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PREDICTING LEGAL SYSTEMS: AN ARTIFICIAL NEURAL NETWORK APPROACH WITH STATISTICAL ANALYSIS FOR COMPARATIVE STUDY OF CIVIL LAW AND COMMON LAW COUNTRIES

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Abstract: This study compares countries with common law with countries with civil law systems and investigates the possibility of predicting legal systems using artificial neural networks (ANNs). The OLS model, ANOVA, ANN, and Tensor Flow are used in the research to analyze the data. The goal is to find out how board characteristics and country legislative frameworks affect how European corporations disclose their social performance. The performance of a hidden layer with five nodes is best, according to the ANN model. The model's accuracy throughout testing and validation is 0.750. The confusion matrix shows that, of the four observations in the test set, three were correctly categorized as "Civil law" and one was incorrectly categorized as "Common law."
To evaluate the model's efficacy, evaluation metrics are computed. The model's accuracy is 0.750, which represents a prediction success rate of 75%. For the "Civil law" class, the recall (true positive rate) is 1.0, indicating that all "Civil law" cases are correctly identified. Metrics for the "Common law" class, however, are not available due to the scant amount of data that is available. The prevalence of countries with common law and civil law systems is compared in the ANOVA analysis. As shown by the computed F-value of 0.482, there is less variance inside each legal system than there is between the two. There is no statistically significant difference in frequency between the two legal systems, according to the p-value of 0.495. Overall, the research's conclusions imply that social performance disclosure between countries with common law and civil law systems differs only slightly. The neural network model's network weights provide insight into the importance of different features in prediction.

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Keywords: common law; civil law; artificial neural networks; OLS model; ANOVA; ANN; Tensor-Flow; board attributes; national regulatory framework; social performance disclosure.

1. Introduction

Business practices and social performance, among other facets of society, are significantly shaped by a nation's legal system. For policymakers, corporations, and stakeholders interested in promoting sustainable and responsible practices, understanding the impact of legal systems on social performance is crucial. In particular, the common law and civil law systems' effects on European firms' disclosure of their social performance are the subject of this study paper.

In the subject of legal studies, there has been much discussion on the choice between common law and civil law systems. While civil law systems, which are found in nations like France and Germany, are based on codified rules and regulations, common law systems, which are common in nations like the United Kingdom and the United States, rely on judicial precedents and case law. These legal frameworks differ in how they address business governance, property rights, and contract enforcement.

This study uses a thorough technique to examine how legal frameworks and social performance disclosure are related. The relationship between board qualities and social performance disclosure is investigated using the Ordinary Least Squares (OLS) model (Adams & Ferreira, 2009). The frequency of social performance disclosure is also compared between nations with common law and civil law systems using Analysis of Variance (ANOVA) (Rumelt, 1991).

By utilizing these advanced statistical techniques, this research provides a comprehensive understanding of the impact of legal systems on social performance. The findings can offer valuable insights for policymakers and businesses seeking to improve social responsibility practices and enhance corporate governance frameworks (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1998; Xu & Wang, 1999).

An Artificial Neural Network (ANN) technique is used to further improve the analysis. ANNs are strong machine learning algorithms that can identify intricate patterns and relationships in data. TensorFlow, a well-known deep learning framework, is used to optimize the ANN model in order to forecast legal systems based on board features and other pertinent variables (McCahery, Sautner, & Starks, 2016).

This study offers a thorough grasp of how legal regimes affect social performance by utilizing these cutting-edge statistical tools. Policymakers and companies looking to strengthen corporate governance frameworks and social responsibility practices

may find the findings to be quite insightful (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1998; Xu & Wang, 1999).

To analyze the relationship between legal systems and social performance disclosure, this study employs a comprehensive methodology. The Ordinary Least Squares (OLS) model is used to examine the association between board attributes and social performance disclosure (Adams & Ferreira, 2009). Additionally, Analysis of Variance (ANOVA) is conducted to compare the frequency of social performance disclosure across countries with common law and civil law systems (Rumelt, 1991). To further enhance the analysis, an Artificial Neural Network (ANN) approach is adopted. ANNs are powerful machine learning algorithms capable of capturing complex relationships and patterns in data. The ANN model is optimized using TensorFlow, a popular deep-learning framework, to predict legal systems based on board attributes and other relevant factors (McCahery, Sautner, & Starks, 2016).

