EMPLOYEE TURNOVER PREDICTION

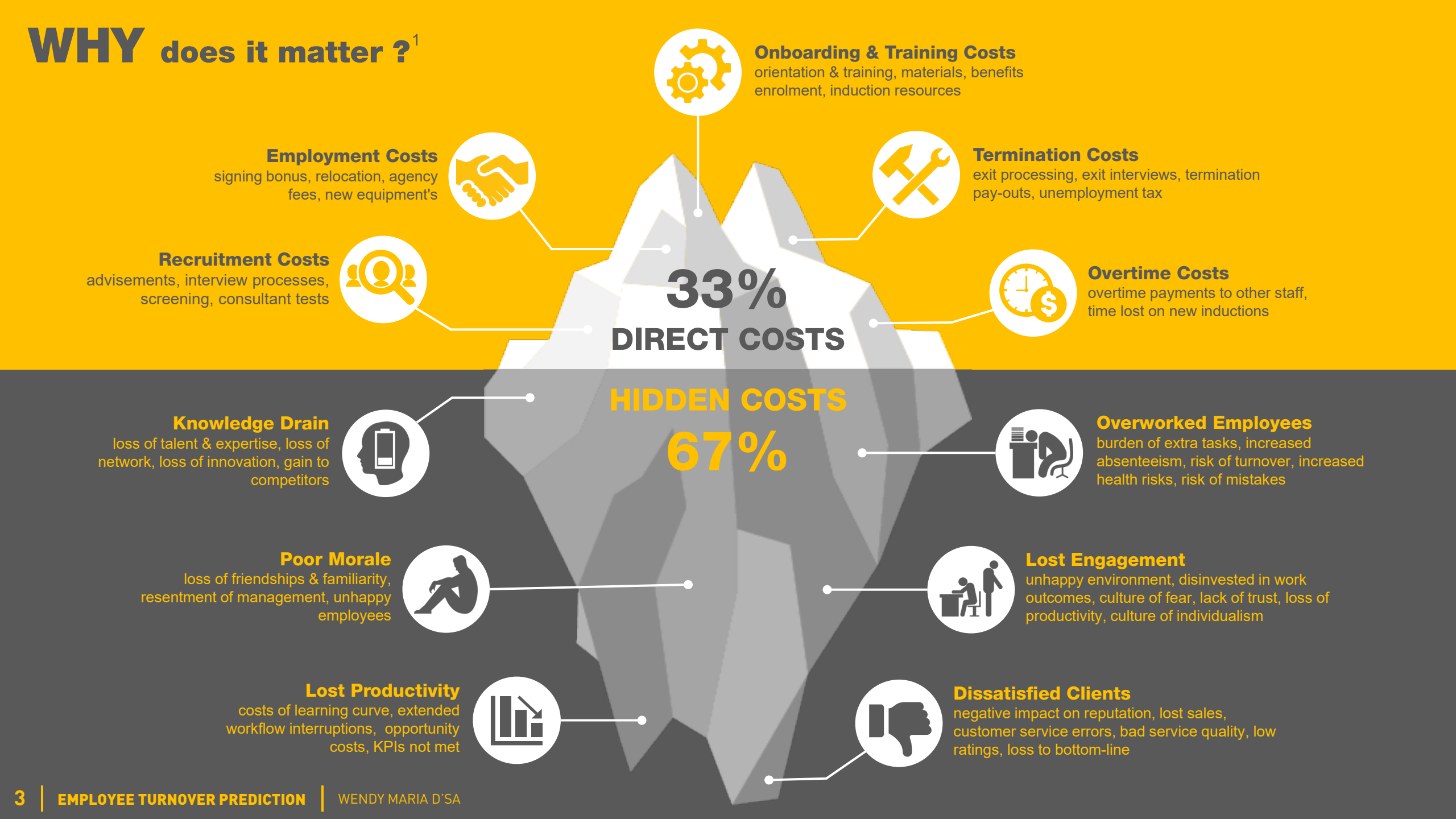
WITH MACHINE LEARNING

[WENDY MARIA D'SA · MINI PROJECT 02 · INSTITUTE OF DATA]

WHAT is Employee Turnover ?

- It is the **measurement of the number of employees who leave an organisation** during a specified time period, typically one year.
- It applies to an **entire organisation** but can also apply to **individual departments or demographic groups** within an organisation.

WHY does it matter ?[1]



Onboarding & Training Costs
orientation & training, materials, benefits enrolment, induction resources

Employment Costs
signing bonus, relocation, agency fees, new equipment's

Termination Costs
exit processing, exit interviews, termination pay-outs, unemployment tax

Recruitment Costs
advisements, interview processes, screening, consultant tests

Overtime Costs
overtime payments to other staff, time lost on new inductions

33%
DIRECT COSTS

HIDDEN COSTS
67%

Knowledge Drain
loss of talent & expertise, loss of network, loss of innovation, gain to competitors

Overworked Employees
burden of extra tasks, increased absenteeism, risk of turnover, increased health risks, risk of mistakes

