RoboGarden Bootcamp Capstone Project

Credit Card Fraud Detection

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Credit Card Fraud Project

- ***Description***: 284,807 credit card transactions made by European cardholders in September 2013
- ***Features:***
  - Time: seconds since first transaction
  - V1 – V28: Anonymous data – Confidentiality
  - Amount: Transaction value
  - Class (T/F): fraudulent / genuine

- ***License***: Public domain (CC0)
- ***Link:*** https://data.world/raghu543/credit-card-fraud-data
- ***File***: creditcard.csv

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Credit Card Fraud Project – By the Numbers

• *normal amount total*	***25,043,410***
• *# transactions over 2 days*	***284,807***
• *fraud amount total*	***58,591 (0.25%)***
• *# zero amount normal transactions*	***1798 (0.6%)***
• *# non-fraud duplicates*	***1062 (0.4 %)***
• *# fraud transactions*	***492 (0.17%)***
• *# zero amount fraud transactions*	***24 (5.5%)***
• *# fraud duplicates*	***19 (4.0 %)***

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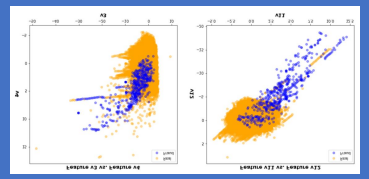
Work Process

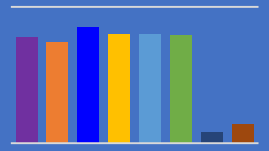
Clean Data

Remove Duplicates

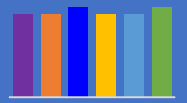
Visualize Data



Screen 8 Classifiers

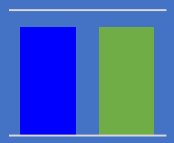


Optimize 6 Classifiers
All Features

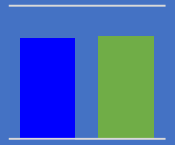


Optimize RF & MPL on
10 Features

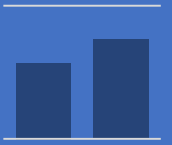
Feature Importance



Optimize RF & MPL on
Under Sampled
Dataset All Features



Run Auto Encoders on
10 Features
4 Features



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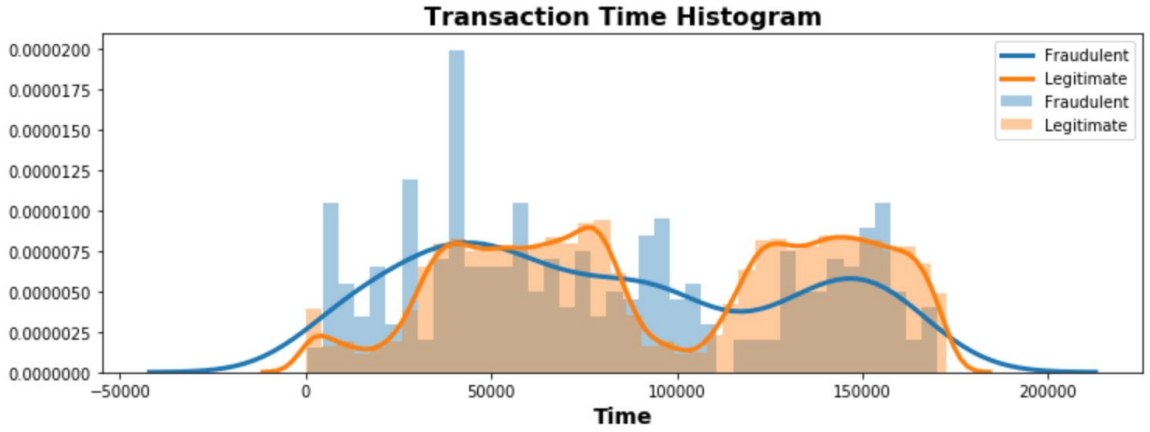
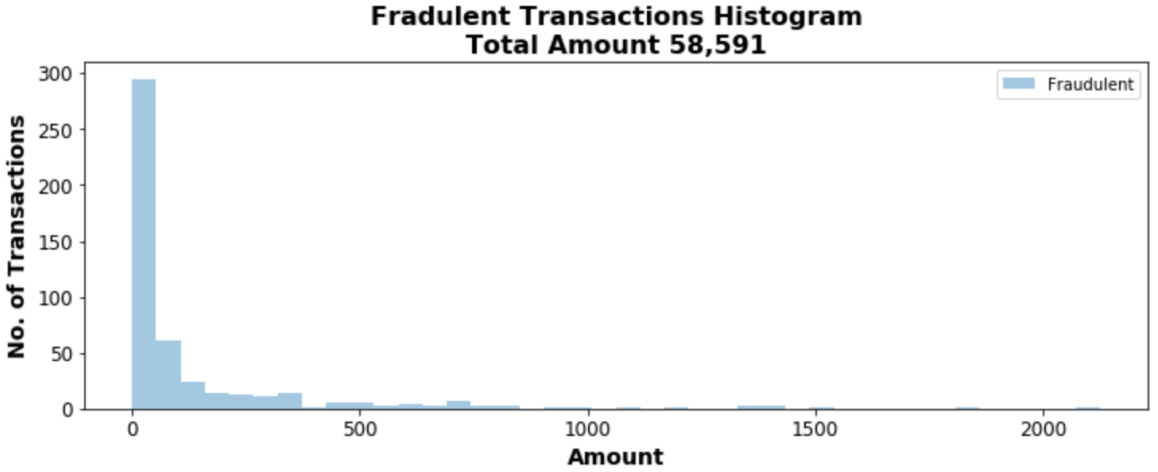
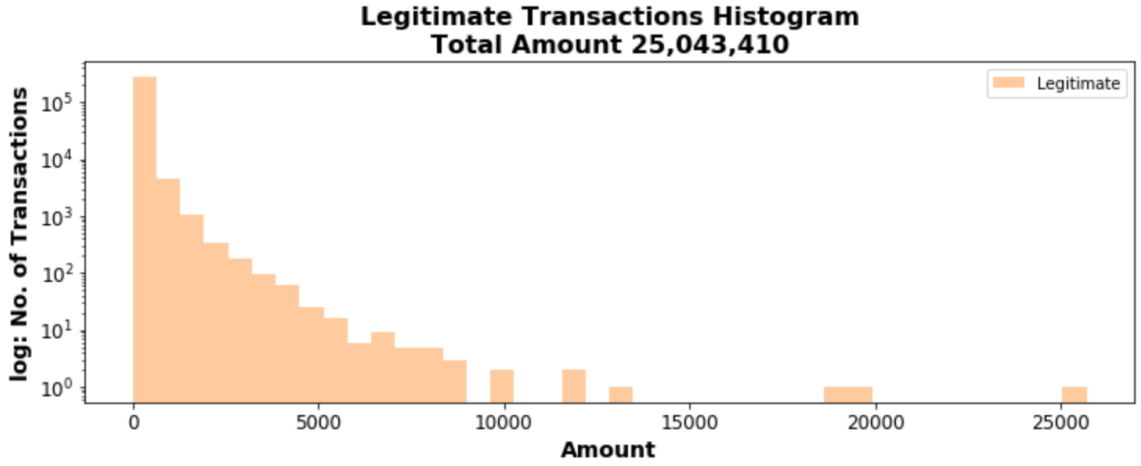
Visualization





