

“You could lose your job as a respectful director”

Empirical Study on Directors in US-Issued Companies

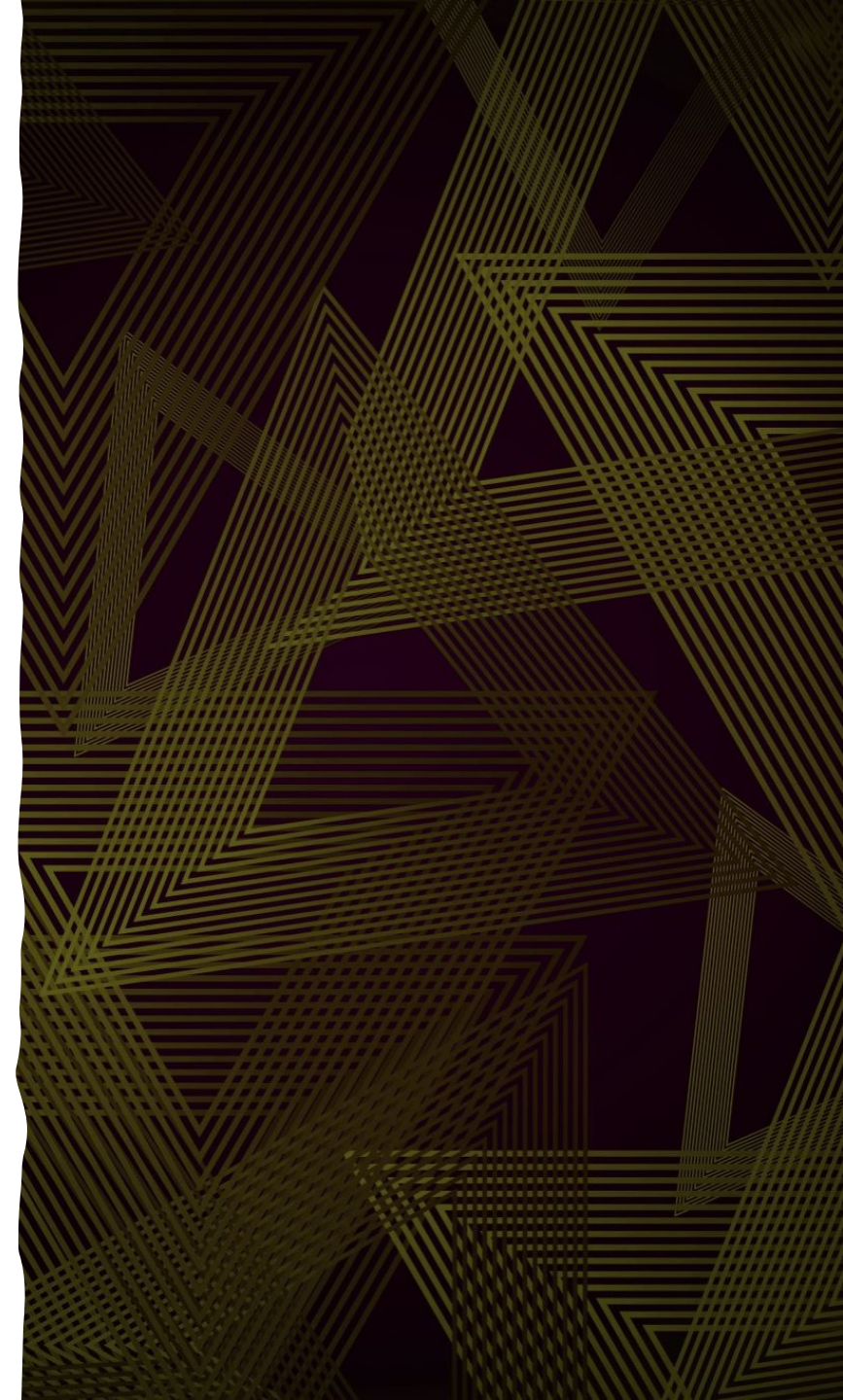
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Content

Research Methodology

Descriptive Analysis

Predictive Models

Conclusions



Research Methodology

Research Steps



Research Assumptions & Hypotheses: identify the research scope and goal



Data Processing: feature engineering, data cleaning ...



Descriptive Analysis: find out the patterns between departures and characteristics of individual directors



Predictive Model Analysis: compare the classification models' performances and conclude reliable statistical results

Research Assumptions & Scope

Assumption 1: all the controversial events recorded in the yearly total counts are negative events for the companies.

Assumption 2: if one director left the company in the year when his/her former company was recorded with one or more controversial events, his/her leave is regarded as a departure order from the company.

Assumption 3: If one director left the company in the year when his/her former company was recorded with NO controversial events, his/her leave is NOT regarded as a departure order from the company.



With our self-designed algorithm,
24,821 directors were successfully identified as “departed” or “non-departed”



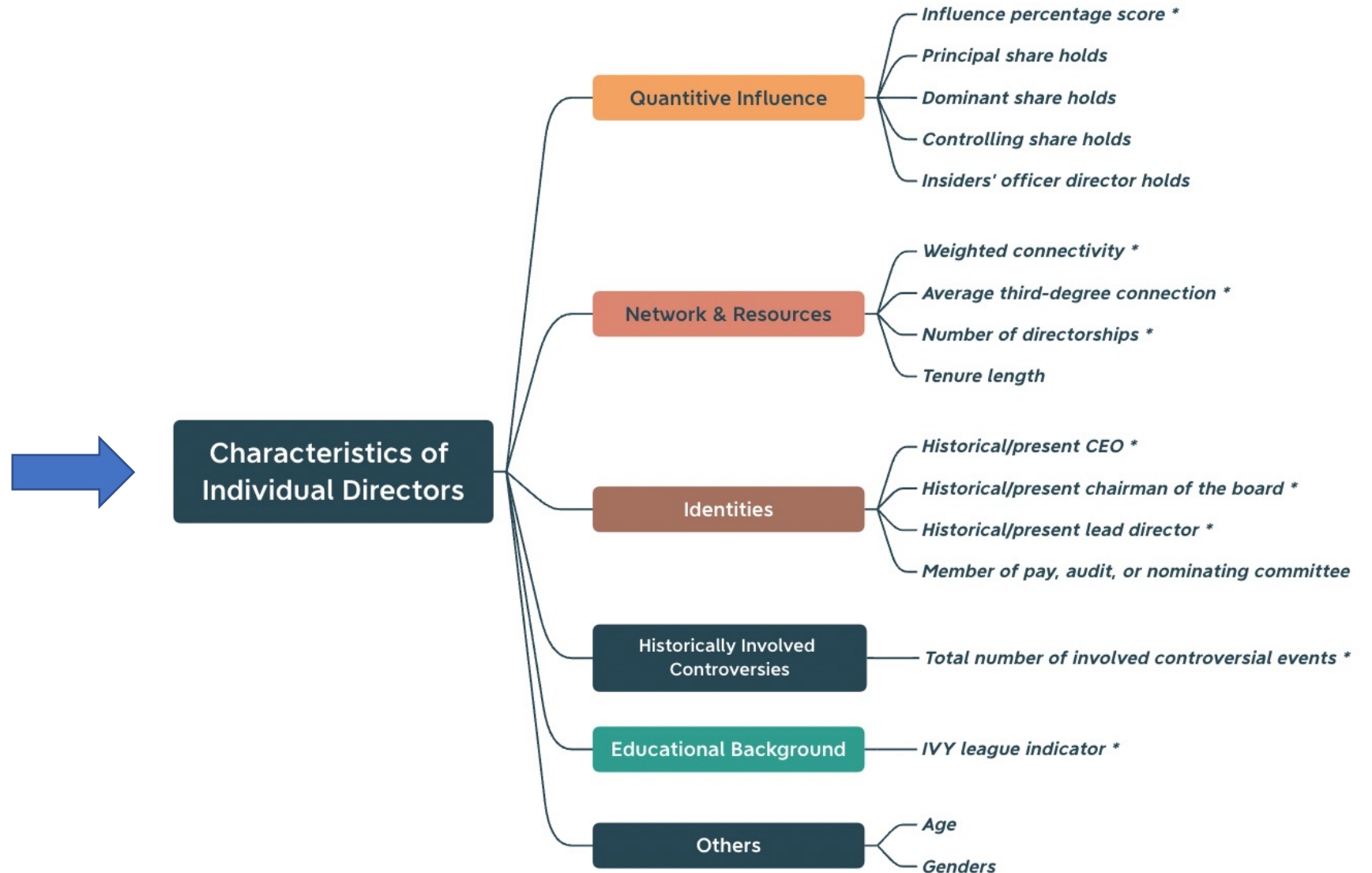
To obtain the best-balanced sample data with enough feature information,
4,155 observations of directors in US-issued companies are applied for further analysis
(361 positive targets and 3,794 negative targets)

