable evolution of the restaurant industry.

METHODOLOGY

Dataset Curation

The data was scraped using the Go-based crawler Go Colly and publicly released on Kaggle under an MIT license, which permits unrestricted academic use, as illustrated in Figure 1 (7). Inspection with df.shape showed that the raw data comprises 14 features and provides information on 17,735 restaurants. Figure 2 shows the 14 features which are Name, Address, Location, Price, Cuisine, Longitude, Latitude, PhoneNumber, Url, WebsiteUrl, Award, GreenStar, FacilitiesAndServices, and Description.

A cleaning step was also performed to remove features unnecessary for the analysis. Five features—Longitude, Latitude, PhoneNumber, Url, and WebsiteUrl—were dropped, yielding a dataset of 17,735. Subsequently, 912 rows containing null values in the FacilitiesAndServices feature were deleted, resulting in a final dataset containing 16,823 observations and nine

index	Name	Address	Location	Price	Cuisine	Longitude	Latitude	PhoneNumber	Url	WebsiteUrl	Award	GreenStar	FacilitiesAndServices	Description
0	Le Louis XV - Alain Ducasse à l'Hôtel de Paris	Place du Casino, Monaco, 98000, France	Monaco, France	€€€€	Mediterranean Cuisine, Modern Cuisine	7.4271047	43.7391839	37798068864.0	https://guide.michelin.com/en/monaco-region/monaco/restaurant/le-louis-xv-alain-ducasse-a-l-hotel-de-paris	https://www.ducasse-paris.com/	3 Stars	0	Air conditioning,Interesting wine list,Restaurant offering vegetarian menus,Terrace,Valet parking,Wheelchair access	It is difficult to present the Louis XV without mentioning Alain Ducasse. You need a raft of superlatives to describe his impact. This native of Orthez (in southwest France) with an enduring love for the Mediterranean is a brilliant chef and businessman. Now a citizen of Monaco, he also heads up an empire of over 30 establishments with a presence on every continent. He was just 33 years old when he was awarded three stars at the Louis XV after reaching an astonishing standard. His famous vegetable-based "Jardins de Provence" set menu, which launched here in Monaco on 27 May 1987, has been one of the touchstones of French gastronomy for the last 30 years. Here, Alain Ducasse's signature style is brought to life by his loyal right-hand man, Emmanuel Pilon, in cuisine that masterfully celebrates the essence of the ingredients and the Mediterranean.
1	L'Ambroisie	9 place des Vosges, Paris, 75004, France	Paris, France	€€€€	Classic Cuisine	2.3645215	48.855494	33142785145.0	https://guide.michelin.com/en/ile-de-france/paris/restaurant/l-ambroisie	https://www.ambroisie-paris.com/	3 Stars	0	Air conditioning,Restaurant offering vegetarian menus	What to say of the creations of Bernard Pacaud, the quality of which is matched only by his modesty? He doesn't give much away, preferring to let his cooking do the talking. His restaurant occupies an almost Florentine residence on the Place des Vosges, decorated with antique mirrors, huge tapestries, black and white marble floors and stunning contemporary wall panels lit by red LEDs. Unaffected by fads, uncompromising about the excellence of his ingredients, he pursues his path – that of a meticulous artisan. His dishes may appear to be simple, but each element is placed with absolute conviction. Just let yourself be swept along: lobster fricassee with civet sauce and Saint-Germain mousseline; Grenoble-style sweetbreads, green asparagus, caper sabayon; tarte fine sablée with bitter cocoa and vanilla ice cream.
2	Flocons de Sel	1775 route du Leutaz, Le Leutaz, Megève, 74120, France	Megève, France	€€€€	Modern Cuisine	6.5969625	45.8302404	33450214999.0	https://guide.michelin.com/en/auvergne-rhone-alpes/megve/restaurant/flocons-de-sel	https://www.floconsdesel.com	3 Stars	0	Car park,Garden or park,Great view,Interesting wine list,Restaurant offering vegetarian menus,Valet parking,Wheelchair access	(Temporarily closed, reopening planned for second half of 2025) Emmanuel Renaut fell in love with Haute Savoie as a child, long before achieving his Meilleur Ouvrier de France title, and his predilection for Alpine produce is deeply ingrained (pike, char and whitefish from Lake Geneva, mushrooms and wild herbs, mountain cheeses). At times he has fun subverting the regional cooking that is expected of him – a case in point being his superb langoustines marinated in citron, caviar with zesty grapefruit and gentian roots. Plants are also given an increasingly important role in his cuisine. An enchanting high-altitude chalet at the summit of fine dining.

Figure 1. Illustration of the Kaggle dataset on Michelin restaurants.

features, free of missing values, for use in the analysis.

Using the revised dataset, Figure 3 shows the distribution for the top 20 countries. Not surprisingly, France and Italy have the most significant numbers of Michelin-listed restaurants. Figure 4 represents the top 30 cuisine types in Michelin restaurants. The most popular cuisines are modern, contemporary, and creative, followed by traditional cuisine, Japanese, and Italian. Figure 5 shows the distribution by Michelin star level and only 152 restaurants have been awarded 3 Stars. According to Figure 6, about 3.6% of the restaurants in the dataset have the Green Star.