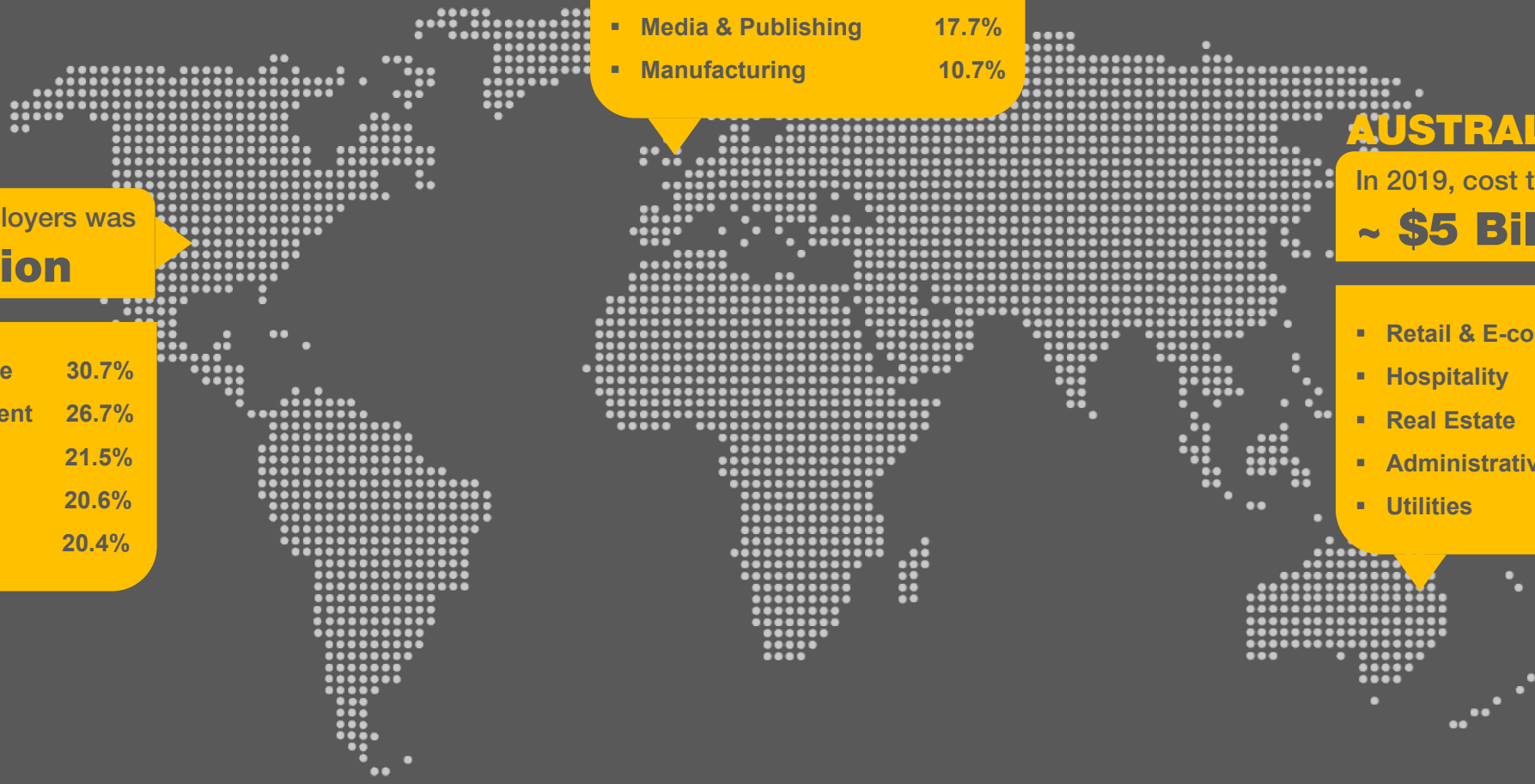
Poor Morale
loss of friendships & familiarity, resentment of management, unhappy employees

Lost Engagement
unhappy environment, disinvested in work outcomes, culture of fear, lack of trust, loss of productivity, culture of individualism

Lost Productivity
costs of learning curve, extended workflow interruptions, opportunity costs, KPIs not met

Dissatisfied Clients
negative impact on reputation, lost sales, customer service errors, bad service quality, low ratings, loss to bottom-line

HOW much does it cost ?



UK [3]

In 2020, cost to employers was

~ $100 Billion

Retail & E-commerce	35.0%
Hospitality	30.0%
Administrative Services	19.3%
Media & Publishing	17.7%
Manufacturing	10.7%

USA [2]

In 2020, cost to employers was

~ $600 Billion

Retail & E-commerce	30.7%
Media & Entertainment	26.7%
Technology	21.5%
Life Science	20.6%
Consulting	20.4%

AUSTRALIA [4]