Research Goal & Hypotheses

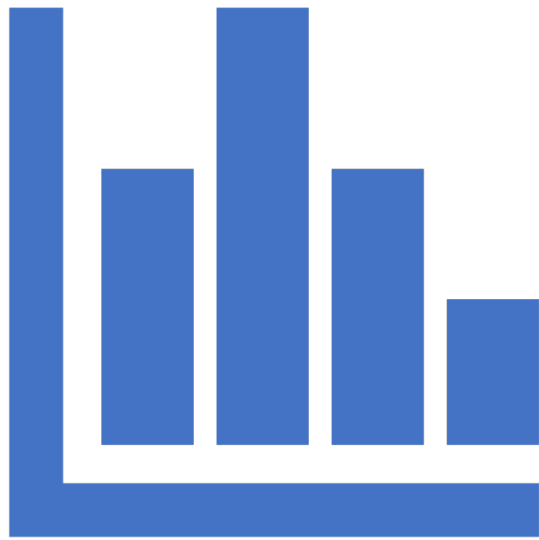
Project Goal:

How each characteristic of the individual director influences the departure when their companies involve controversial events.

16 Hypotheses were formed to be tested and answer:

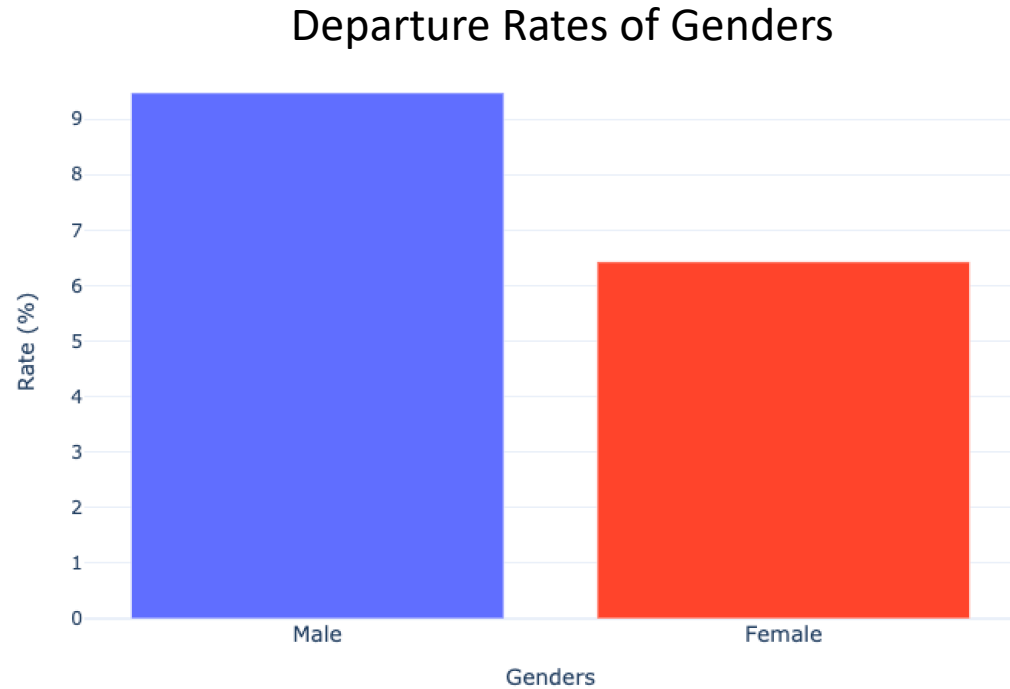


Note. Features with asterisks are generated from feature engineering processes.

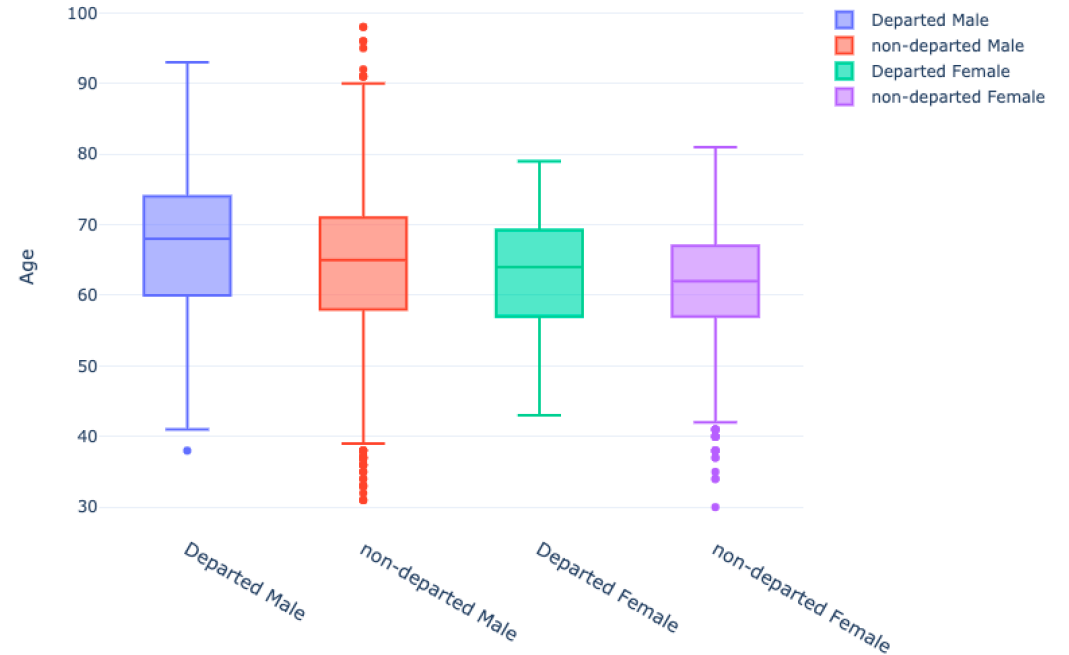


Descriptive Analysis

I. Departure VS Age – Genders



Age Distributions Grouped by Genders & Departure



In US-issued companies (2017–2022),

- Male directors have a higher departure rate (9.47%) than female directors (6.43%);
- The age distributions of departed directors (in both genders) are higher than the non-departed directors;
- Directors under 40 years old were quite "safe".