DATA ANALYSIS

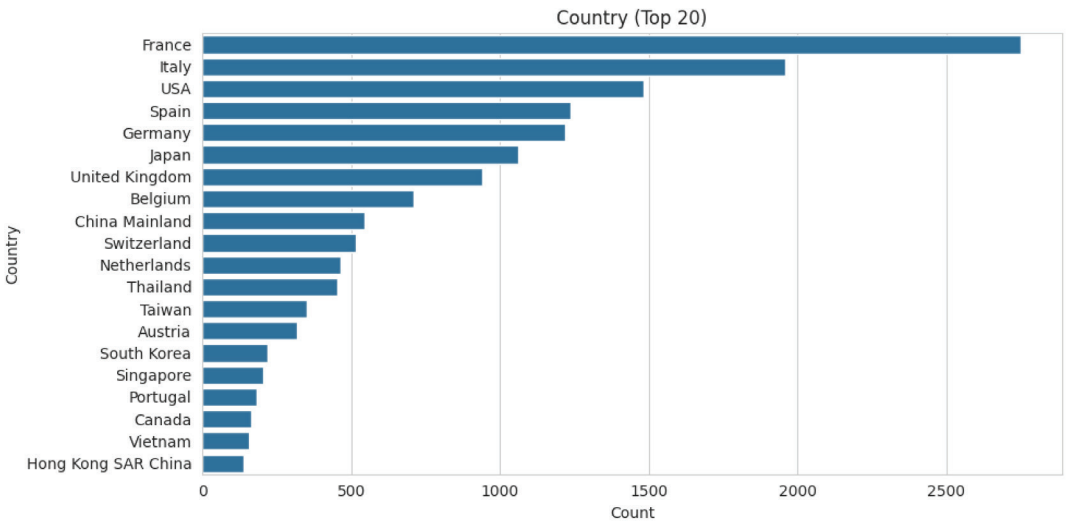
The pursuit of the objectives set forth at the start of this research is summarized in Table 1. The table identifies the thematic questions for topics concerning Green Star fairness, price bias, regional fairness, ESG keyword association, and the practical effect of facilities or menus in receiving the Michelin Star or Green Star. The purpose is to structurally evaluate whether the Green Star and relevant factors play an independent or systematic influence on Michelin star recognition.

Green Star Fairness

Analysis A tested whether ESG certification (Green Star) exerts an independent influence on Michelin star ratings. Three columns—Award, GreenStar, and Price—were extracted. The Award string was converted via a Python lambda function to the integer variable Star_num (0, 1, 2, 3) and further recoded into the binary variable Star3 (1 = three stars, 0 = otherwise). For Price, currency symbols (€, $, ¥, £, ₩, etc.) were

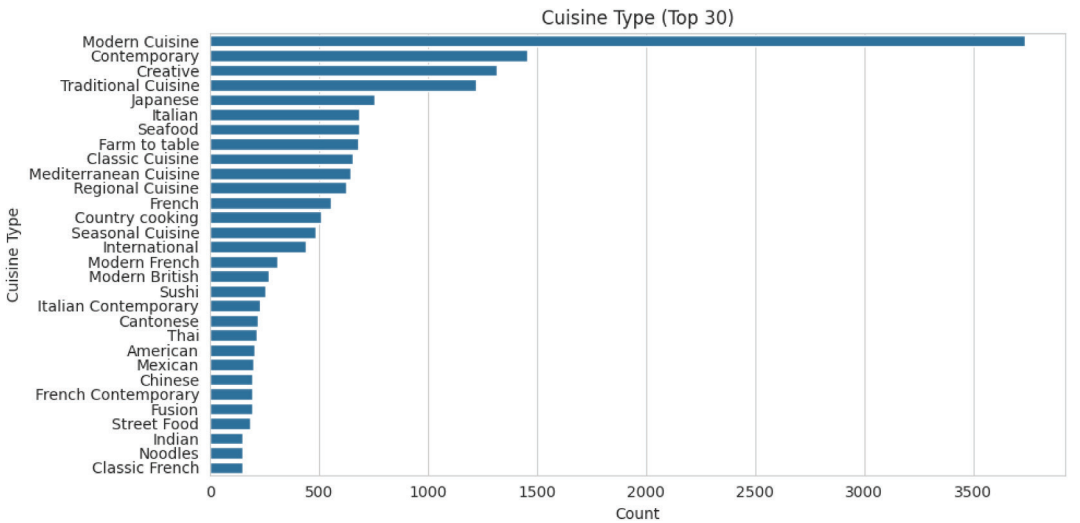
Figure 2. The dtypes of the 14 features provide the name, address, location, and price range of the restaurant; type of cuisine served at the restaurant; the longitude and latitude coordinates of the restaurant; and contact information, including telephone number, Michelin Guide URL, and the official website URL of the restaurant. It also identifies the type of award the restaurant received (3 Stars, 2 Stars, 1Star, Bib Gourmand) and indicates whether the restaurant has been awarded a Michelin Green Star for sustainable gastronomy. Information on the facilities and services offered at the restaurant, as well as a description of the restaurant, is also available.