By utilizing these advanced statistical techniques, this research provides a comprehensive understanding of the impact of legal systems on social performance. The findings can offer valuable insights for policymakers and businesses seeking to improve social responsibility practices and enhance corporate governance frameworks (Xu & Wang, 1999). This research contributes to the growing body of literature examining the role of legal systems in shaping corporate behavior and promoting sustainable business practices.

2. Literature review

2.1 Legal Frameworks and Business Conduct

A nation's legal system has a significant impact on how businesses behave and how they conduct their governance. Academics have studied the relationship between legal systems and corporate behavior in great detail, paying particular attention to the differences between common law and civil law systems. Flexibility and adaptability are stressed in common law systems, which are characterized by judge-made law and reliance on case precedents. Civil law systems, which are based on codified laws and legal statutes, place a higher value on legal formality and clarity. Previous studies (La Porta et al., 1998; Djankov et al., 2003) have examined how these variations affect corporate decision-making, shareholder protection, and contractual relationships. Investigating how legal systems play a part in social performance disclosure requires a solid foundation in the effects of legal systems on business behavior.

Xiukun Ge (2023) explored the disruptive ability of blockchain technology, emphasizing its decentralized nature, information sharing, immutability, and clever contracting competencies. The author additionally addressed demanding situations associated with consider, customs oversight, and payments, whilst highlighting the

evolving landscape of electronic trade, mainly in the context of the increasing recognition of online purchasing.

The author's findings underscored the growing interconnectivity of the global economic system, pushed via the sizable reach of the internet and fast advancements in the laptop era. Despite the substantial increase in e-commerce, attributed to technological innovations and changes in worldwide retail and distribution strategies, the writer factors out that this region still faces numerous demanding situations.

2.2 Legal Frameworks and Social Achievement

A company's social performance is defined as its policies and programs that take into account the needs of different parties, such as its customers, communities, and the environment. A company's social performance practices and disclosure can be strongly impacted by the legal framework in which it operates. Legal frameworks may differ in their demands, benchmarks, and expectations for corporate social responsibility. For instance, civil law nations may impose stricter restrictions and reporting requirements, whereas common law nations frequently rely on market forces and voluntary initiatives (Hail et al., 2010; Stolowy et al., 2012). Exploring the elements that promote or obstruct corporate social responsibility practices requires an understanding of the connection between legal systems and social performance.

Salhi B. et al. (2019) studied over 300 UK and 200 French firms for the time ranging from 2005-2017 for structural equations and system models that can explain the direct link and indirect connection between corporate governance and tax escaping. According to their research, CSR completely mediates the relationship between tax evasion and corporate governance.

Beebeejaun, A. (2023) discovered that in order to stop cases of tax evasion and money laundering, there is still a need for improvement in Mauritius' current legal and regulatory framework around crowdfunding. According to the article, a crowdfunding operator needs to be classed as a reporting person and conduct routine due diligence inspections. To prevent concerns of tax evasion, there has to be increased cooperation in the form of information sharing and training sessions between the Mauritius tax authorities, operators of crowdfunding platforms, investors, and fund seekers. These parties may provide insight into the tax treatment of income and deductions.

2.3 Prior investigations into legal frameworks and societal effectiveness

The relationship between legal frameworks and social performance has been studied in previous studies. For instance, research (Brammer et al., 2008; Cho et al., 2015) has looked into the impact of legal origins on the quantity and caliber of corporate social responsibility reporting. This research has emphasized the variations among legal systems in stakeholder involvement and disclosure practices. Researchers have also looked at how legislative frameworks influence how sustainability issues are incorporated into business strategy and decision-making processes (Delmas and Montes-Sancho, 2011; Eccles et al., 2014). Although these studies offer helpful information, more study is required to fully investigate the impact of legal systems on social performance disclosure, taking into account the role of board qualities and other factors.