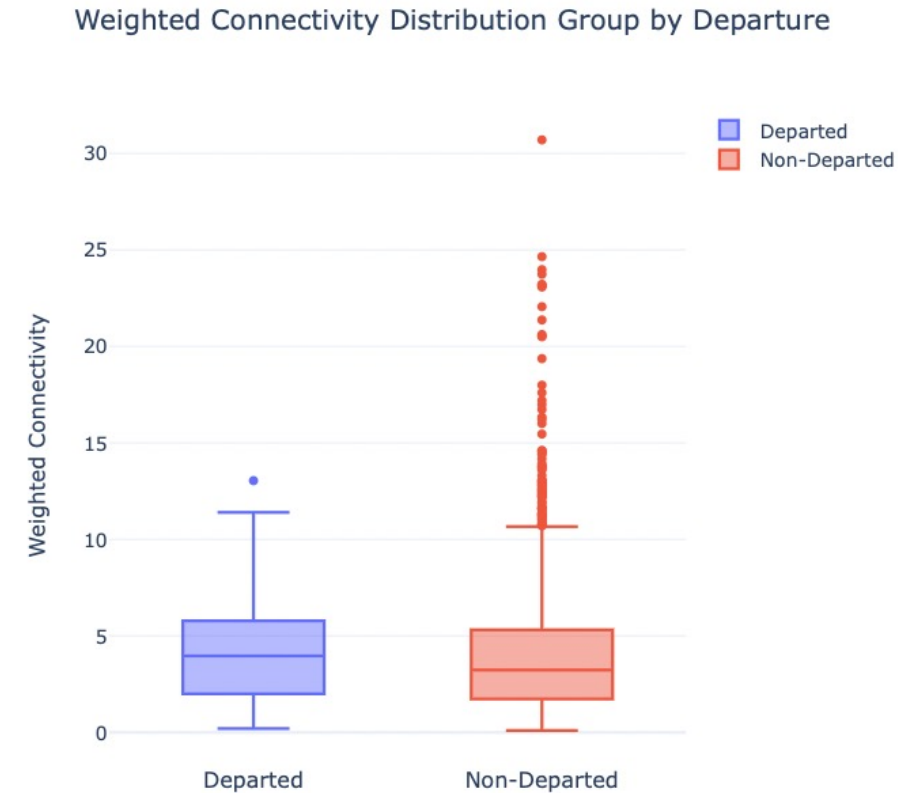
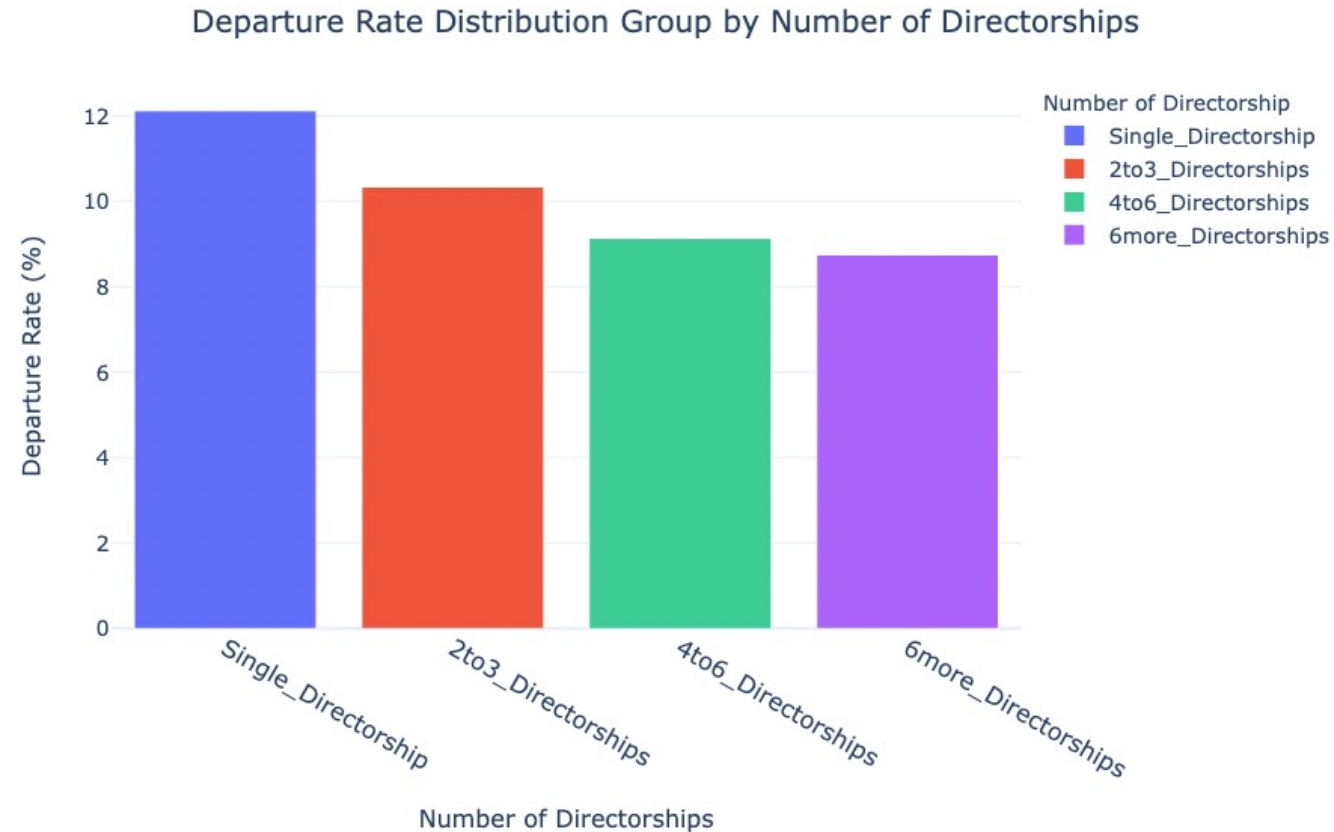
II. Departure VS Identities

Identity	Departure Rate (%)		
	Yes	No	Difference
Pay Committee Member	0.10	11.48	-11.38
Nominating Committee Member	0.39	11.35	-10.96
Audit Committee	0	11.69	-11.69
Company Founder	6.54	8.74	-2.2
past or present CEO	10.30	8.47	1.83
past or present Chairman	9.83	8.53	1.3
past or present lead director	10.27	8.56	1.71