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 17735 entries, 0 to 17734
Data columns (total 14 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   Name                  17735 non-null  object
 1   Address               17735 non-null  object
 2   Location              17735 non-null  object
 3   Price                 17735 non-null  object
 4   Cuisine               17735 non-null  object
 5   Longitude             17735 non-null  float64
 6   Latitude              17735 non-null  float64
 7   PhoneNumber           17369 non-null  float64
 8   Url                   17735 non-null  object
 9   WebsiteUrl            15248 non-null  object
 10  Award                 17735 non-null  object
 11  GreenStar             17735 non-null  int64
 12  FacilitiesAndServices 16823 non-null  object
 13  Description           17735 non-null  object
dtypes: float64(3), int64(1), object(10)
memory usage: 1.9+ MB
```



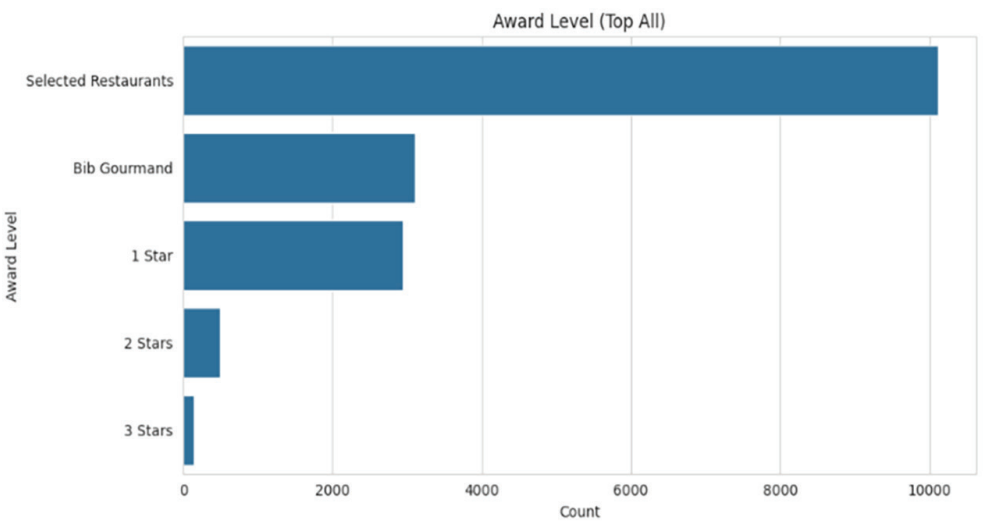
	Country	Count
0	France	2752
1	Italy	1958
2	USA	1482
3	Spain	1236
4	Germany	1221
5	Japan	1062
6	United Kingdom	942
7	Belgium	709
8	China Mainland	544
9	Switzerland	516

Figure 3. Visual representations of the top 20 countries with the most Michelin restaurants.



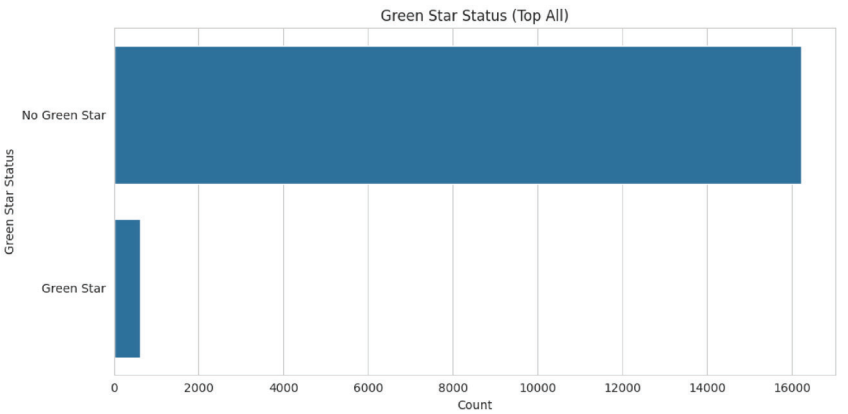
	Cuisine Type	Count
0	Modern Cuisine	3735
1	Contemporary	1455
2	Creative	1315
3	Traditional Cuisine	1219
4	Japanese	757
5	Italian	687
6	Seafood	687
7	Farm to table	679
8	Classic Cuisine	655
9	Mediterranean Cuisine	646

Figure 4. Distribution of the top 30 cuisine types.



	Award Level	Count
0	Selected Restaurants	10115
1	Bib Gourmand	3105
2	1 Star	2951
3	2 Stars	500
4	3 Stars	152

Figure 5. Distribution by Michelin star level.



	Green Star Status	Count
0	No Green Star	16217
1	Green Star	606

Figure 6. Distribution according to the presence or absence of a Green Star.

Table 1. Analytical framework for ESG certification and Michelin star outcomes

Topic	Question	Method
A. Star–Green Star Fairness	Does ESG certification (Green Star) exert an independent effect on Michelin star assignment?	pandas.crosstab + scipy.stats.chi2_ contingencystatsmodels.logit
B. Price Bias	Is ESG recognition applied uniformly across different price brackets?	pandas.pivot_table + matplotlibstatsmodels. logit (GreenStar×Price_band)
C. Regional Fairness	Is certification distributed evenly from one country to another?	pandas.groupby·agg
D. ESG Keyword–Star Association	Do ESG-related keywords in Michelin's narrative descriptions influence star ratings or Green Star designation?	sklearn TfidfVectorizer + LogisticRegression(L1)cross_val_score (AUC)statsmodels.logit
E. Facility/Menu Practice Effect	Do eco-friendly facilities or menu practices contribute to the likelihood of receiving stars or certification?	TfidfVectorizer + NMF(10) → ESG_topic_ scorepearsonrstatsmodels.logit

extracted using regular expressions, counted, and stored as Price_band (levels 1–4) to quantify price. GreenStar was already coded 0/1 and was used unchanged. Preprocessing was completed with pandas and the re module in a few dozen lines of code.

A contingency table of certification status and star count was created with pandas.crosstab, and a chi-square test of independence was performed using scipy.stats.chi2_contingency. With 16,823 observations, the test yielded $\chi^2 = 46.72$, $p = 7.171 \times 10^{-11}$, decisively rejecting the null hypothesis of independence. As evident in Figure 7, certified and non-certified restaurants therefore show systematically different star distributions, necessitating control for the price effect whereby higher-priced establishments are more likely to obtain stars.