In 2019, cost to employers was

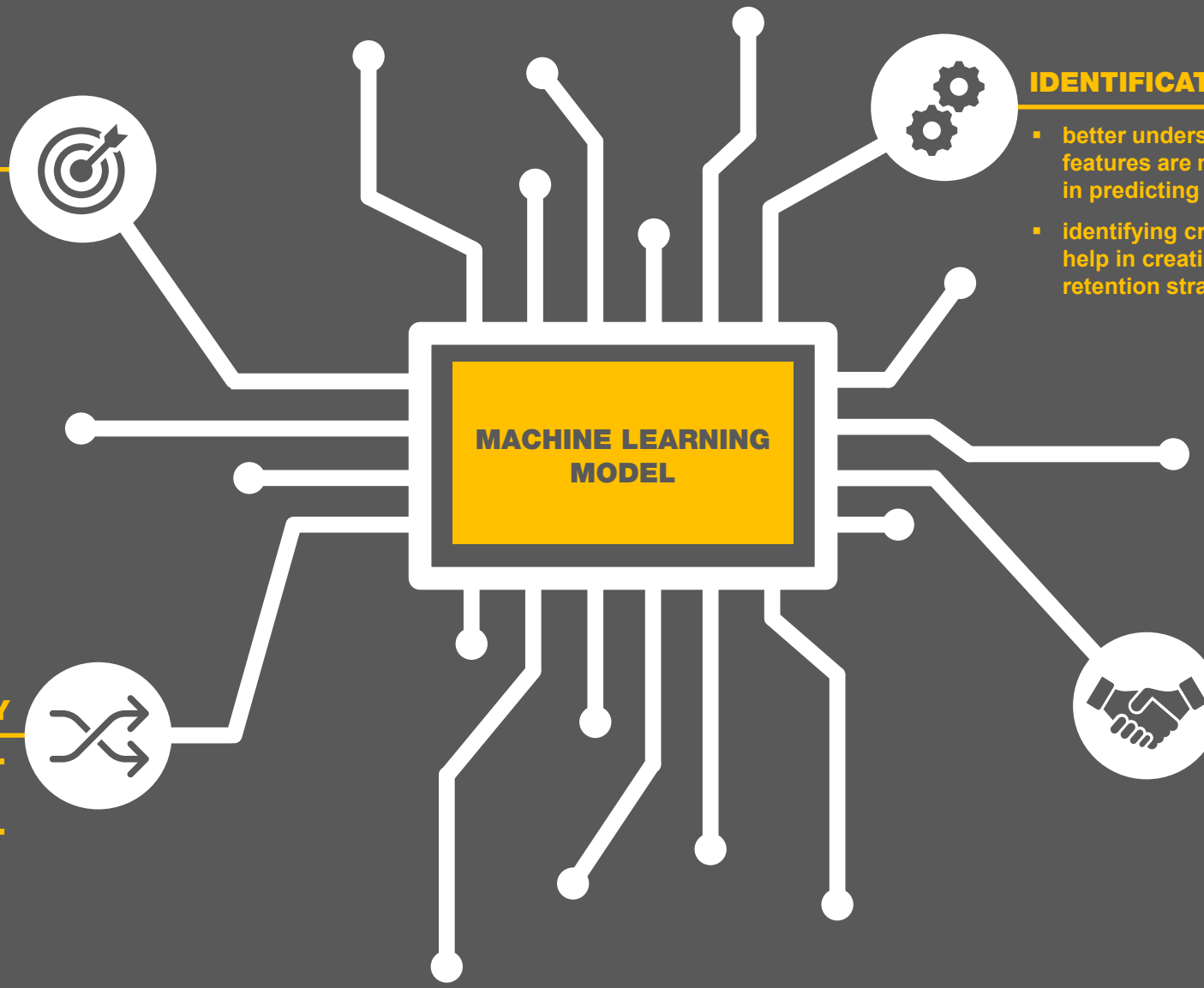
~ $5 Billion

Retail & E-commerce	41.0%
Hospitality	18.0%
Real Estate	11.7%
Administrative Services	11.3%
Utilities	10.7%

HOW much does it cost ?[5]

	ENTRY LEVEL	MID MANAGEMENT	EXECUTIVE
AVG. ANNUAL SALARIES	$ 50k	$ 150k	$ 250k
REPLACEMENT COST 60:30:10 RATIO	~ 20% of annual salary $ 10k	~ 100% of annual salary $ 150k	~150 - 215% of annual salary $ 375k
LOSS OF TALENT @ 200 EMPLOYEE REALTY FIRM @ 11.7% avg. turnover	14 ppl	7 ppl	2 ppl
TOTAL COST	$ 140k	$ 1.05m	$ 750k
			$ 1.94m per year
LOSS OF TALENT @ 5000 EMPLOYEE RETAIL FIRM @ 41.0% avg. turnover	1230 ppl	615 ppl	205 ppl
TOTAL COST	$ 12.3m	$ 92.25m	$ 76.88m
			$ 181.4m per year

HOW can machine learning help reduce employee turnover ?



PREDICTION

- learn turnover patterns and predict with high accuracy
- answer critical questions on employee metrics
- foresee vacant positions and allocate resources accordingly
- guide decisions on recruitment and retention strategies

IDENTIFICATION

- better understand which features are most influential in predicting turnover
- identifying critical features help in creating targeted retention strategies

FLEXIBILITY

- can be retrained and reused quickly with new features
- accuracy and efficiency improve with subsequent training with new data

COLLABORATION

- work as a stand-alone model, and/or
- as input into advanced analytics, and/or
- work together with humans to further improve detection and predictive performances

QUESTION

PROFILE

COMPANY TYPE	▶	Pharmaceutical
COMPANY SIZE	▶	4000 - 4500 employees
TURNOVER	▶	15.0% per year
DIRECT COSTS	▶	$ 53 – 60 Million per year

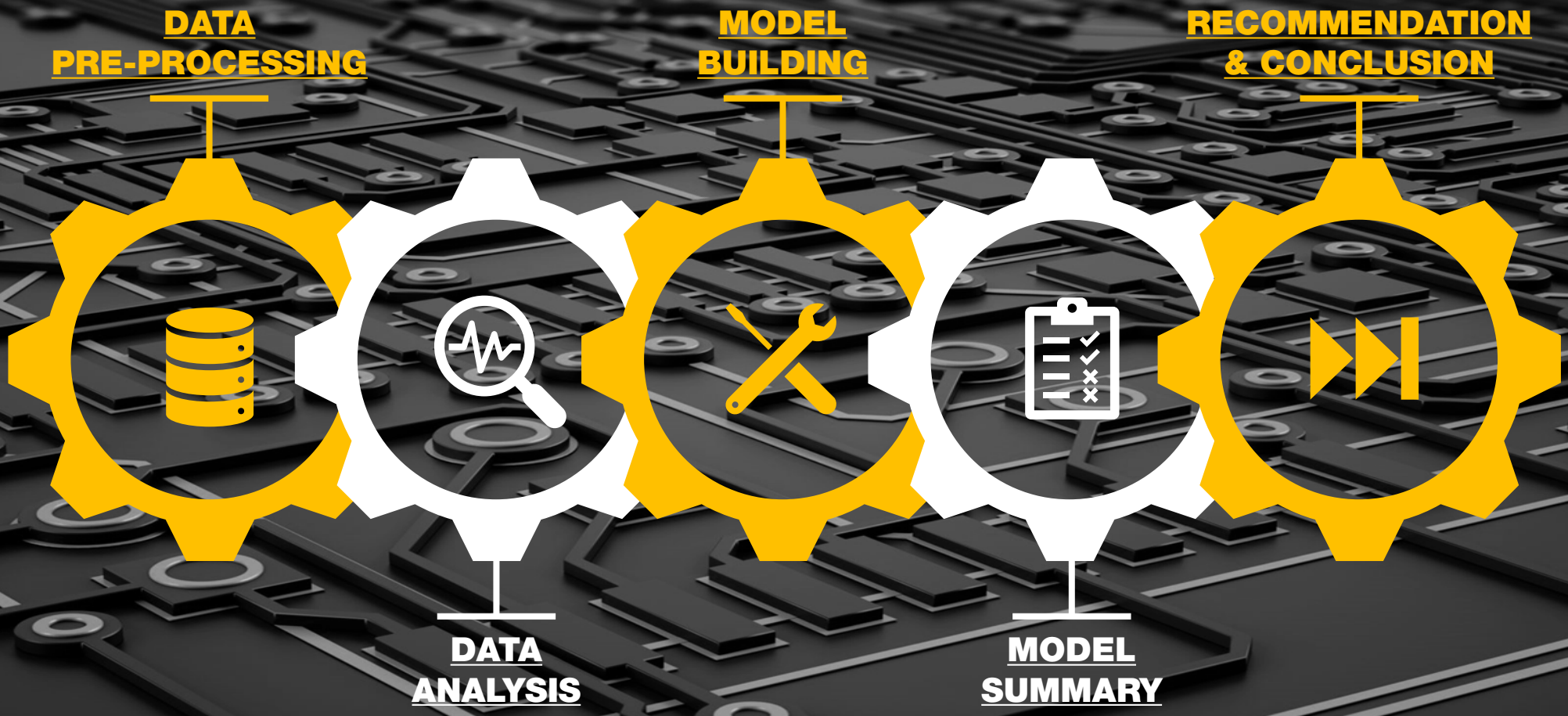
GOAL

Create a MVP
Machine Learning Prediction Model
that will assist the company reduce turnover

ANSWER

- WHO, WHEN, WHY of employee turnover ?
- What are the most important factors to reduce turnover ?
- What changes should be made ?