In US-issued companies (2017–2022),

- Directors having positions in the committees were very unlikely to be departed;
- Company founders are less likely to be kicked out (not a promise).
- Past or present important leaders of companies have more but slight chance (less than 2%) to be departed;

III. Departure VS Resources

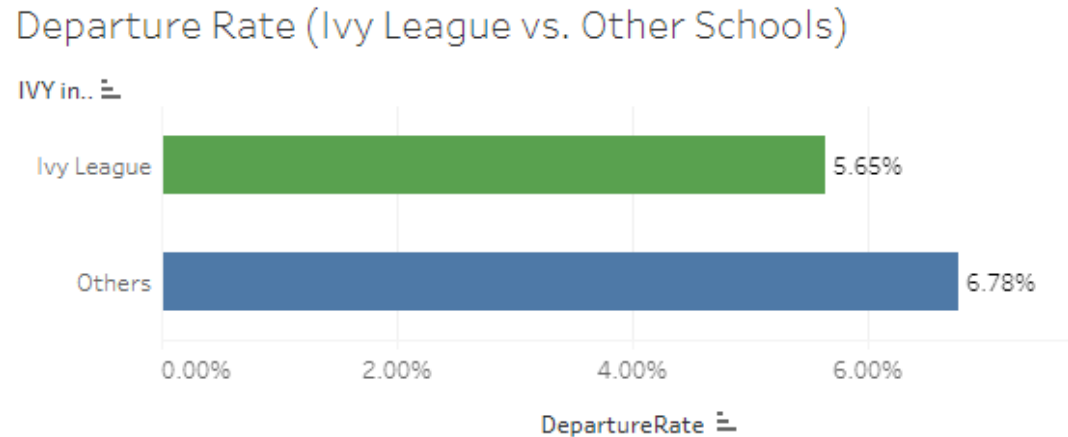


For the board directors in US-issued companies (2017—2022),

- More directorships, less likely to be departed – having more resources that the company needs;
- Outliers in weighted connectivity indicate that directors with extremely high weighted connectivity (greater than 11) are unlikely to be departed.

IV. Departure on Different Education Backgrounds

Of 151 people who were departed from the company, 38 are graduates from Ivy League Schools and 113 are not.



In US-issued companies (2017—2022):

- Ivy League graduates have slightly less departure rate (5.65%) than other school graduates have (6.78%)



Predictive Model Analysis

AUTO ML & Logistic Regression

AUTO ML



Data
Preparation



Model
Training



Hyperparameter
Tuning



Analysis &
Interpretability



Model
Selection



Experiment
Logging

	Model	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC	TT (Sec)
rf	Random Forest Classifier	0.9071	0.8620	0.1656	0.4536	0.2395	0.2021	0.2322	0.591
et	Extra Trees Classifier	0.8984	0.8692	0.1696	0.3668	0.2292	0.1827	0.1996	0.406
gbc	Gradient Boosting Classifier	0.8808	0.8584	0.2759	0.3186	0.2921	0.2280	0.2304	1.001
dt	Decision Tree Classifier	0.8762	0.6688	0.4161	0.3423	0.3735	0.3059	0.3088	0.053
ada	Ada Boost Classifier	0.8567	0.8512	0.4339	0.3001	0.3528	0.2759	0.2828	0.308
lr	Logistic Regression	0.7069	0.8453	0.8931	0.2213	0.3545	0.2459	0.3464	1.272
knn	K Neighbors Classifier	0.7054	0.6122	0.4301	0.1356	0.2059	0.0810	0.1024	0.072
lda	Linear Discriminant Analysis	0.6989	0.8416	0.9272	0.2216	0.3574	0.2484	0.3569	0.045
nb	Naive Bayes	0.6072	0.8230	0.9612	0.1818	0.3057	0.1821	0.3058	0.027
qda	Quadratic Discriminant Analysis	0.5698	0.7787	0.9656	0.1723	0.2917	0.1642	0.2870	0.031

Logistic Regression Model

Results: Logit Summary

```

=====
Model:                Logit                Pseudo R-squared:    0.494
Dependent Variable:    y                    AIC:                3801.5974
Date:                 2022-12-03 22:27      BIC:                4005.6466
No. Observations:      5336                Log-Likelihood:      -1869.8
Df Model:              30                  LL-Null:            -3698.6
Df Residuals:          5305                LLR p-value:         0.0000
Converged:             0.0000              Scale:              1.0000
=====

```



Features	Coef.	Std.Err.	z	P> z	[0.025	0.975]
const	1.0951	0.3426	3.1964	0.0014	0.4236	1.7667
AGE	0.0249	0.0052	4.8224	0.0000	0.0148	0.0351
Tenure	0.0139	0.0111	1.2474	0.2123	-0.0079	0.0357
DirectorshipCount	-0.3786	0.0492	-7.7017	0.0000	-0.4749	-0.2822
AVG_IPS	0.0439	0.0077	5.7395	0.0000	0.0289	0.0590
AVG_Weighted_Connection	-0.0686	0.0310	-2.2153	0.0267	-0.1292	-0.0079
INSIDERS_OFFICERS_DIRECTORS_HELD_PCT	0.0145	0.0044	3.3043	0.0010	0.0059	0.0232
PRINCIPAL_SHAREHOLDER_PCT	-0.0063	0.0042	-1.5200	0.1285	-0.0145	0.0018
CONTROLLING_SHAREHOLDER_PCT	0.0018	0.0036	0.4920	0.6227	-0.0053	0.0088
Avg_3rd_connect_17_22	0.0456	0.0183	2.4902	0.0128	0.0097	0.0815
Ttl_controv_17_22	0.0162	0.0149	1.0879	0.2766	-0.0130	0.0453
GENDER_Male	-0.1826	0.0999	-1.8291	0.0674	-0.3784	0.0131
COMPANY_FOUNDER_T	-1.2018	0.3999	-3.0056	0.0027	-1.9855	-0.4181
EXEC_OR_NON-EXEC_Non-Executive	0.8415	0.2784	3.0227	0.0025	0.2959	1.3872
HistIdentity_CEO_T	-2.4385	0.2149	-11.3447	0.0000	-2.8598	-2.0172
HistIdentity_Chairman_T	-1.1411	0.2148	-5.3129	0.0000	-1.5621	-0.7201
HistIdentity_LeadDirector_T	-1.5302	0.3137	-4.8783	0.0000	-2.1450	-0.9154
PayCommitteeMember_Positive	-6.0649	0.8003	-7.5780	0.0000	-7.6335	-4.4963
AuditCommitteeMember_Positive	-6.8575	0.8467	-8.0990	0.0000	-8.5170	-5.1980
NominatingCommitteeMember_Positive	-5.9681	0.8034	-7.4290	0.0000	-7.5427	-4.3936
INDEPENDENT_OF_MANAGEMENT_Yes	-0.8369	0.2325	-3.6003	0.0003	-1.2926	-0.3813
MULTIPLE_CLASSES_OF_VOTING_STOCK_Yes	-1.7029	0.2143	-7.9456	0.0000	-2.1230	-1.2829
OutsideRelatedReason_Positive	-2.2499	0.2995	-7.5130	0.0000	-2.8369	-1.6630
OutsideRelatedReason2_Positive	-0.2996	0.6590	-0.4546	0.6494	-1.5912	0.9920
CONTROLLED_VIA_STOCK_PYRAMID_Yes	0.5934	0.7041	0.8428	0.3993	-0.7866	1.9735
HAS_CORPORATE_PARENT_Yes	0.2339	0.5529	0.4231	0.6722	-0.8497	1.3176
IVY_indicator_True	-2.7702	0.2013	-13.7638	0.0000	-3.1647	-2.3757
IVY_indicator_UNKNOWN	-1.4904	0.0972	-15.3325	0.0000	-1.6809	-1.2999
CEO_leav_T	1.4923	0.2403	6.2098	0.0000	1.0213	1.9633
Chairman_leav_T	0.8665	0.2576	3.3632	0.0008	0.3615	1.3715
Lead_D_leav_T	-0.7514	0.4353	-1.7262	0.0843	-1.6046	0.1017