To this end, a logistic regression model was fitted with statsmodels.formula.api.logit: $\text{logit}(P(\text{Star3})) = \beta_0 + \beta_1\ \text{GreenStar} + \beta_2\ \text{Price\_band}$. Maximum-likelihood estimation yielded $\beta_1 = 1.396$ (SE = 0.20, z = 6.97, $p < 0.001$) and $\beta_2 = 4.04$ (SE = 0.50, $p < 0.001$), both of which were significantly positive. Exponentiation gives $\exp(1.396) \approx 4$, indicating that, within the same price band, Green Star restaurants have approximately four times the odds of holding three Michelin stars compared with non-certified peers. The McFadden pseudo-R^2 is 0.27, indicating that the two predictors account for approximately 27% of the variance in three-star attainment. Convergence was normal despite the rarity (~0.8 %) of three-star cases, and coefficient significance was robust to heteroskedasticity-consistent standard errors as seen in Figure 8.

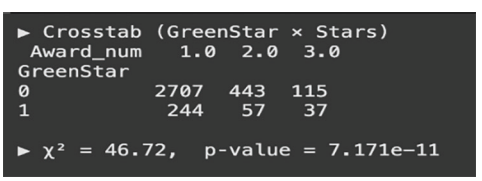


Figure 7. Crosstabulation of ESG Certification (Green Star) and Michelin Star assignment.

4) The chi-square test provides primary evidence of a statistical association between star ratings and certification. At the same time, the logistic model indicates that ESG certification, regardless of price, increases the odds of a three-star rating by approximately fourfold. This suggests that Michelin evaluations recognize sustainability certification in and of itself, in addition to gastronomic quality. However, because certification entails financial and administrative costs, small and medium-sized restaurants may struggle to translate equivalent eco-friendly practices into the highest accolade. Thus, in Figure 9, Michelin stars partially reflect ESG performance, but economic barriers to certification conditionally constrain their fairness.

Price Bias

Analysis B explores price bias by testing whether Michelin rewards sustainability certification equally across all price bands. Three columns were retained: Award, GreenStar, and Price. Award strings were re-encoded as the integer variable Star_num (0, 1, 2,

3) and the binary variable Star3 (1 = three stars, 0 = otherwise). GreenStar remained coded 0/1. Price strings were parsed with regular expressions to count currency symbols, and the count was stored as Price_band (levels 1–4). All preprocessing was executed in Python with pandas and re.

With the data prepared, a pivot table (pandas.pivot_table) was used to compute mean star scores by Price_band, placing certified (1) and non-certified (0) restaurants in adjacent columns. A line plot generated with matplotlib.pyplot visualized these means as presented in Figure 10. In band 1, both groups approached zero; in band 2 the means were 0.014 versus 0.032; in band 3 0.213 versus 0.468; and, in band 4 0.876 versus 1.327, indicating that the gap widens as price increases.

To test the interaction statistically, a logistic regression was fitted with statsmodels.formula.api.logit: Star3 ~ GreenStar × Price_band. The estimates were: Price_band = 4.21 (SE 0.57, $p < 0.001$), GreenStar = 1.57 (1.06, $p = 0.14$), and the interaction GreenStar × Price_band = –0.86 (1.15, $p = 0.46$). Re-estimating with Price_band treated as categorical showed a positive GreenStar effect only in the high-price bands (3–4); in low-price bands, the near-absence of three-star cases caused unstable or failed estimates. Simulations indicated that for band 4 restaurants, certification raises the predicted probability of three stars from about 3.4 % to 11.9 %, whereas in bands 1–2 the difference is practically zero as displayed in Figure 11.