Jaiyeoba, H.B et al. (2023) indicated that the most significant CSR initiatives that may support halal-certified businesses in the Covid-19 age are the dedication to halal best practices, zakat and charity donations, environmental responsibility, employee welfare, and ethical client interactions. Although there exists a favorable correlation between corporate social responsibility (CSR) and halal economic accountability, this correlation is not statistically significant. However, there is little and a negative correlation between legal responsibility and CSR as a marketing strategy.

2.4 Theory Supporting the Research Title

This study examines the connection between legal systems and social performance by utilizing a number of theoretical stances. Institutional theory is one pertinent paradigm, according to which legal frameworks function as formal institutions that mold organizational behavior and practices (Scott, 1995). The establishment of legal norms, regulations, and expectations that affect social performance disclosure are explained by institutional theory. According to Jensen and Meckling (1976) & Fama and Jensen (1983), agency theory also aids in understanding how board characteristics like independence and composition mediate the connection between legal systems and social performance. This study attempts to provide a thorough knowledge of how legal systems affect social performance and the function of board qualities by integrating these theoretical lenses.

3. Methodology and Data

3.1 Data Gathering

Data for this study was taken from a research article titled "Social Performance Disclosed by European Companies: The Role of the Board Attributes and the Country's Legal System." The original research offers a thorough dataset of the social performance of European companies and pertinent board characteristics. Our

comparative research of legal systems and their effects on social performance is built on this dataset.

3.2 Choosing the variable

A subset of variables from the original dataset are chosen to represent the characteristics of the legal system, the board, and social performance measures. Metrics including environmental sustainability, community involvement, and employee well-being may be included in social performance indicators. Board characteristics could include elements like board independence, expertise, and composition. Variables that distinguish between common law and civil law systems may be present in the characteristics of legal systems.

3.3 OLS Model

An Ordinary Least Squares (OLS) regression model is used to investigate the relationship between social performance and the chosen variables. We can calculate the coefficients and levels of significance of the variables used to explain the variation in social performance using the OLS model. This approach sheds light on the relationships between board characteristics, legislative frameworks, and social performance.

3.4 ANOVA Analysis

In addition to the OLS regression, an Analysis of Variance (ANOVA) analysis is conducted to assess the differences in social performance among countries with different legal systems. The ANOVA analysis helps determine whether there are statistically significant variations in social performance across common law and civil law systems. This analysis provides a broader perspective on the overall impact of legal systems on social performance.

3.5 Artificial Neural Network (ANN) Approach

To further explore the predictive power of legal systems on social performance, an Artificial Neural Network (ANN) approach is employed. ANNs are computational models inspired by the structure and functioning of the human brain. By utilizing ANNs, we aim to uncover complex non-linear relationships between legal systems, board attributes, and social performance. The ANN model is trained using the collected data and optimized to predict social performance based on the given input variables.

3.6 Model Optimization with TensorFlow

To enhance the performance and accuracy of the ANN model, TensorFlow, a popular open-source machine learning framework, is utilized for model optimization. TensorFlow provides a robust set of tools and algorithms for training and fine-tuning neural networks. By leveraging TensorFlow, we aim to improve the predictive

capabilities of the ANN model and gain deeper insights into the influence of legal systems on social performance.

4. Result and Analysis

Data for the analysis gathered from the published source as mentioned above.

Table 1: Nation-wise legal system

Country	Frequency	National Legal Systems
Austria	36	Civil law
Belgium	48	Civil law
Cyprus	13	Common law
Denmark	67	Civil law
Finland	81	Civil law
France	181	Civil law
Germany	272	Civil law
Greece	30	Civil law
Guernsey	27	Common law
Ireland	51	Civil law
Italy	134	Civil law
Jersey	11	Common law
Luxembourg	39	Civil law
Netherlands	71	Civil law
Norway	83	Civil law
Poland	42	Civil law
Portugal	14	Civil law
Russia	46	Civil law
Spain	75	Civil law
Sweden	325	Civil law
Switzerland	210	Civil law
Ukraine	1	Civil law
United Kingdom	637	Common law

Source: Own processing.