PIPELINE


DATA PRE-PROCESSING
DATA ANALYSIS
MODEL BUILDING
MODEL SUMMARY
RECOMMENDATION & CONCLUSION

DATASET

DATA SOURCE

Kaggle ▶ https://www.kaggle.com/vjchoudhary7/hr-analytics-case-study

Note ▶ Data consists of both numerical and categorical values

DATA PROCESSING

Observations ▶ 4410

About Employee ▶ 2 Numerical + 4 Categorical

About Job ▶ 10 Numerical + 6 Categorical + 3 Features engineered

About Time ▶ 2 Numerical time series + 3 Features engineered

About Satisfaction ▶ 3 Categorical

About Performance ▶ 2 Categorical

GENERAL DATA

- Age
- Gender
- Education level
- Education field
- Marital Status
- Distance from work
- Department
- Business travel
- Employee ID
- Job level
- Job role
- Monthly income
- No. of companies worked
- Percentage salary hike
- Standard hours
- Stock options
- Total working years
- Training time last year
- Years at company
- Last promotion
- Years with current manager
- Attrition
- **Median compensation**
- **Compensation ratio**
- **Compensation level**

EMPLOYEE SURVEY

- Employee ID
- Environment satisfaction
- Job satisfaction
- Work life balance

MANAGER SURVEY

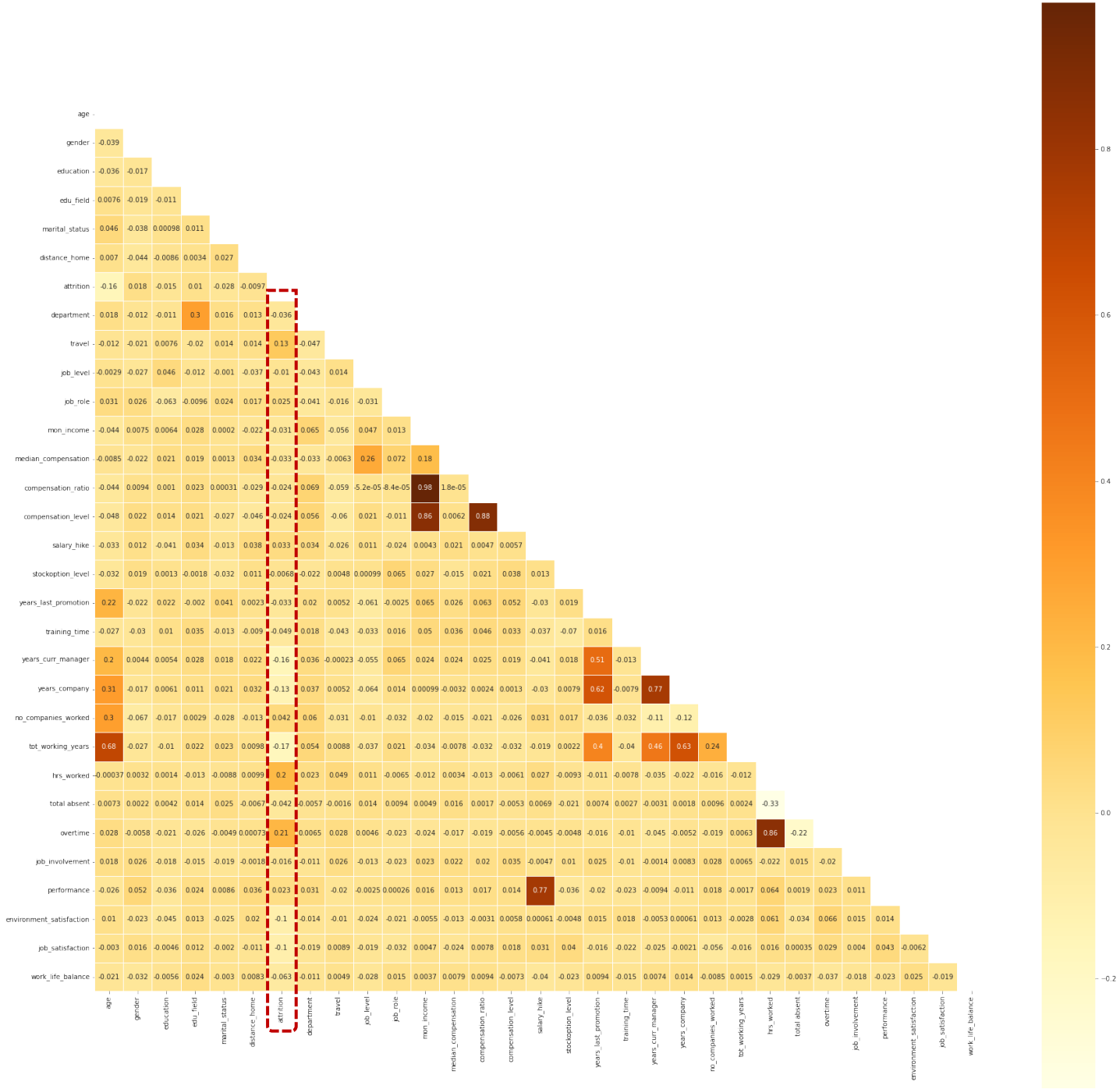
- Employee ID
- Job involvement
- Performance rating

TIME IN | TIME OUT

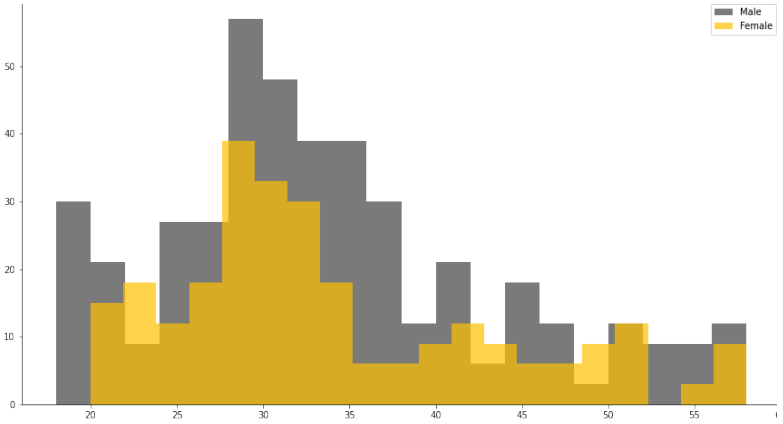
- Employee ID
- Start time – entire year
- End time – entire year
- **Hours worked**
- **Total absent**
- **Overtime**