Performance Metrics:

Class	Precision	Recall	Accuracy
0 - not departed	0.95	0.75	
1 - departed	0.21	0.62	
			0.74

- only 22% of directors that were predicted as Departed are Departed
- 62% of all Departed directors were identified correctly

LR Feature Importance

-  - the odds of departures increase (positive impacts)
-  - the odds of departures decrease (negative impacts)

Name	Odds ratio
Constant/Intercept	2.98

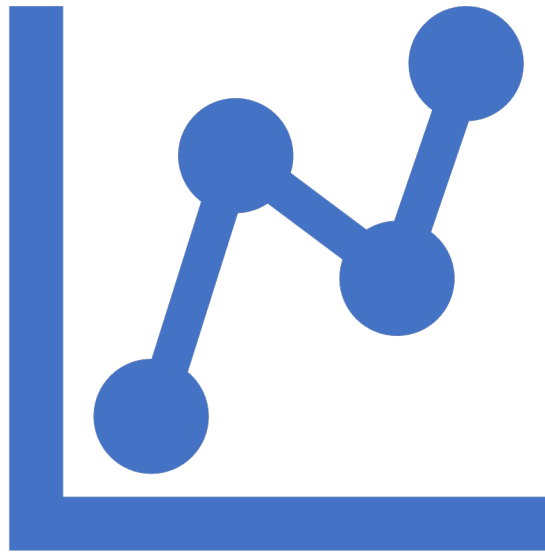
Numeric Features	
Name	Odds ratio
Avg 3 rd degree connection	1.046
Avg Influence share %	1.044
Age	1.02
Insiders Officers Directors Held %	1.01
Avg Weighted Connection (edge)	0.93
Directorship Count *	0.68

* Departure likelihood gets 32% reduced with 1 more directorship

* Being the CEO and Chairman at the moment of controversial events increases their departure likelihoods to 2 - 4 times

Categorical Features	
Feature	Odds ratio
CEO while leaving – True *	4.44
Chairman while leaving – True *	2.37
Non-Executive	2.31
Independent of Management - Yes	0.43
Was a Chairman while on the board - True	0.31
Company Founder - True	0.30
Was a Lead Director while on the board - True	0.21
Multiple Classes Of Voting Stock - Yes	0.18
Outside Related Reason - Positive	0.10
Was a CEO while on the board - True	0.08
Ivy League Alumni - True	0.06
Nominating Committee Member – Positive	0.0025
Pay Committee Member - Positive	0.0023
Audit Committee Member - Positive	0.001

* * Directors with these characteristics (blue cells) are at lower risk to be departed



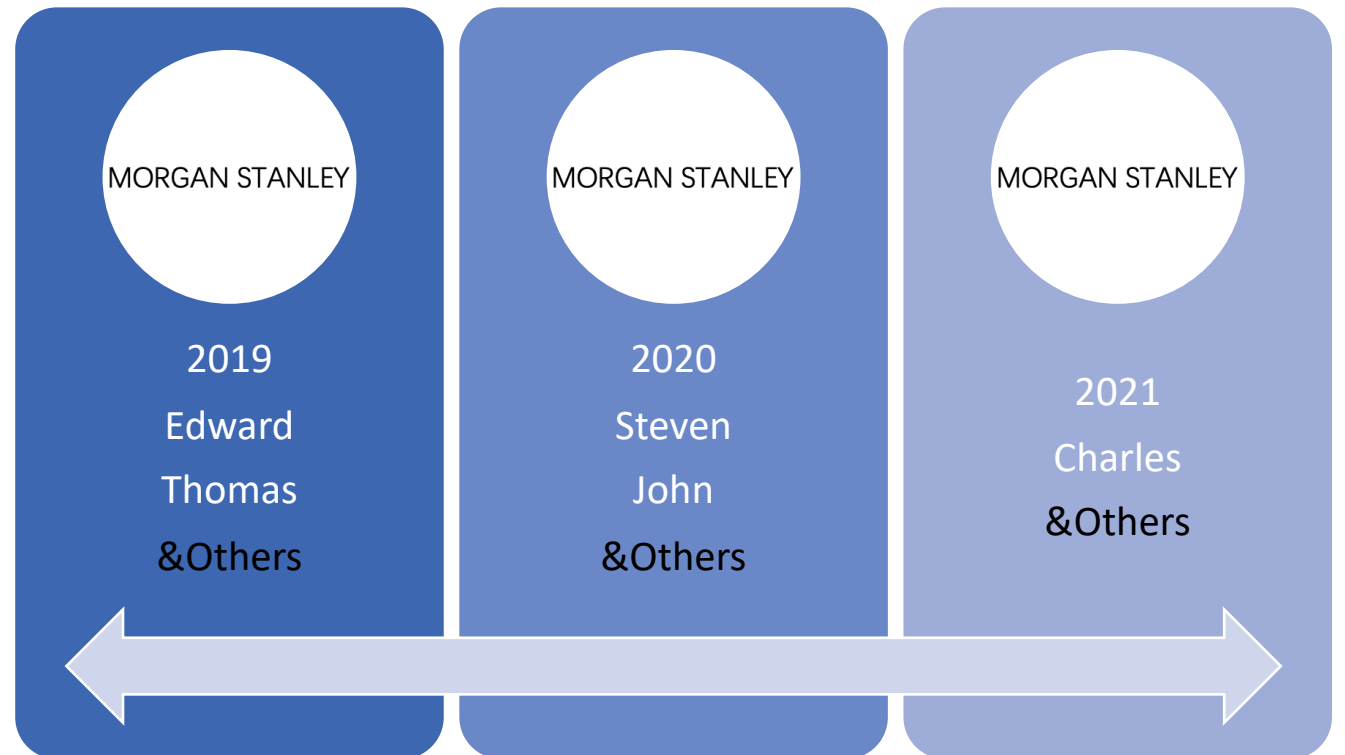
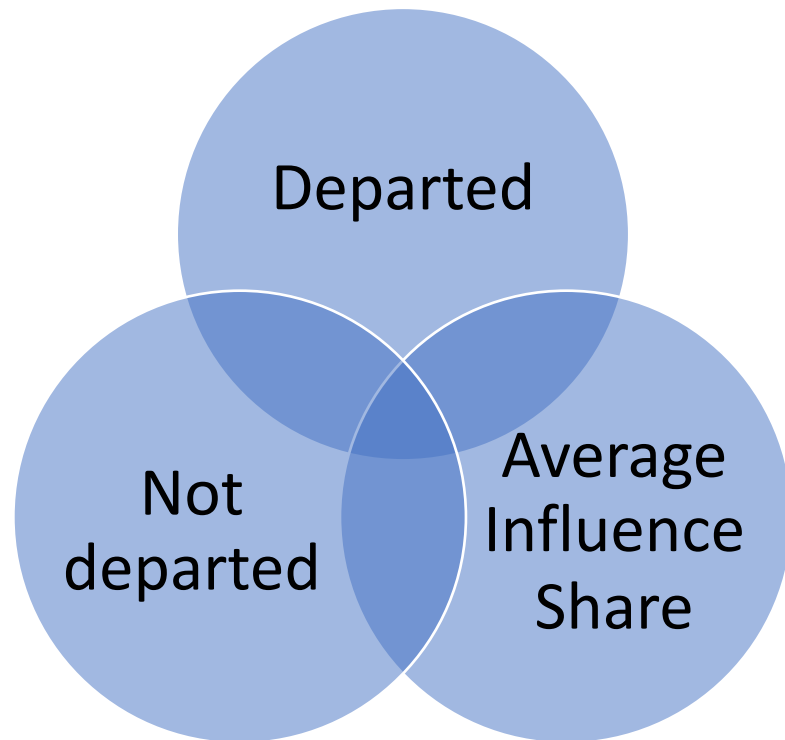
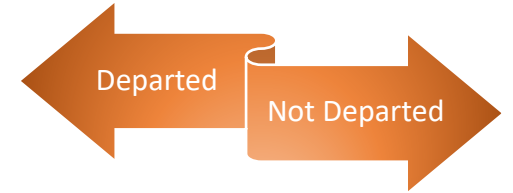
Predictive Model Analysis The Second Approach