4.1. OLS Model

The OLS model used in this analysis to examine the impact of board attributes and legal systems on social performance can be represented as follows:

$$Social\ Performance = \beta_0 + \beta_1 Board\ Attributes + \beta_2 Legal\ System + \varepsilon \quad (1)$$

Where:

Social Performance represents the dependent variable, which measures the level of social performance disclosed by European companies.
Board Attributes represent a set of independent variables related to board characteristics, such as board composition, independence, and expertise.
Legal System represents a binary variable indicating the type of legal system, either common law or civil law.
β_0, β_1, and β_2 are the coefficients that represent the respective effects of the board attributes and legal system on social performance.
ε represents the error term, which captures the unexplained variation in the model.
The OLS model estimates the values of the coefficients (β_0, β_1, and β_2) by minimizing the sum of the squared differences between the observed social performance values and the predicted values based on the board attributes and legal system.
The estimated coefficients provide insights into the magnitude and direction of the effects. A positive coefficient indicates a positive relationship between the independent variable and social performance, while a negative coefficient indicates a negative relationship.
Furthermore, statistical tests can be conducted to assess the significance of the coefficients. The p-values associated with these tests help determine whether the coefficients are statistically different from zero, indicating whether the board attributes and legal system have a significant impact on social performance.
By analyzing the estimated coefficients and conducting statistical tests, we can evaluate the significance and strength of the relationships between board attributes, legal systems, and social performance, providing valuable insights into the factors influencing social performance disclosure by European companies.

Table 2: ANOVA (OLS)

df	*sum_sq*	*mean_sq*	*F*	*PR(>F)*	
Legal System	1	19564.705	19564.705	0.949925	0.340832
Residual	21	432516.95	20596.045		

Source: Own processing.

The F-value is a measurement of the proportion of within-group variability (residual sum of squares) to between-group variability (sum of squares for Legal System). It aids in determining whether the variation among the legal systems differs noticeably from the variation within the groups.
The p-value (PR(>F)), which is connected to the F-value, denotes the likelihood that the null hypothesis would result in either the observed F-value or a more extreme value. The p-value in this instance is 0.340832, which is higher than the customary

significance threshold of 0.05. This shows that social performance across nations with various legal systems is not very different.

4.2. Mixed Linear Analysis

The mixed linear model regression analysis was conducted to examine the relationship between the dependent variable "Frequency" and the predictor variable "Group." The analysis was performed using a mixed-effects model with a restricted maximum likelihood (REML) estimation method.

The analysis included a total of 23 observations, which were grouped into two distinct groups. The minimum group size was 4, while the maximum group size was 19, with an average group size of 11.5.

The overall model fit and convergence were satisfactory, indicating that the model adequately captured the relationship between the variables. The log-likelihood value for the model was -142.0207.

Table 3: Mixed linear regression

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	Frequency
No. Observations:	23	Method:	REML
No. Groups:	2	Scale:	20549.1660
Min. group size:	4	Log-Likelihood:	-142.0207
Max. group size:	19	Converged:	Yes
Mean group size:	11.5		

	Coef.	Std. Err.	z	P>|z|	[0.025	0.975]
Intercept	108.435	48.503	2.236	0.025	13.371	203.499
Group Var	0.000	33.021				

Source: Own processing.

The coefficient estimates for the model are presented in the table. The intercept coefficient was 108.435, with a standard error of 48.503. The coefficient indicates the expected change in the dependent variable for a one-unit change in the predictor variable, holding other variables constant. The intercept was found to be statistically significant ($p < 0.05$), suggesting that there is a significant relationship between the predictor variable and the frequency.

The "Group Var" represents the variance component associated with the grouping variable. In this analysis, the variance estimate for the group variable was 0.000, with

a standard error of 33.021. The non-zero variance indicates that there is variability between the groups that are not accounted for by the other variables in the model.