OVERVIEW

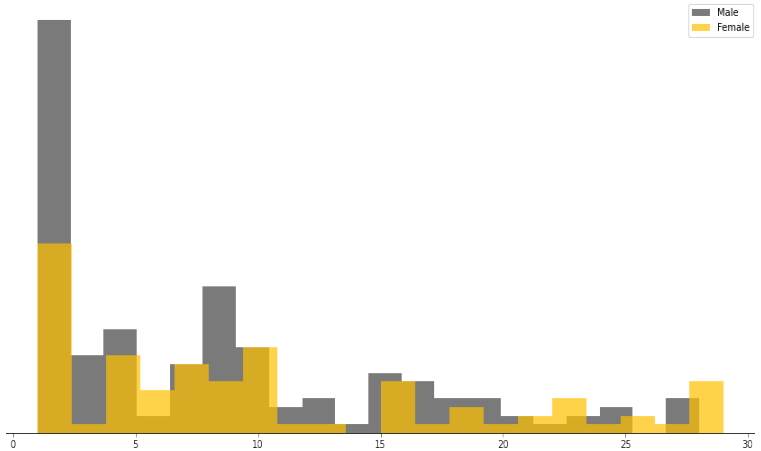
- Overall, the features are **quite independent** to each other.
- There are a **few positive and negative correlations**, such as
  - **Positive:** compensation level vs. monthly income; hours worked vs. overtime, salary hike vs. performance, monthly income vs. compensation ratio…etc.
  - **Negative:** hours worked vs. total absent, total absent vs. overtime, attrition vs. total working years, etc.



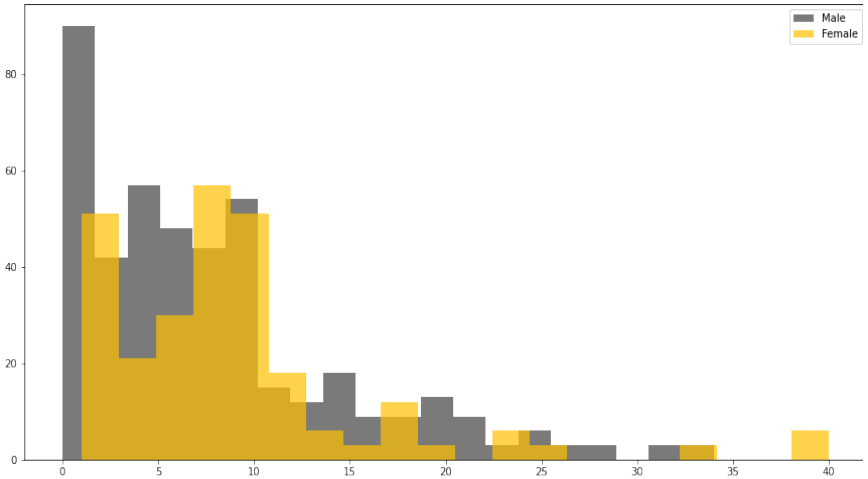
OVERVIEW



Age Distribution and Gender



Distance to work and Gender

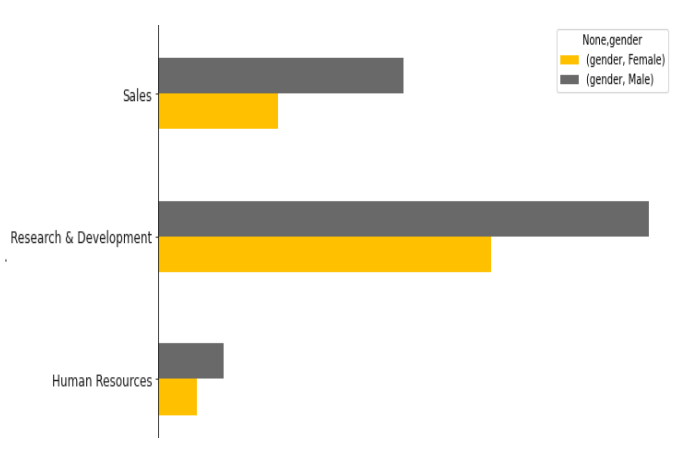


Total working years to work and Gender

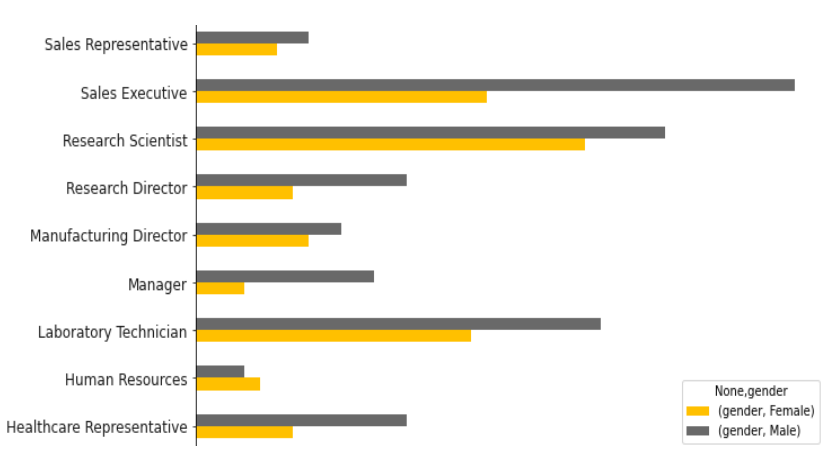
WHO

- High turnover among employees between the **ages of 25 to 35 with more male leavers than female** - could also be due to more male employees than female.
- Employees **commuting smaller distances have a higher turnover** with more female leavers travelling @ 1-10 kms.
- Turnover is higher among **employees at the start and mid career level** - which is also confirmed by the age distribution. This means that younger talent with fresher innovative ideas are leaving which could make the company less competitive.