These results show that Michelin does not reward sustainability certification uniformly: the Green Star has a stronger impact on star ratings among expensive restaurants. Consequently, Michelin's stated incorporation of ESG considerations is only

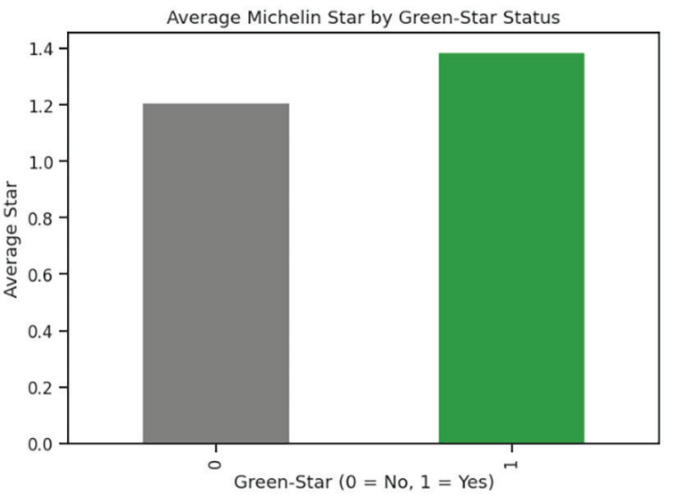


Figure 9. Comparison of average Michelin ratings by ESG certification.

Average Stars by Price Band & Green-Star

GreenStar	0	1
Price_band		
1	1.000000	NaN
2	1.023529	1.000000
3	1.035849	1.075949
4	1.302033	1.500000

Figure 10. Average stars by price band and Green Star.

Optimization terminated successfully.
Current function value: 0.037617
Iterations 12

Logit Regression Results

Dep. Variable:	Star3	No. Observations:	16823
Model:	Logit	Df Residuals:	16820
Method:	MLE	Df Model:	2
Date:	Sat, 19 Apr 2025	Pseudo R-squ.:	0.2699
Time:	17:23:01	Log-Likelihood:	-632.83
converged:	True	LL-Null:	-866.72
Covariance Type:	nonrobust	LLR p-value:	2.644e-102

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-16.7573	1.385	-12.103	0.000	-19.471	-14.044
GreenStar	1.3959	0.200	6.972	0.000	1.004	1.788
Price_band	3.3653	0.351	9.592	0.000	2.678	4.053

Possibly complete quasi-separation: A fraction 0.48 of observations can be perfectly predicted. This might indicate that there is complete quasi-separation. In this case some parameters will not be identified.

Figure 8. Logistic regression of Michelin three-star attainment on ESG certification (Green Star) and price band.

partially realized under a price bias. Lower-priced establishments, even when certified, gain little star-rating benefit, implying that assessment fairness varies with economic status. As suggested in Figure 12, minimizing the influence of price or recalibrating star rewards for lower-priced venues would be necessary for the system to function as an equitable ESG incentive.

Regional Fairness

Analysis C was undertaken to examine how evenly sustainability certification (Green Star) is distributed across regions. The variables Location, Award, and GreenStar were selected. Using the pandas string methods str.split and str.strip, the Location string was split at commas, the last token was extracted as the country name, and this was stored in a new variable, Country. Since Award had already been converted to the integer star count (Star_num) in earlier work, it was used unchanged; likewise, GreenStar remained a 0/1 indicator.

To quantify national differences, pandas.groupby was applied to compute three metrics for each country: (i) n, the number of listed restaurants; (ii) green_ratio, the mean of GreenStar, representing the certification rate; and (iii) avg_star, the mean of Star_num, representing the average star score. The resulting table was sorted in descending order of n, and the fifteen countries with the largest samples were retained. A bar chart of green_ratio values was produced with matplotlib.pyplot.bar, although interpretation was presented numerically.

Certification rates varied markedly by country. Switzerland recorded the highest rate, 6.01 % (71 of 1 221 establishments), followed by Germany (5.81 %) and Spain (4.61 %). In contrast, many non-European countries remained around two percent: the United States 2.23 %, Japan 2.92 %, South Korea 0.91 %, mainland China 0.74 %. When certification rates were compared with average star scores, Japan showed the highest avg_star (0.43) yet only a mid-range certification rate. In contrast, Austria displayed a high certification rate (10.4 %) but an avg_star of 0.32, like Germany. Thus, Figure 13 shows that a one-to-one correspondence between certification and star score was not observed across countries.

The findings demonstrate that the Michelin Green

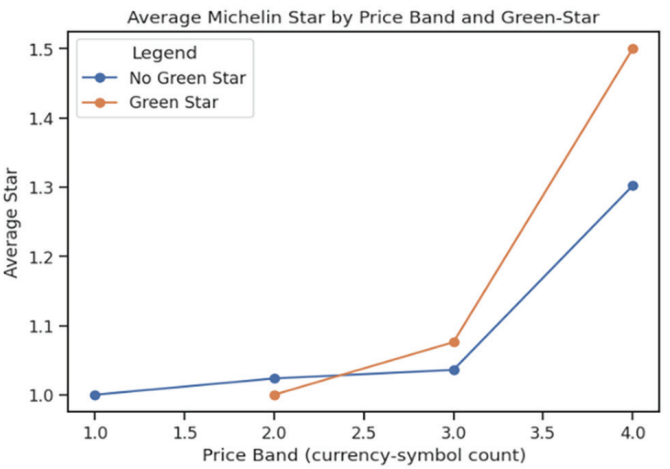


Figure 12. Average Michelin star by price band and Green Star.