Models & SMOTE

Data Structure

Study by case

- ❑ Each case is mutual exclusive.
- ❑ The influence share remains the year fraud happened.
- ❑ Explore more about the difference between two groups of people



Feature Selection

- 30380 rows × 28 columns

pct_share	EXEC_OR_NON-EXEC	OWNERSHIP_CATEGORY
that_influence_year_fraud_happened	OUTSIDE_RELATED_REASON	MULTIPLE_CLASSES_OF_VOTING_STOCK
that_year_share	OUTSIDE_RELATED_REASON_2	PRINCIPAL_SHAREHOLDER_PCT
AGE	INDEPENDENT_OF_MANAGEMENT	CONTROLLING_SHAREHOLDER_PCT
GENDER	HAS_CORPORATE_PARENT	GICS_SUB_IND
Tenure	CONTROLLED_VIA_STOCK_PYRAMID	Sector
PAY_COMMITTEE_MEMBER	DOMINANT_SHAREHOLDER_PCT	target
AUDIT_COMMITTEE_MEMBER	FAMILY_FIRM	3rd_median
NOMINATING_COMMITTEE_MEMBER	FOUNDER_FIRM	
COMPANY_FOUNDER	INSIDERS_OFFICERS_DIRECTORS_HELD_PCT	

Balance data by SMOTE

Synthetic Minority Oversampling Technique

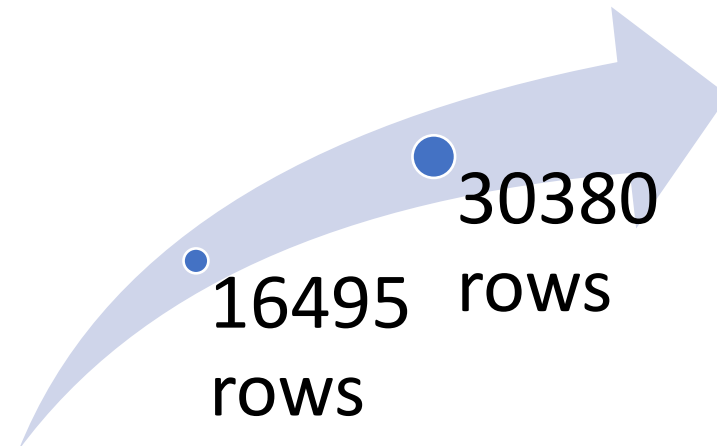
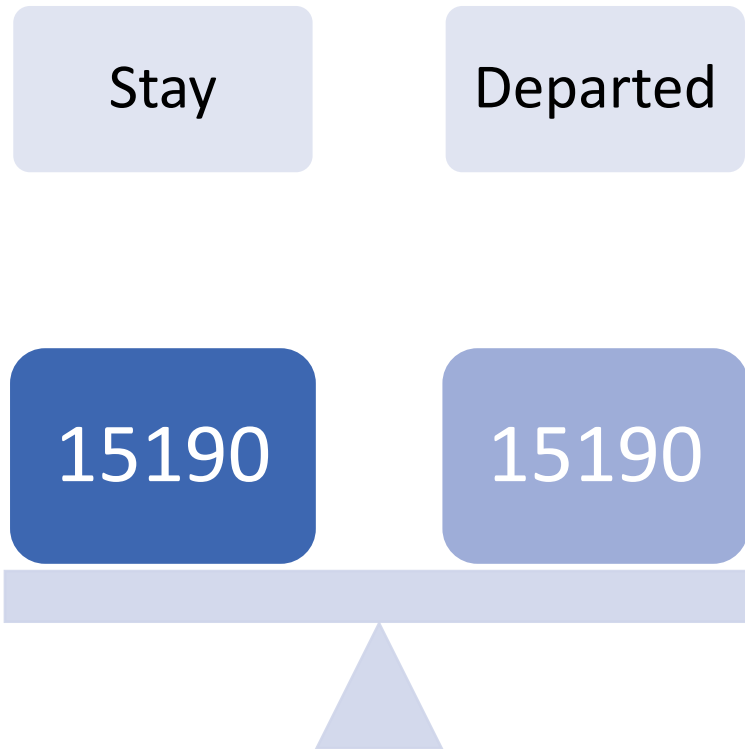
Stay