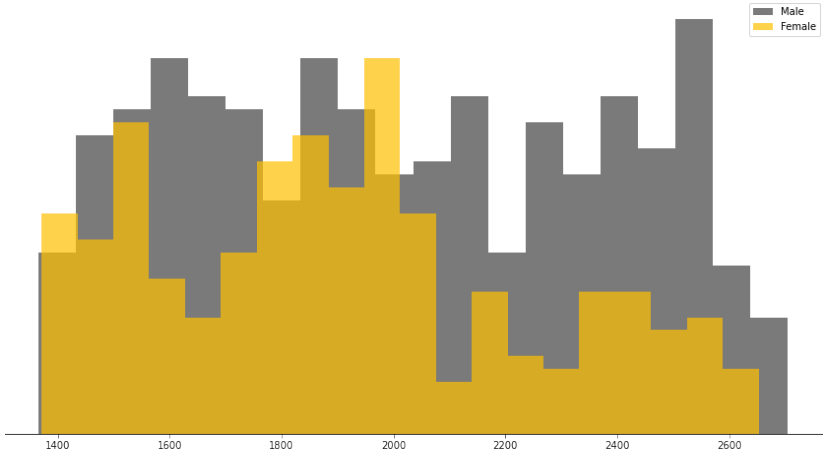
OVERVIEW



Department and Gender



Job Role and Gender

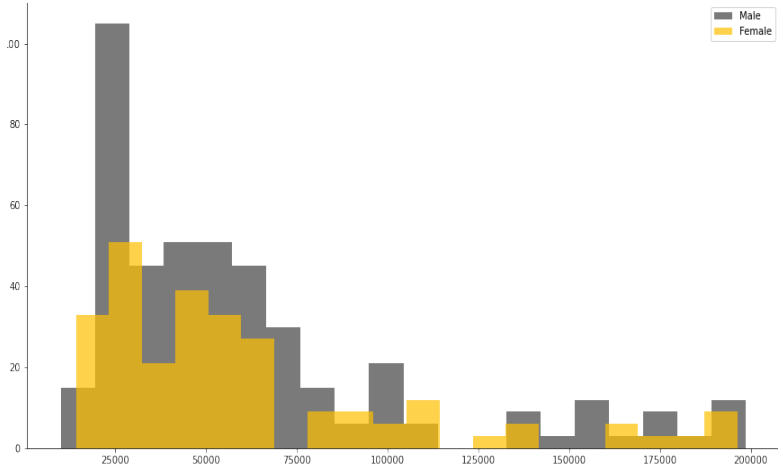


Hours worked and Gender

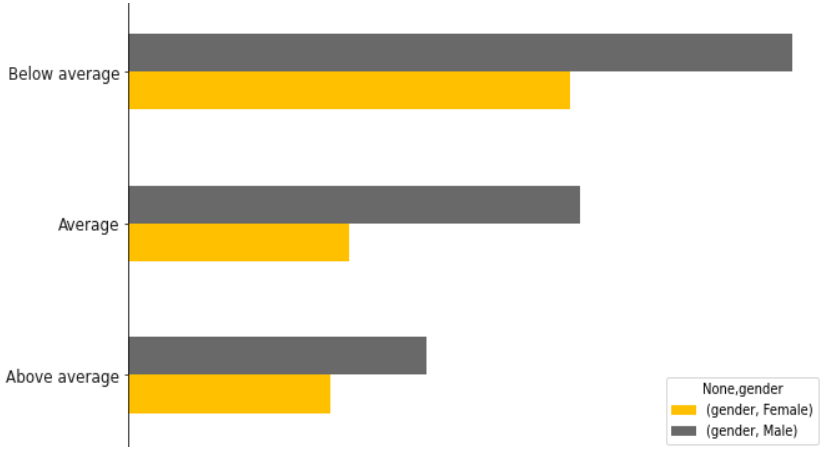
WHERE

- Turnover is high in the **Research & Development** department followed by **Sales**.
- Turnover is higher among **Laboratory Technicians and Research Scientist** - not a good sign for a pharmaceutical company as there is knowledge drain.
- The highest turnover is among male **Sales Executives** - not very good for company sales and brand value outlook for customers.
- Higher turnover among **males working longer hours than female** – it would be prudent to check against age as younger females may put in longer hours at start of career.
- Not a lot of difference in turnover and hours worked in males while **female employees working lesser hours** are quitting – this should be also checked against compensation levels.

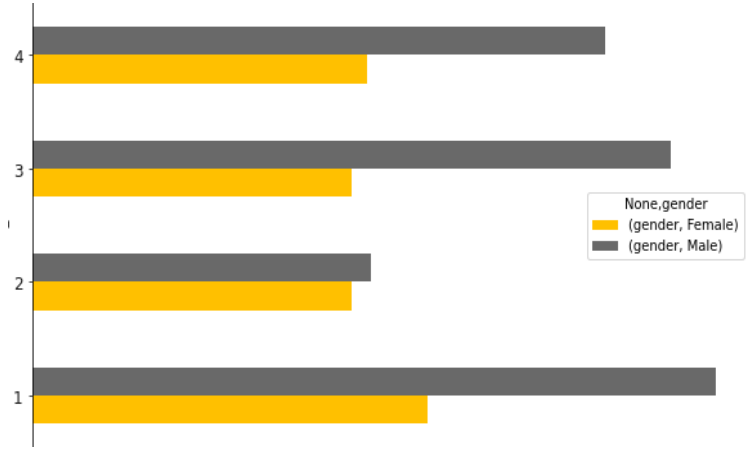
OVERVIEW



Salary and Gender



Compensation Level and Gender



Env. Satisfaction and Gender

WHY

- High turnover among **employees on the lower pay scale** which is also validated by the compensation level chart.
- Employees with **below average compensation** tend to leave more. The company may need to investigate pay disparity among employees on similar job titles and levels.
- **Male employees with lower work environment satisfaction** tend to leave, although there is not much difference with those who are more satisfied with their work environment.