- **Frauds are more weighted to smaller amounts**



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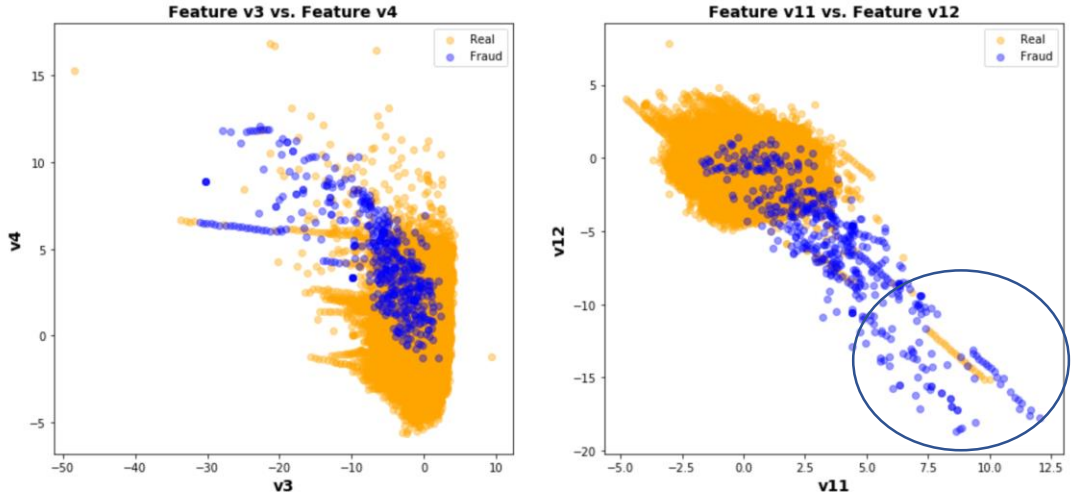
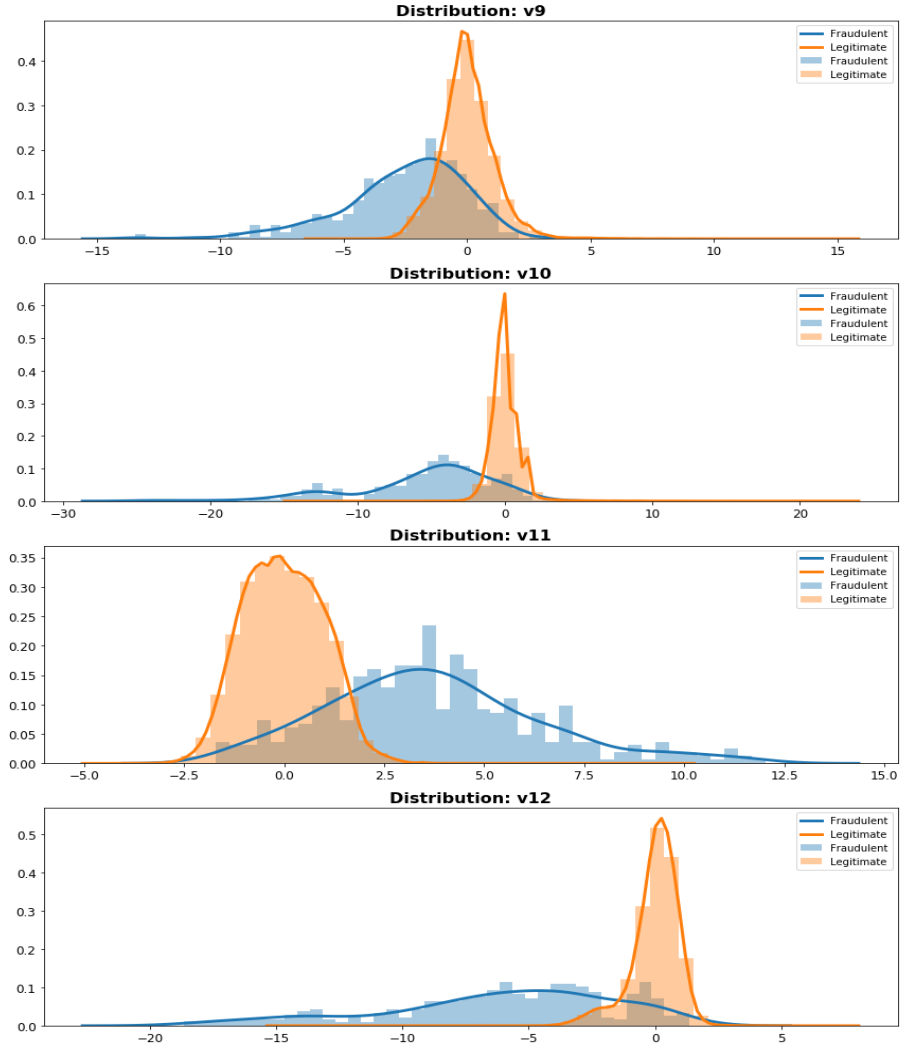
Visualization