Departed



Balance data by SMOTE

Synthetic Minority Oversampling Technique
30380 rows × 28 columns



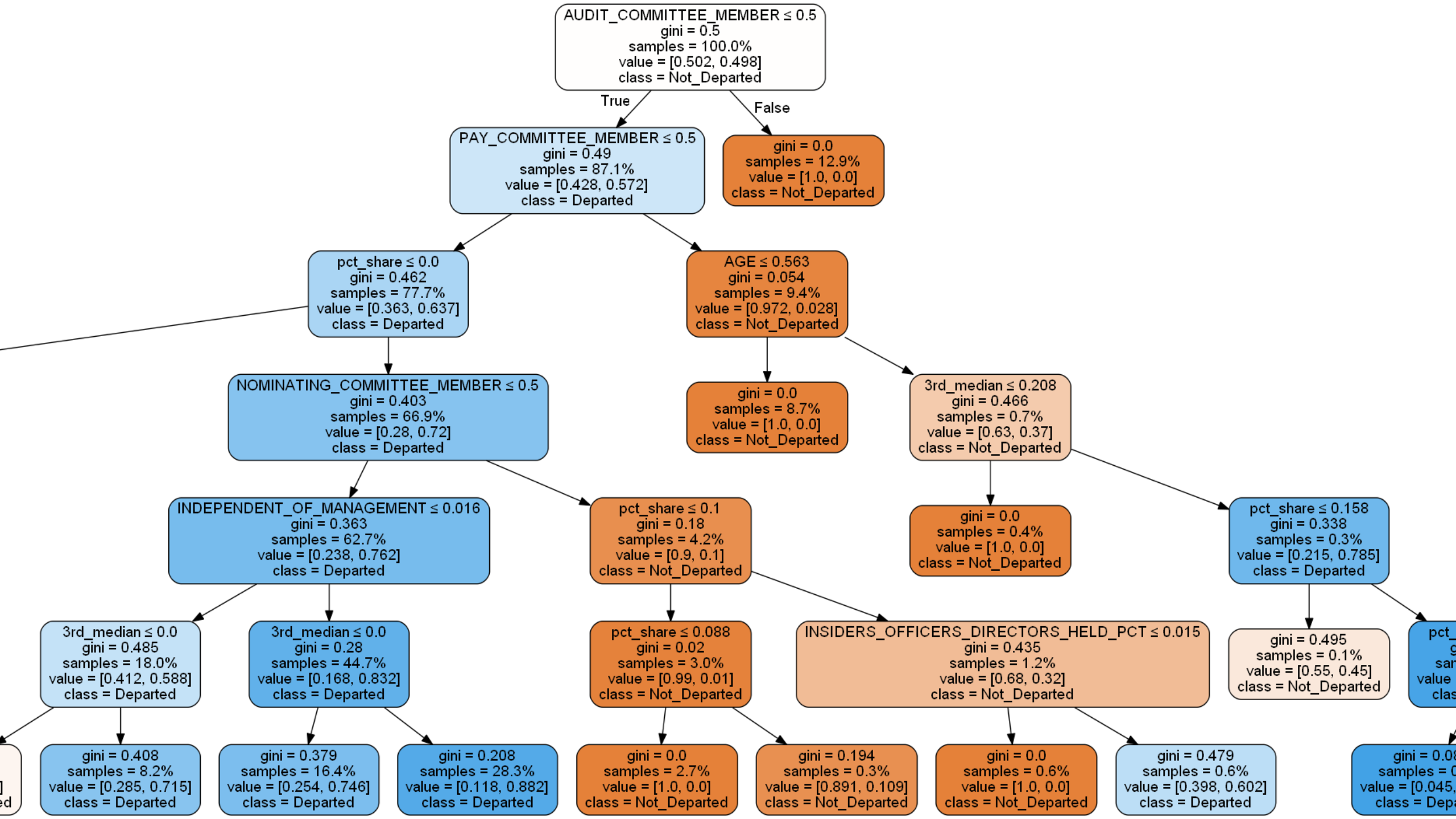
Logistic Regression

- 79% accuracy after SMOTE
- 74% precision on predicting departed members
- PAY_COMMITTEE_MEMBER has highest coef

Before	precision	recall	f1-score	support		
0.0	0.93	0.99	0.96	5332	PAY_COMMITTEE_MEMBER	-4.3702
1.0	0.48	0.07	0.12	442	that_year_share	-4.1945
					INDEPENDENT_OF_MANAGEMENT	3.7536
accuracy			0.92	5774	OUTSIDE_RELATED_REASON	3.0710
macro avg	0.70	0.53	0.54	5774	NOMINATING_COMMITTEE_MEMBER	-3.0643
weighted avg	0.89	0.92	0.90	5774	EXEC_OR_NON-EXEC	-2.5090
After	precision	recall	f1-score	support		
0.0	0.87	0.67	0.76	5276	3rd_median	2.4655
1.0	0.74	0.90	0.81	5357	AGE	-2.2262
					pct_share	1.9199
accuracy			0.79	10633	DOMINANT_SHAREHOLDER_PCT	1.3273
macro avg	0.81	0.79	0.79	10633	COMPANY_FOUNDER	-0.9227
weighted avg	0.80	0.79	0.79	10633	Tenure	0.6717

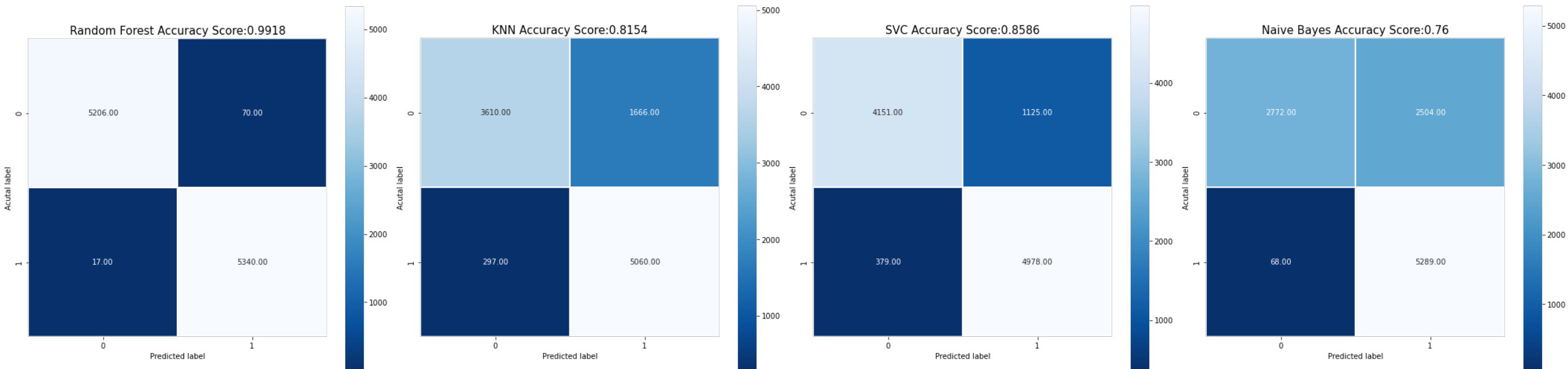
- 85% accuracy after SMOTE
- 82% precision on predicting departed members

[illegible]