PRE-PROCESSING & MODEL SETUP

1 FEATURE ENGINEERING

6 New features

2 DATASET BALANCING

Over-sampling by SMOTE | (2589, 30) (2589,)

Combination sampling | (1267, 30) (887,)

3 CROSS VALIDATION

Kfold Method (10) | oversampled dataset

Leave One Out | combination dataset

4 TEST CASES

All Features | 30

Important features | Threshold Score > 0.03

15 features (oversampled dataset)

13 features (combination dataset)

LOGISTIC REGRESSION

K NEAREST NEIGHBOUR (KNN)

SUPPORT VECTOR MACHINE (SVM)

NAÏVE BAYES

RANDOM FOREST

COMPARISON

LOGISTIC REGRESSION	OVERSAMPLED	All features (30)	0.72
		Important features (15)	0.69
	COMBINATION	All features (30)	0.73
		Important features (13)	0.70
K NEAREST NEIGHBOUR (KNN)	OVERSAMPLED	All features (30)	0.81
		Important features (15)	0.88
	COMBINATION	All features (30)	0.87
		Important features (13)	0.91
SUPPORT VECTOR MACHINE (SVM)	OVERSAMPLED	All features (30)	0.95
		Important features (15)	0.88
	COMBINATION	All features (30)	0.90
		Important features (13)	0.80
NAÏVE BAYES	OVERSAMPLED	All features (30)	0.69
		Important features (15)	0.69
	COMBINATION	All features (30)	0.69
		Important features (13)	0.68
RANDOM FOREST	OVERSAMPLED	All features (30)	0.98
		Important features (15)	0.98
	COMBINATION	All features (30)	0.96
		Important features (13)	0.95

2

1

- **All models perform well on cross validation** which means that they generalize well.
- **The gap between the models with all features and important features is small** therefore we can be confident that most of the classification power is stored within the 13-15 important features.
- **The performance of the SVM model decreases as we drop features,** may need to decrease the threshold to include more features
- **The best model based on the cross-validation scores is Random Forest** followed by the **SVM model with full features –** both on the oversampled dataset

KEY METRICS

			accuracy	recall	F1	roc/auc
LOGISTIC REGRESSION	OVERSAMPLED	All features (30)	0.74	0.70	0.47	0.79
		Important features (15)	0.71	0.67	0.42	0.75
	COMBINATION	All features (30)	0.78	0.62	0.47	0.80
		Important features (13)	0.79	0.55	0.46	0.75
K NEAREST NEIGHBOUR (KNN)	OVERSAMPLED	All features (30)	0.76	0.94	0.56	0.94
		Important features (15)	0.87	0.94	0.69	0.97
	COMBINATION	All features (30)	0.88	0.87	0.69	0.96
		Important features (13)	0.92	0.95	0.88	0.98
SUPPORT VECTOR MACHINE (SVM)	OVERSAMPLED	All features (30)	0.92	0.85	0.77	0.95
		Important features (15)	0.87	0.77	0.65	0.88
	COMBINATION	All features (30)	0.88	0.80	0.68	0.92
		Important features (13)	0.83	0.66	0.56	0.84
NAÏVE BAYES	OVERSAMPLED	All features (30)	0.66	0.63	0.37	0.71
		Important features (15)	0.69	0.73	0.42	0.74
	COMBINATION	All features (30)	0.72	0.59	0.40	0.73
		Important features (13)	0.70	0.65	0.41	0.72
RANDOM FOREST	OVERSAMPLED	All features (30)	0.97	0.85	0.91	0.98
		Important features (15)	0.98	0.89	0.94	0.99
	COMBINATION	All features (30)	0.96	0.98	0.89	0.99
		Important features (13)	0.96	0.99	0.88	0.99

2

1

- **Most models perform well on accuracy** with the **highest belonging to Random Forest**.
- **KNN and Random Forest have the best recall rates on both samples,** which serves our purpose as we need to minimize false negatives
- **The accuracy of the combination dataset is higher and the ROC/AUC increases –** while the recall rates reduce slightly (except for Random Forest), prediction performances may increase if trained on larger real information.
- **Overall, the best model is Random Forest** trained on the combination dataset – with or w/o full features. This indicates that the classification process for turnover is complex and non-linear.

PERFORMANCE

OVERALL BEST MODEL

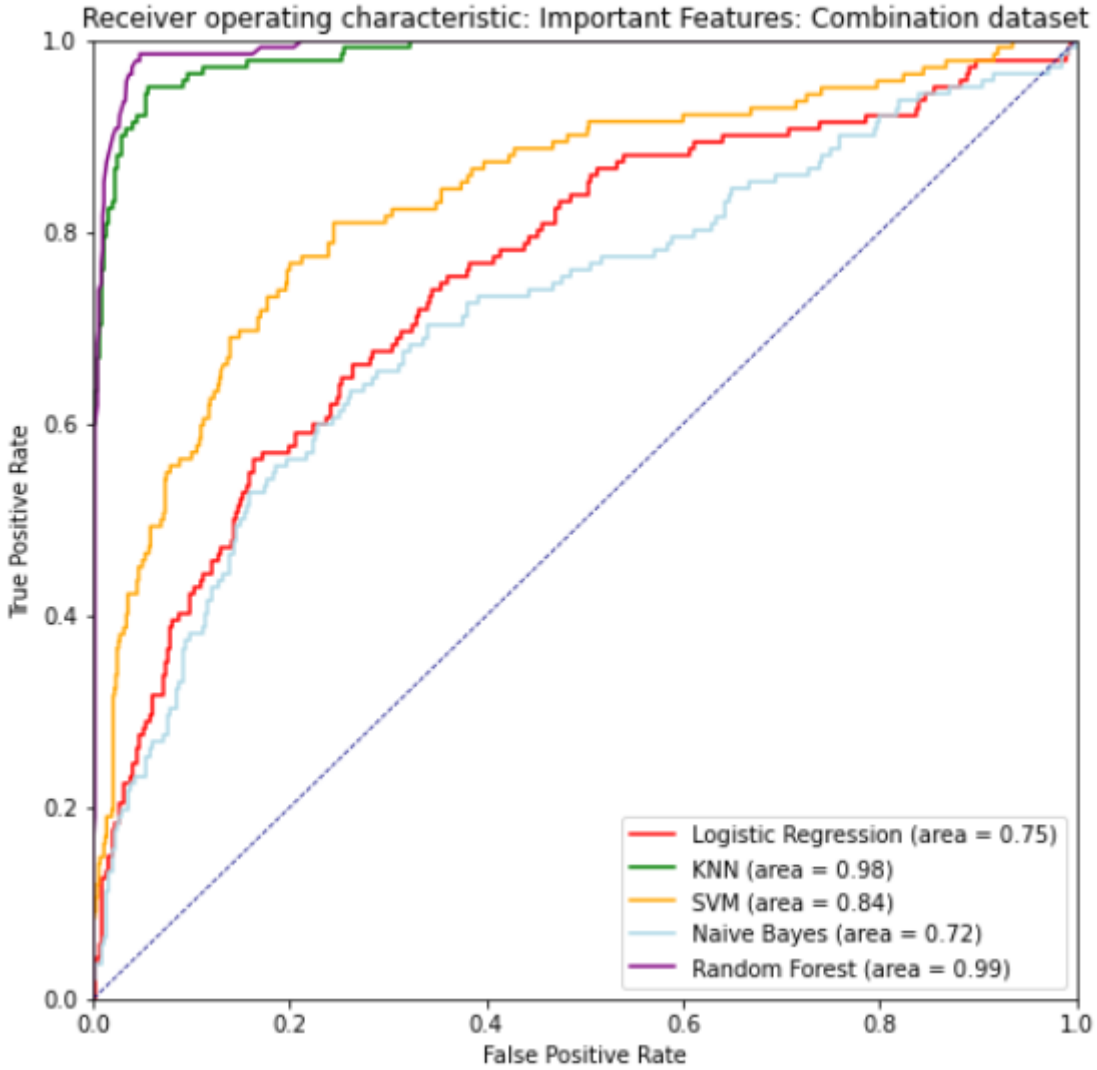
on train, test, accuracy, recall, and predictive performance for turnover detection