```
         Current function value: 0.038294
         Iterations: 35
                          Logit Regression Results
==============================================================================
Dep. Variable:                  Star3   No. Observations:                16049
Model:                          Logit   Df Residuals:                    16041
Method:                           MLE   Df Model:                            7
Date:                Sat, 19 Apr 2025   Pseudo R-squ.:                 0.2811
Time:                        17:23:02   Log-Likelihood:                -614.57
converged:                      False   LL-Null:                       -854.87
Covariance Type:            nonrobust   LLR p-value:                1.187e-99
================================================================================================
                                   coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------------------------
Intercept                      -25.8869   1.25e+04     -0.002      0.998   -2.46e+04    2.45e+04
C(Price_band)[T.2]              -7.7465   2.54e+05  -3.04e-05      1.000   -4.99e+05    4.99e+05
C(Price_band)[T.3]              18.4584   1.25e+04      0.001      0.999   -2.45e+04    2.46e+04
C(Price_band)[T.4]              22.6168   1.25e+04      0.002      0.999   -2.45e+04    2.46e+04
GreenStar                       -0.1458   1.59e+05  -9.15e-07      1.000   -3.13e+05    3.13e+05
GreenStar:C(Price_band)[T.2]    -0.1481   2.12e+06  -6.98e-08      1.000   -4.16e+06    4.16e+06
GreenStar:C(Price_band)[T.3]     2.3704   1.59e+05   1.49e-05      1.000   -3.13e+05    3.13e+05
GreenStar:C(Price_band)[T.4]     1.5147   1.59e+05    9.5e-06      1.000   -3.13e+05    3.13e+05
================================================================================================
```

Figure 11. Effects of Green Star and price band on Michelin 3 star outcomes.

Star program is not applied uniformly worldwide. Even with identical environmental performance, country-specific factors—such as inspection infrastructure, local policy environments, and the breadth of data collection—cause certification probabilities to diverge from the one-percent range to over six percent. Regarding the overarching question of whether Michelin star ratings fairly represent restaurants' ESG management, these regional disparities indicate a failure to meet the prerequisite of fairness. Certain countries offer a higher likelihood of certification for the same sustainability level, and, as a result, a greater probability that certification will translate into an elevated star rating. To secure genuine global equity, Michelin must standardize the size and criteria of national inspection teams and harmonize regional data coverage and access to certification through additional institutional design.

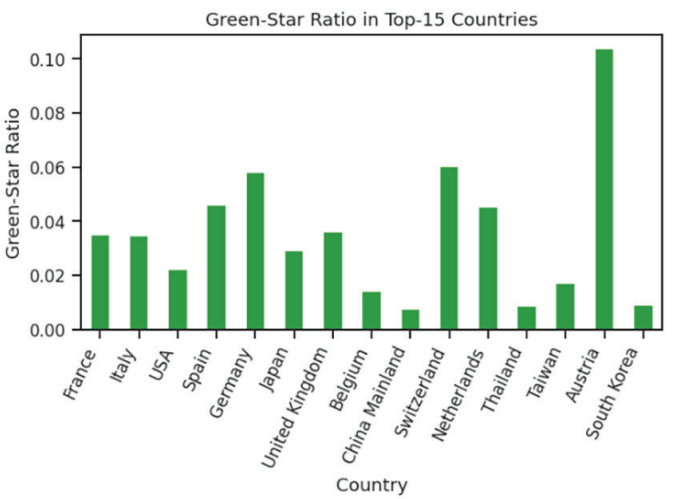
ESG Keyword–Star Association

Analysis D was a text-mining experiment designed to investigate the relationship between sustainability-related keywords in restaurant descriptions and Green Star certification and Michelin star ratings. The variables employed were Description (restaurant narrative), GreenStar (ESG-certification indicator), and Award (star grade); the previously created Price_band was included as an auxiliary variable to control for price bias partially.

Using Python's sklearn.feature_extraction.text. TfidfVectorizer, English stop words were removed (stop_words='english') and unigrams plus bigrams were extracted (ngram_range=(1, 2)). Setting min_df=5 to filter rare terms produced a sparse TF–IDF matrix of roughly 16 000 rows and 30 000 columns. A logistic-regression classifier from sklearn.linear_model, fitted with an L1 penalty (liblinear solver), was trained to predict GreenStar; the L1 regularization performed implicit feature selection by retaining only informative terms. Five-fold stratified cross-validation gave a mean ROC-AUC of 0.846 (≈ 0.05 s.d.), indicating that certification status can be classified with high accuracy from the descriptions alone. Figure 14 shows that the model's class-probability output was saved as a continuous index, ESG_text_score_auto, quantifying the "intensity of sustainability references."

Pearson correlation between this text score and GreenStar yielded r = 0.498, p ≈ 0, showing a strong positive association. In contrast, correlating the same score with the numerical star count (Star_num) gave r = 0.108, p ≈ 5.8×10^{-45}; while positive, the magnitude was far smaller. The initial inference is that abundant ESG keywords markedly increase the likelihood of certification, whereas their connection to star rating is weak.

To determine whether the text score influences the three-star evaluation after controlling for price, a logistic regression model—Star3 ~ ESG_text_score_



Country	n	green_ratio	avg_star
France	2752	0.034884	1.224684
Italy	1958	0.034729	1.171429
USA	1482	0.022267	1.237154
Spain	1236	0.046117	1.225352
Germany	1221	0.058149	1.210356
Japan	1062	0.029190	1.265193
United Kingdom	942	0.036093	1.229947
Belgium	709	0.014104	1.183206
China Mainland	544	0.007353	1.200000
Switzerland	516	0.060078	1.259843
Netherlands	464	0.045259	1.176471
Thailand	455	0.008791	1.250000
Taiwan	352	0.017045	1.208333
Austria	318	0.103774	1.278481
South Korea	219	0.009132	1.275000

Figure 13. Green Star among the top 15 countries.

auto + Price_band—was estimated with statsmodels.formula.api.logit. Maximum-likelihood results yielded a coefficient for ESG_text_score_auto of 1.23 (standard error 0.66, z = 1.86, p = 0.064). Hence, the effect is positive at the 10% significance level, but not significant at the conventional 5% level used in policy and practice. In Figure 15, the Price_band coefficient remained significant (4.14, $p < 0.001$), reaffirming that higher price levels sharply raise the probability of receiving three stars.

These findings imply that Michelin draws on ESG-related terminology in review texts when awarding Green Star certification. Yet, the same textual cues have minimal impact on star ratings, particularly the three-star distinction. Sustainability-focused narrative benefits "certification" but is not decisive for "stars." Thus, while ESG discourse is incorporated into parts of Michelin's evaluation system, culinary quality and price remain paramount in star decisions. The results also suggest that strategically inserting ESG keywords may inflate the likelihood of certification, underscoring the need for stronger on-site verification to uphold the validity of text-based assessments.

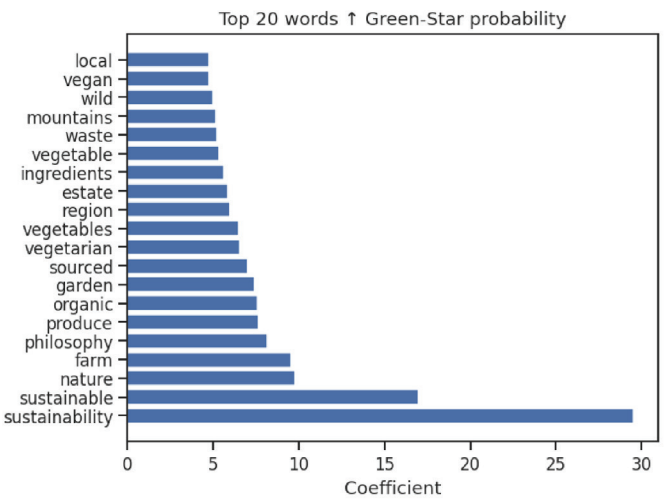


Figure 14. Top 20 words associated with Green Star probability.

Facility/Menu Practice Effect

Analysis E investigated whether eco-friendly facility and menu practices contribute independently to Michelin Green Star certification and star ratings. Four columns—FacilitiesAndServices, GreenStar, Award, and Price_band—were used. FacilitiesAndServices comprises lengthy text that required textual processing; Award had already been converted to the integer star count (Star_num); Price_band is the four-level price indicator derived from the number of currency symbols.

Using Python's sklearn.feature_extraction.text.TfidfVectorizer, FacilitiesAndServices was converted into a term–document matrix, with min_df = 5 to retain only terms appearing in at least five documents and stop_words = 'english' to remove common stop-words. The matrix was then subjected to non-negative matrix factorisation (sklearn.decomposition.NMF, n_components = 10, init = 'nndsvd'), yielding the latent-topic matrices W (documents × topics) and H (topics × terms). Inspection of the top twenty terms in each topic revealed two topics rich in sustainability-related keywords, including "vegetarian," "organic," "garden," "sustainable," "vegan," "local," and similar terms. The document-level weights for these two topics were