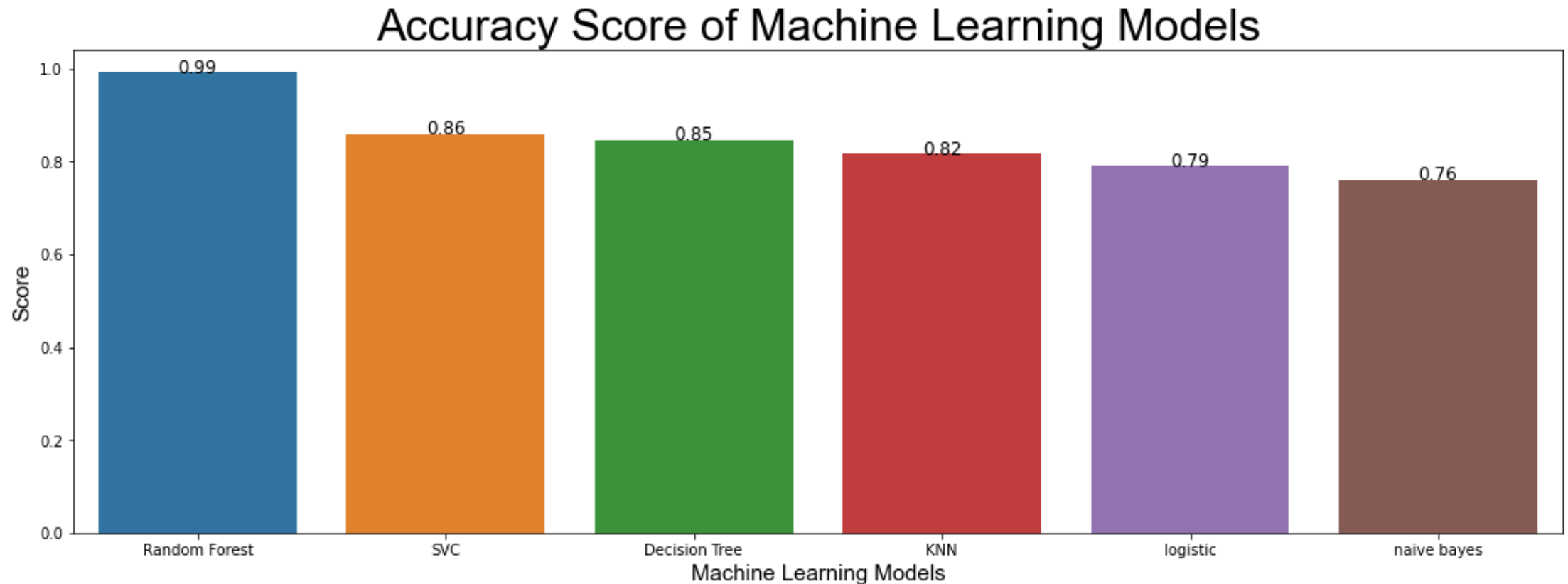
Random Forest & SVC & KNN & Naive Bayes

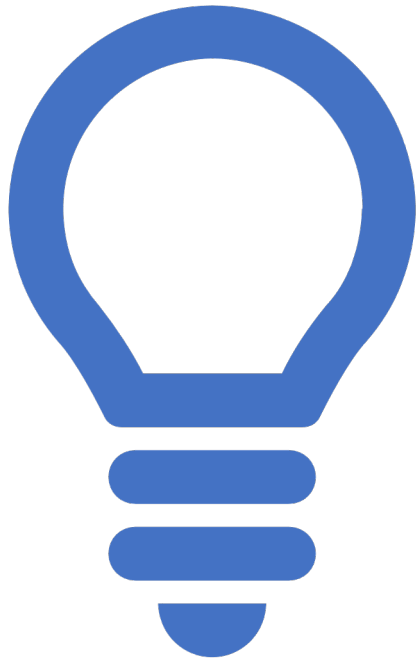
Random Forest	SVC	KNN	Naïve Bayes
99%	86%	82%	76%



Bar Chart to Compare All Machine Learning Models

- 30380 rows × 28 columns





Conclusions

Identities – Departures

i. Being the CEO or Chairman of the board during controversial events have significantly positive impacts on departure results:

their departure likelihoods are 2 to 4 times compared to the directors who are not in the positions.

ii. Used to be CEOs, Chairmen, or lead directors before the controversial events have significantly negative impacts on departure results:

their departure likelihoods are reduced to less than 30% compared to those who had never been in these positions.

iii. Being a member of nominating, pay, or audit committees have significantly negative impacts on departure results:

their departure likelihoods are less than 1% of whom are not in these committees during the controversial events.

Network and Resources – Departures



i. The number of third-degree connections has significant **positive** impacts:

The departure likelihood gets 50% to 60% more when third-degree connection increases by 10.



ii. The number of directorships has significant **negative** impacts on departure results:

The departure likelihood gets around 30% reduced with one more directorship in different company.

Quantitative Influence – Departure

i. The influence percentage has significant positive impacts on departure results:

The departure likelihood increases about 40% with 10% additional influence percentage.

ii. Insider officers' directors holds have significant positive impacts on departure results:

The departure likelihood increases about 10% with 10% additional insider officer directors holds.

Educational Background – Departure

Graduating from IVY league colleges has significantly negative impacts on departure results:

Their departure likelihoods are less than 10% of the directors who have never been to these colleges.

Age – Departure

Age has significant positive impacts on the departure results:

The departure likelihood gets 20% increased with ten years older.

Predictive Modeling

The classification method of **Random Forest** turned out to have the highest accuracy in predicting the departures of directors when their companies involved controversial events regarding both data structures we applied.

Further improvement of the predictive model could be achieved by following aspects:

- i. Overcome the imbalance distributions of independent variables;
- ii. Variable control in sectors, capital levels, etc.;
- iii. Combining the two strategies of processing IPS in different structures;
- iv. Modifying the assumptions and target-identifying algorithm with additional and more detailed data sources.

Thank you for your listening

Open to any questions!



References:

- Ali, M. (2020). *Classification*. Classification - pycaret 3.0.0 documentation. Retrieved December 5, 2022, from <https://pycaret.readthedocs.io/en/latest/api/classification.html>
- Martin, K. G. (2022, October 14). *Why use odds ratios in logistic regression?* The Analysis Factor. Retrieved December 5, 2022, from <https://www.theanalysisfactor.com/why-use-odds-ratios/>

Appendix A: Research Hypotheses

- **H1.1:** the **influence percentage score** of the director has a negative influence on departures when controversial events happen (false, significantly positive influence)
- **H1.2:** the percentage of **dominant share holds**, **insiders' official directors' holds**, **principal share holds**, and **controlling share holds** all have a negative influence on departures when controversial events happen. (insiders' official directors' holds is true while others are false)
- **H2.1:** having positions in the **pay committee**, **audit committee**, and **nominating committee** negatively influences the likelihood of departures when controversial events happen compared to the situation of not having positions in these committees. (True)
- **H2.2:** directors who used to be or currently are **chairmen of the board**, **lead directors**, or **CEOs** have a lower likelihood to be departed than the directors who are not these characters in companies. (CEO & chairman true; lead directors false)
- **H2.3:** directors who are **company founders** or **executive directors** are less likely to be departed than the directors who do not have these identities. (True)

Appendix A: Research Hypotheses

- **H3.1:** the **weighted connectivity** of the director has a negative influence on the departure when the company involves controversial events. (false)
- **H3.2:** the **average third-degree connection** of the director has a negative influence on the departure when the company involves controversial events. (False, significant positive influence)
- **H3.3:** the **number of directorships** across different companies has a negative impact on the departure when controversial events happen. (True)
- **H3.4:** the **tenure length** has a negative impact on the departure when controversial events happen. (false)

- **H4.1:** the option of **multiple classes of voting stock** has negative impacts on the departure when controversial events happen. (True)
- **H4.2:** the option of **independent management** has negative impacts on the departure when controversial events happen. (True)

Appendix A: Research Hypotheses

- **H5:** having the **educational background of the IVY league colleges** has a negative influence on the departure when controversial events happen. (True)
- **H6:** the **male director** has a lower likelihood to be departed when controversial events happen than the female director. (False)