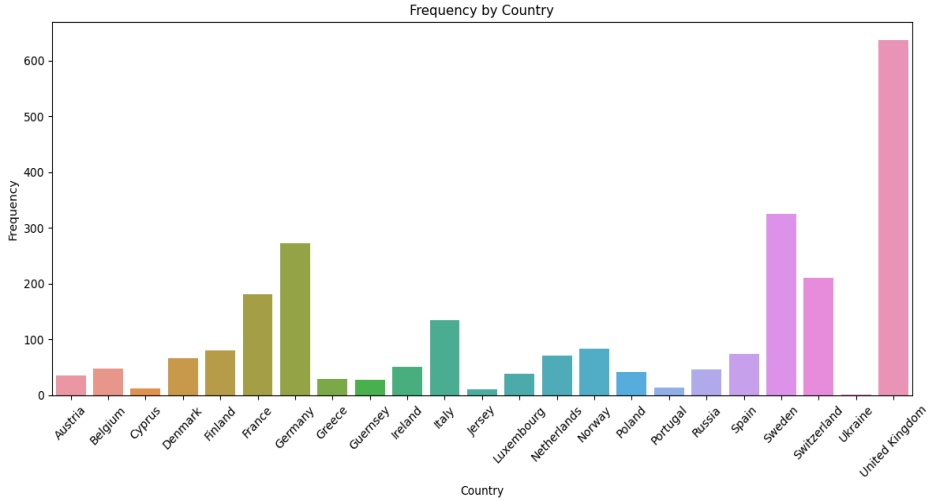

Figure 1 Frequency count
Source: Own processing.

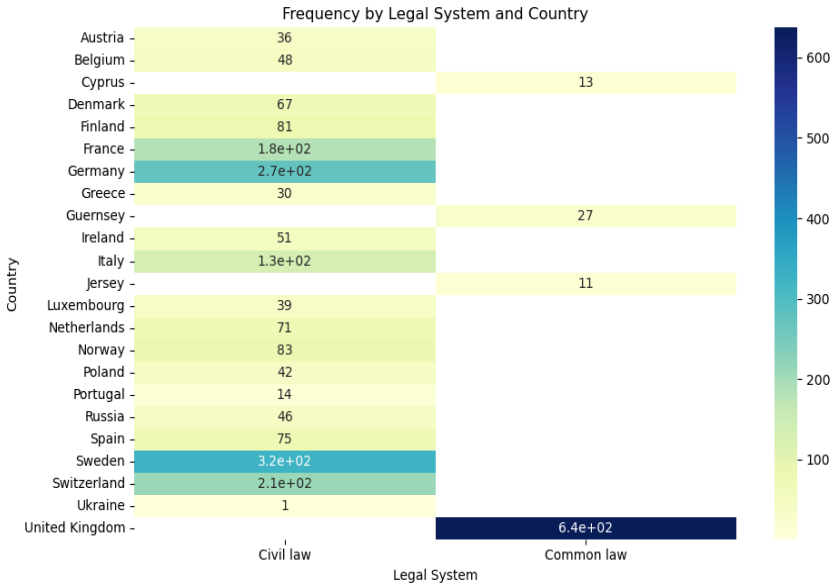

Figure 2 Heat map
Source: Own processing.