```
Optimization terminated successfully.
         Current function value: 0.038693
         Iterations 12
                           Logit Regression Results
==============================================================================
Dep. Variable:                  Star3   No. Observations:                16823
Model:                          Logit   Df Residuals:                    16820
Method:                           MLE   Df Model:                            2
Date:                Sat, 19 Apr 2025   Pseudo R-squ.:                 0.2490
Time:                        17:23:07   Log-Likelihood:                -650.93
converged:                       True   LL-Null:                       -866.72
Covariance Type:            nonrobust   LLR p-value:                1.924e-94
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept     -16.9723      1.386    -12.242      0.000     -19.690     -14.255
ESG_text_score_auto     1.2327      0.664      1.855      0.064      -0.070       2.535
Price_band     3.4540      0.351      9.844      0.000       2.766       4.142
==============================================================================

Possibly complete quasi-separation: A fraction 0.49 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
```

Figure 15. Logistic regression of three-star attainment on ESG keyword score and price band.

summed to form a continuous index, ESG_topic_score_auto, as presented in Figures 16 and 17, which quantifies the strength of "eco-friendly facility and menu practices" expressed in each restaurant's description.

Using scipy.stats.pearsonr, the correlations between ESG_topic_score_auto and GreenStar, and between ESG_topic_score_auto and Star_num, were calculated separately. The correlation with GreenStar was r = 0.137 ($p \approx 8.6 \times 10^{-71}$), statistically significant yet small in magnitude. Owing to numerous missing values, the correlation with Star_num was either not computable or not meaningful. Thus, Figure 18 shows that although a slight rise in certification accompanies more frequent mentions of eco-friendly facilities and menus, their explanatory power remains modest.

To gauge the independent effect of these practices

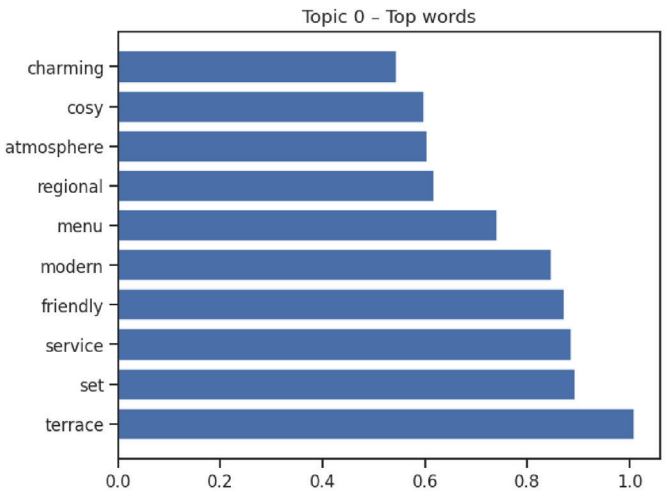


Figure 16. Top words distribution for Topic 0 atmosphere and service descriptors.

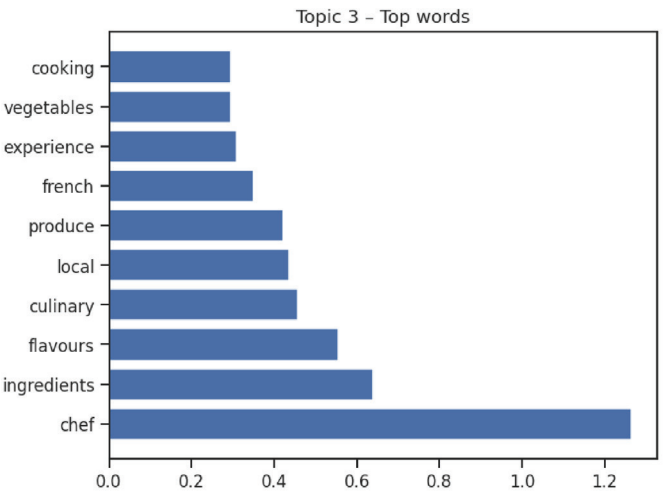


Figure 17. Top words distribution for Topic 3 on chef and ingredient-focused descriptors.