RANDOM FOREST CLASSIFIERS

OVERALL BEST MODEL

in scenarios where the computing resource requirement is too high

K NEAREST NEIGHBOUR CLASSIFIER



- When using Random Forest, models will benefit from increased real data with an increase in minority class observations.
- Since most of the features are quite independent and contribute equally, it may work well to perform PCA feature selection to reduce number of features in order to run the models more efficiently, especially with large datasets.
- Try target encoding on categorical features to compare performances.

CONCLUSION

IMPORTANT FEATURES

- hours worked
- total career span
- salary & compensation levels
- future prospects
- work environment & satisfaction
- deep dive analytics on important features

RETAIN YOUNG WORKERS

- better training
- better work-life-balance
- better benefits

REDUCE KNOWLEDGE DRAIN

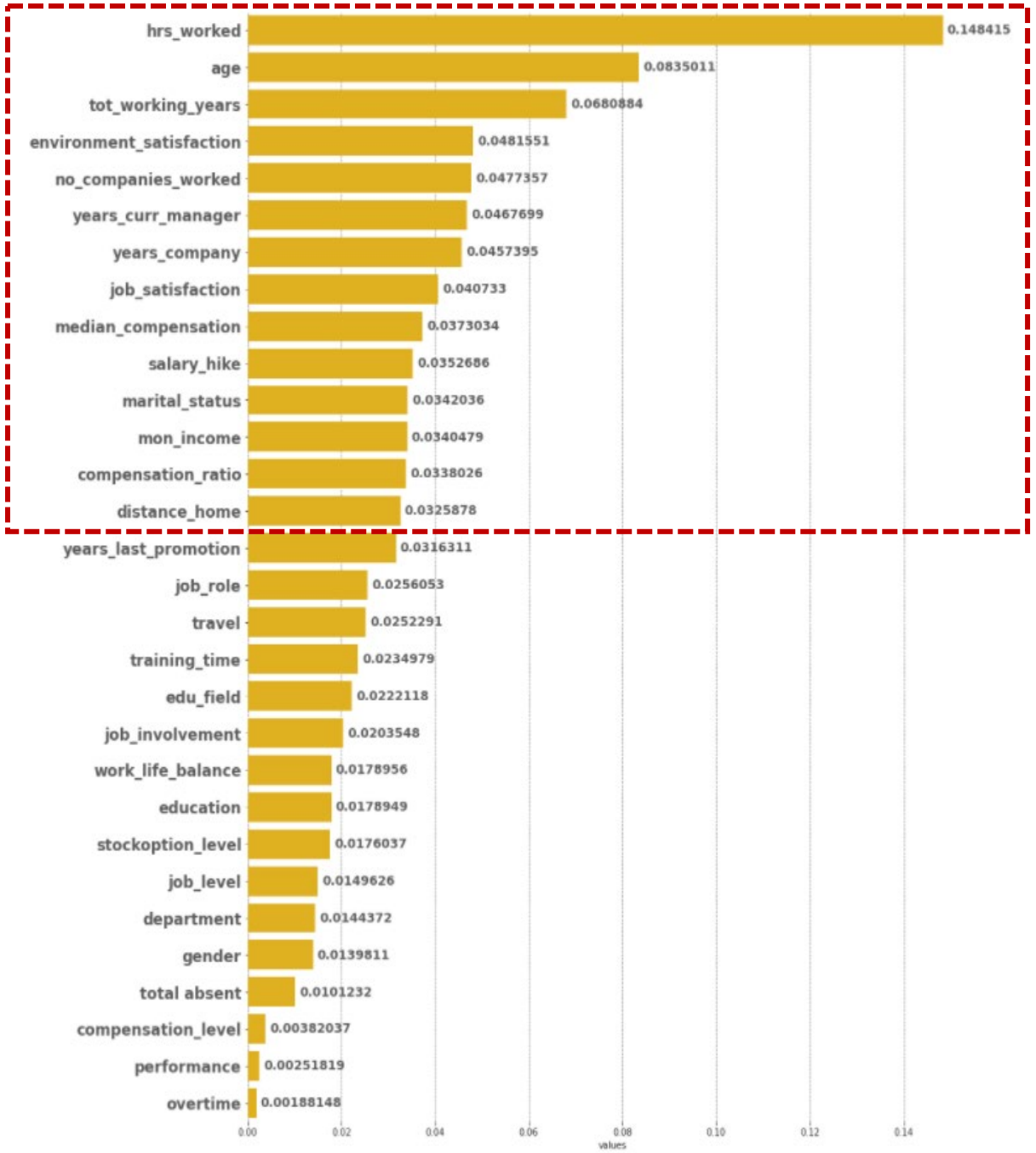
- R&D department
- work disruption, lost productivity
- dissatisfied customers
- gain by competitors

BETTER COMPENSATION LEVELS

- sales executives
- better compensation levels
- promotions
- pay disparity

PLAN HOURS WORKED

- plan back-up options based on predicted turnover
- absenteeism
- distribute workload



Train people well enough so they can leave, treat them well enough so they don't want to.

- Sir Richard Branson

THANK YOU

SOURCES

1.
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