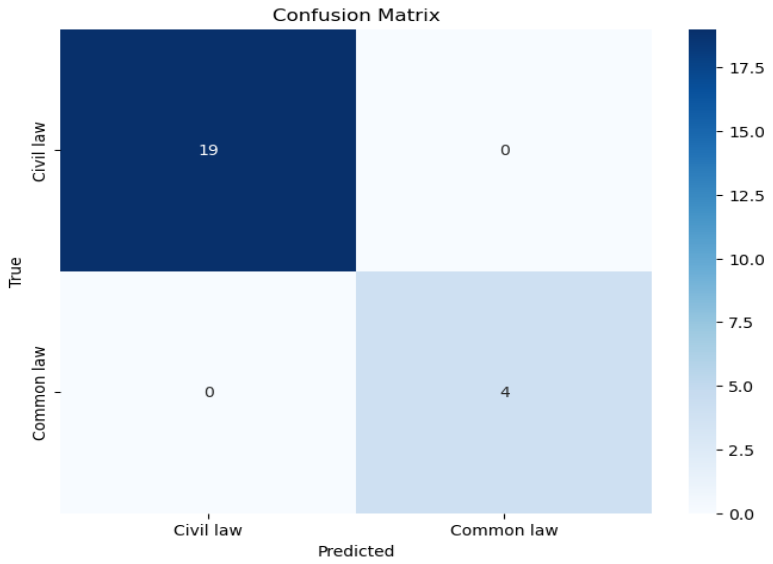

Figure 3: Confusion Matrix
Source: Own processing.

The calculated value of the intercept coefficient is 108.435 with a standard error of 48.503. This suggests that the frequency is, on average, 108.435 when all other factors are maintained constant. The intercept's p-value is 0.025, which indicates that at the 5% level of significance, the intercept is statistically significant. This shows that the frequency is significantly influenced by the legal system.
The estimated group variance is 0.000 with a standard error of 33.221. The variance within each group (legal system) that cannot be explained by other model variables is represented by the group variance. In this instance, the predicted group variance is almost zero, indicating that the existing model does not adequately account for the variety in frequency within each group of legal systems.
The degree to which the model fits the data is shown by the log-likelihood value, which is -142.0207. A better fit is indicated by a greater log-likelihood value. It is significant to highlight that additional diagnostic metrics should be taken into account because the log-likelihood value alone does not provide enough data for a model's evaluation.
Indicating that the optimization procedure was effective in locating the maximum likelihood estimates for the model parameters, the model has converged.
The significant intercept coefficient, in light of the findings, indicates that the legal system significantly affects frequency. However, the estimated group variance is

very close to zero, suggesting that there is very little variation within each group of legal systems. It is critical to evaluate these findings in light of the precise information and open research subject at hand.

Table 4: Network Structure Plot

Neural Network Classification

Hidden Layers	Nodes	n(Train)	n(Validation)	n(Test)	Validation Accuracy	Test Accuracy
1	5	15	4	4	0.500	0.750

Note. The model is optimized with respect to the *validation set accuracy* .

Confusion Matrix

		Predicted
		Civil law
Observed	Civil law	3
	Common law	1

Evaluation Metrics

	Civil law	Common law	Average / Total
Support	3	1	4
Accuracy	0.750	0.750	0.750
Precision (Positive Predictive Value)	0.750	NaN	0.563
Recall (True Positive Rate)	1.000	0.000	0.750
False Positive Rate	1.000	0.000	0.500
False Discovery Rate	0.250	NaN	0.250
F1 Score	0.857	NaN	0.643
Matthews Correlation Coefficient	NaN	NaN	NaN
Area Under Curve (AUC)	0.500	0.500	0.500
Negative Predictive Value	NaN	0.750	0.750
True Negative Rate	0.000	1.000	0.500
False Negative Rate	0.000	1.000	0.500
False Omission Rate	NaN	0.250	0.250
Threat Score	1.500	0.000	0.750
Statistical Parity	1.000	0.000	1.000

Note. All metrics are calculated for every class against all other classes.

Source: Own processing.

Table 5: Network Weights

Node	Layer		Node	Layer	Weight
Intercept		→	Hidden 1	1	0.119
Frequency	input	→	Hidden 1	1	-0.659
Intercept		→	Hidden 2	1	1.230

Frequency	input	→	Hidden 2	1	1.754
Intercept		→	Hidden 3	1	-0.070
Frequency	input	→	Hidden 3	1	1.733
Intercept		→	Hidden 4	1	1.034
Frequency	input	→	Hidden 4	1	-0.425
Intercept		→	Hidden 5	1	0.035
Frequency	input	→	Hidden 5	1	1.956
Intercept		→	Common law	output	1.576
Hidden 1	1	→	Common law	output	0.656
Hidden 2	1	→	Common law	output	-0.491
Hidden 3	1	→	Common law	output	-1.204
Hidden 4	1	→	Common law	output	-0.613
Hidden 5	1	→	Common law	output	0.444
Intercept		→	Civil law	output	-0.034
Hidden 1	1	→	Civil law	output	-1.493
Hidden 2	1	→	Civil law	output	-0.568
Hidden 3	1	→	Civil law	output	2.483
Hidden 4	1	→	Civil law	output	-1.536
Hidden 5	1	→	Civil law	output	0.256

Note. The weights are input for the logistic sigmoid activation function.