```
Stars r= nan p= nan
GreenStar r= 0.13651927422931528 p= 8.591739308208935e-71
Optimization terminated successfully.
         Current function value: 0.038696
         Iterations 12
                           Logit Regression Results
==============================================================================
Dep. Variable:                  Star3   No. Observations:                16823
Model:                          Logit   Df Residuals:                    16820
Method:                           MLE   Df Model:                            2
Date:                Sat, 19 Apr 2025   Pseudo R-squ.:                  0.2489
Time:                        17:23:12   Log-Likelihood:                -650.99
converged:                       True   LL-Null:                       -866.72
Covariance Type:            nonrobust   LLR p-value:                2.039e-94
==========================================================================================
                             coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------------------
Intercept                -17.0648      1.388    -12.293      0.000     -19.786     -14.344
ESG_topic_score_auto       6.8347      4.094      1.670      0.095      -1.189      14.858
Price_band                 3.4342      0.351      9.773      0.000       2.745       4.123
==========================================================================================

Possibly complete quasi-separation: A fraction 0.49 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
```

Figure 18. Logistic regression of three-star attainment on ESG facility/menu topic score and price band.

after controlling for price, the logistic model: Star3 ~ ESG_topic_score_auto + Price_band estimated with statsmodels.formula.api.logit (n = 16 823; Pseudo $R^2 \approx 0.25$). The coefficient for ESG_topic_score_auto was 6.83 (SE 4.09, z = 1.67, p = 0.095), indicating a positive effect at the 10 % level but not at the conventional 5 % threshold. By contrast, Price_band remained strongly significant ($\beta = 3.43$, SE 0.35, $p < 0.001$), reaffirming that higher price levels sharply increase the probability of securing three stars. Hence, the eco-facility/menu score contributes little to explaining three-star attainment; price and upscale positioning continue to dominate.

Overall, the Michelin data reveal only weak effects of eco-friendly facility and menu practices on both certification and star rating. The slight association with Green Star suggests that such amenities marginally improve certification odds, yet, once price is considered, they exert no discernible influence on the highest rating tier. This pattern likely reflects a superficial correlation, in which high-priced restaurants happen also to feature gardens, organic ingredients, or vegetarian menus.

In the context of whether Michelin star ratings fairly reflect ESG performance, Analysis E indicates that investments in specific facilities and menus rarely translate into higher star scores. If sustainability infrastructure is not a robust independent metric in Michelin assessments, smaller establishments that undertake costly eco-friendly upgrades risk receiving little star-level reward. The findings imply that Michelin would need to diversify its criteria—evaluating not only expensive infrastructural measures but also lower-cost sustainability actions—to reward ESG practices more equitably.

DISCUSSION

Visualizations and tabulated results show that Michelin-listed restaurants are heavily concentrated in culinary strongholds such as France, Italy, the United States, Spain, Germany, and Japan. In terms of cuisine type, Modern, Contemporary, Creative, and Traditional Cuisine dominate, with Japanese, Italian, and Seafood also prominent. The rating profile forms a pronounced pyramid: Selected Restaurants are most numerous, followed by Bib Gourmand, then one-, two-, and three-star establishments in sharply diminishing order. Green Star sustainability certification is rare—about 6 % overall—and in many countries, especially outside Europe (notably in Asia and North America), the share falls to 1–3 %, revealing substantial regional disparities.

Restaurants holding a Green Star display a higher mean Michelin-star count (1.38) than non-certified venues (1.21). Further analysis by price band and region shows, however, that a significant star differential emerges only in the highest price tier (band 4); in lower and middle bands, the reward effect is negligible. Thus, while ESG certification markedly increases the probability of attaining the top rating (three stars), the effect is concentrated among upscale restaurants, with price exerting the more decisive influence.

Among the fifteen countries with the largest samples, European nations such as Austria, Switzerland, the Netherlands, and Germany exhibit conspicuously high Green Star rates. In contrast, Asian countries like Korea, Japan, China, and the United States show markedly lower proportions. This pattern indicates that Michelin's sustainability certification is not distributed equitably on a global scale.

A higher frequency of sustainability-oriented terms—such as sustainability, nature, farm, organic, local, and vegan—in restaurant descriptions is associated with an increased probability of receiving a Green Star. By contrast, the influence of ESG-related keywords, facility characteristics, and menu attributes on Michelin star ratings—particularly the three-star distinction—is negligible or only weakly significant. In other words, while the Green Star formally reflects sustainability considerations, star allocation continues to be driven predominantly by non-ESG factors, including price level, traditional measures of culinary quality, and national dining traditions.

CONCLUSION

This study set out to evaluate whether Michelin star ratings fairly reflect restaurants' ESG practices and sustainable culinary quality, to identify the conditions under which such recognition materializes, and to derive actionable guidance for rating systems. Using a global corpus of 16,823 listings and a suite of statistical and text-analytic models, we find that sustainability certification (Green Star) is associated with higher star attainment, but the effect concentrates at the top price tier and varies substantially by country. ESG keywords and eco-facility/menu attributes strongly predict Green Star certification, yet exert, at best, a weak independent influence on star ratings. Together, these results indicate that Michelin's current framework only partially incorporates ESG performance and does so unevenly

across economic and regional contexts.

With respect to the first objective of this study—testing whether stars capture ESG quality—holding price constant, Green-Star restaurants have markedly higher odds of three-star status, evidencing partial recognition. Regarding the second objective —interactions with context—ESG recognition translates into star advantages primarily among high-price establishments and in select European countries, revealing price- and region-conditioned fairness. As for the third objective —quantifying independent predictors—confirms that price remains the dominant driver of three-star outcomes, whereas ESG-text and eco-facility indices carry limited marginal weight. Finally, the fourth objective —policy guidance—emerges directly from these patterns: absent structural adjustments, the rating system risks rewarding capital intensity more than sustainability performance.

Although the Michelin Guide retains considerable authority, a gap persists between its evaluation framework and contemporary gastronomic trends and social imperatives such as ESG and sustainability. It is therefore essential to enlarge the formal weight of ESG- and sustainability-related criteria and to devise an assessment scheme that is balanced across regions and price bands. To ensure that Green Star certification is translated transparently and equitably into star ratings, the inspection system must become more open, and multifaceted indicators should be introduced that fully recognize low-cost ESG practices (e.g., local sourcing, food-waste reduction). A future-oriented gastronomic rating system should integrate multiple values—culinary excellence, social benefits (environmental stewardship and community contribution), and economic diversity (support for mid- and lower-priced establishments)—thereby fostering positive change for the industry, consumers, and policymakers alike. The present study is significant in that it illuminates the fairness of Michelin evaluations through quantitative data analysis and code-based methods. It is hoped that students entering the food sector, industry practitioners, and policymakers will draw on these findings to design a more equitable and sustainable gastronomic ecosystem.

This research acknowledges its limitations. The scraped corpus covers Michelin-listed restaurants only, limiting generalizability to the broader population of eateries and mirroring the Guide's own geographic footprint. Multilingual descriptions introduce language and translation artifacts for text mining, and our price proxy conflates market positioning with cost-of-living differences. Cross-sectional analyses identify associations rather than causal effects, leaving unobserved confounding—such as inspector density or chef pedigree—possible. Severe imbalance in three-star cases inflates uncertainty around top-tier estimates. Finally, ESG-related texts and facilities may reflect marketing emphasis rather than verified practices, underscoring the need for audit-based validation.

FUTURE DIRECTION

Integrating ESG into Star Decisions

A tractable path for incorporation is a dual-track rubric in which culinary quality and verified sustainability are scored on parallel 0–100 scales and combined with published weights (e.g., 80:20 initially, with scope for periodic recalibration). Inspectors would use standardized checklists aligned with international sustainability standards, and a random subset of assessments would undergo a third-party audit. Publishing annual summaries of ESG scoring distributions and audit outcomes would increase transparency and public trust.

Mitigating Price and Regional Biases

To prevent capital intensity from masquerading as quality, thresholds for star tiers can be calibrated within price bands, complemented by a fixed ESG bonus independent of average spend. Regionally, inspection intensity and certification access should be harmonized through per-country coverage targets and shared application portals. These adjustments would make ESG recognition convertible to stars for small and mid-priced venues and reduce cross-country disparities.

Exploring Alternative Frameworks

Beyond adjustments to Michelin, multi-criteria decision analysis (MCDA) and fairness-aware machine-learning models can integrate inspector judgments with verifiable ESG indicators, community-sourced evidence (e.g., waste-reduction programs), and external certifications. Open-data scorecards published alongside listings would enable independent replication and periodic algorithmic audits, ensuring that sustainability signals are neither ignored nor overstated.

Data and Methods Roadmap

Future work should assemble multilingual corpora with human-verified ESG labels to train cross-lingual

NLP; link establishments to administrative data on energy, sourcing, and labor practices; and exploit natural experiments (e.g., Green-Star policy rollouts) using difference-in-differences designs. A structured error taxonomy—distinguishing between text inflation, selection into certification, and inspector capacity limits—would clarify where reforms yield the most significant gains in fairness.

CONFLICT OF INTERESTS

The author declares that there are no conflicts of interest related to this work.

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