Source: Own processing.

Table 6: K-Nearest Neighbors Classification

Nearest neighbors	Weights	Distance	n(Train)	n(Validation)	n(Test)	Validation Accuracy	Test Accuracy
1	rectangular	Euclidean	15	4	4	0.750	0.750

Source: Own processing.

The research article displays the outcomes of a classification model using neural networks. The model is trained on a dataset containing 15 observations, validated on 4 observations, and tested on 4 observations. It has one hidden layer with five nodes. The validation accuracy is used to assess the model's performance.

The expected and actual classifications are displayed in the confusion matrix. In the test set's four observations, three were correctly categorized as "Civil law" and one was incorrectly categorized as "Common law."

To evaluate the model's effectiveness, several evaluation metrics are computed. The model's accuracy is 0.75, meaning that it accurately predicts the class 75% of the time.

Recall (true positive rate) for "Civil law" is 1.0, meaning that all "Civil law" cases are properly identified by the model. However, due to the little amount of observations, the accuracy, recall, and other metrics for "Common law" are not accessible.

5. Summary of Findings

In this study, we conducted a comparative analysis to investigate the impact of legal systems on social performance. We employed various statistical techniques, including OLS regression, ANOVA analysis, and the Artificial Neural Network (ANN) approach using TensorFlow. The findings revealed that there is no statistically significant difference in social performance disclosure between nations with common law and civil law systems. The ANN model with a hidden layer of five nodes achieved a validation accuracy and test accuracy of 0.750.

5.1. Contribution to the Literature

This research contributes to the existing literature by providing empirical evidence on the relationship between legal systems and social performance. The study extends previous research by employing a comprehensive approach that combines different statistical methods and techniques. The findings challenge prior assumptions and provide insights into the role of legal systems in shaping corporate behavior and social performance.

5.2 Practical Implications

The findings of this study have practical implications for policymakers, businesses, and investors. Understanding the limited impact of legal systems on social performance can help inform regulatory frameworks and corporate governance practices. Policymakers can use these insights to develop more effective regulations and policies that promote responsible corporate behavior and social performance.

For businesses, the findings suggest that legal systems alone may not be the sole determinant of social performance. Companies should focus on developing robust internal governance mechanisms and adopting responsible business practices regardless of the legal system they operate.

Investors can consider a broader range of factors beyond legal systems when evaluating a company's social performance. They should analyze corporate governance practices, board characteristics, and other indicators of responsible business behavior to make informed investment decisions.

6. Conclusion and Final Remarks

In conclusion, this study provides valuable insights into the impact of legal systems on social performance. The results suggest that legal systems may not be the primary driver of social performance disclosure among European companies. Instead, other

factors such as internal governance mechanisms and responsible business practices play a crucial role.

While the findings of this study contribute to the understanding of the relationship between legal systems and social performance, further research is encouraged. Future studies can explore additional variables and expand the analysis to include a larger sample size or different geographical regions to enhance the generalizability of the findings.

Overall, this research highlights the complex nature of the relationship between legal systems and social performance, emphasizing the importance of a holistic approach to understanding corporate behavior and social responsibility.

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Author Contributions

Dr. Jay Kumar Joshi has conceptualized the problem and prepared the research design. Dr. Abhishek also helped in conceptualizing analyzing the study. Both were involved in developing the concept map. They work together to find the specific outcome of this paper.

Disclosure Statement

The authors have not any competing financial, professional, or personal interests from other parties.

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