Normals with Frauds

- **2D Scatter plots show some overlap & separation.**

- **4 of 28 Fraud vs. Normal Histograms Show:**
  - **Several have distinctive range differences.**
  - **Some distributions are aligned.**
  - **(remaining histograms in additional charts section)**



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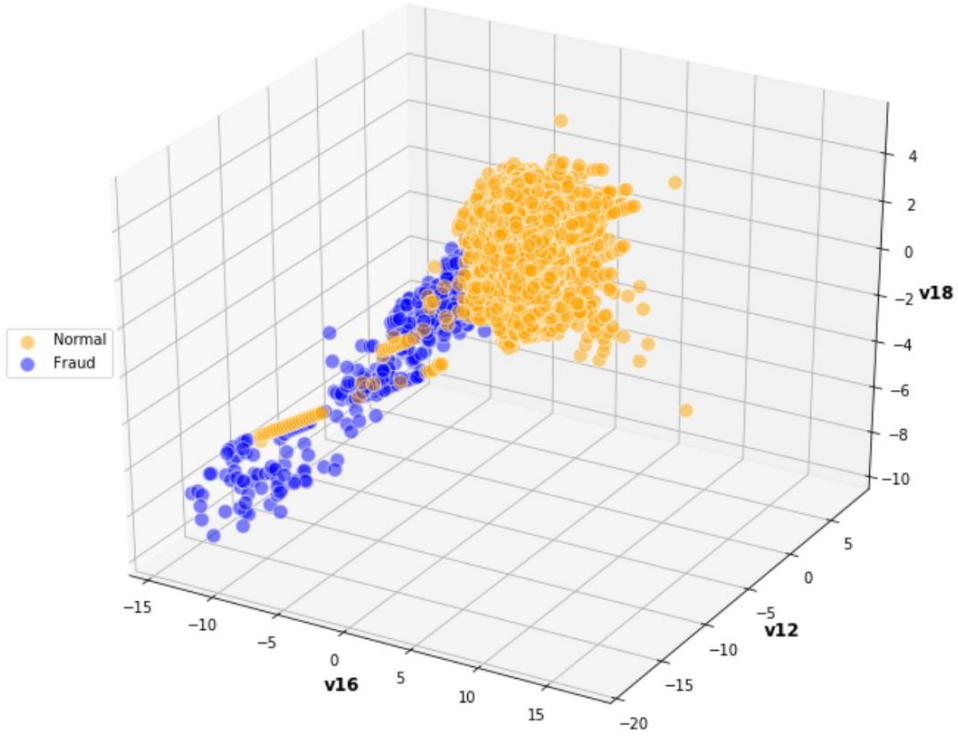
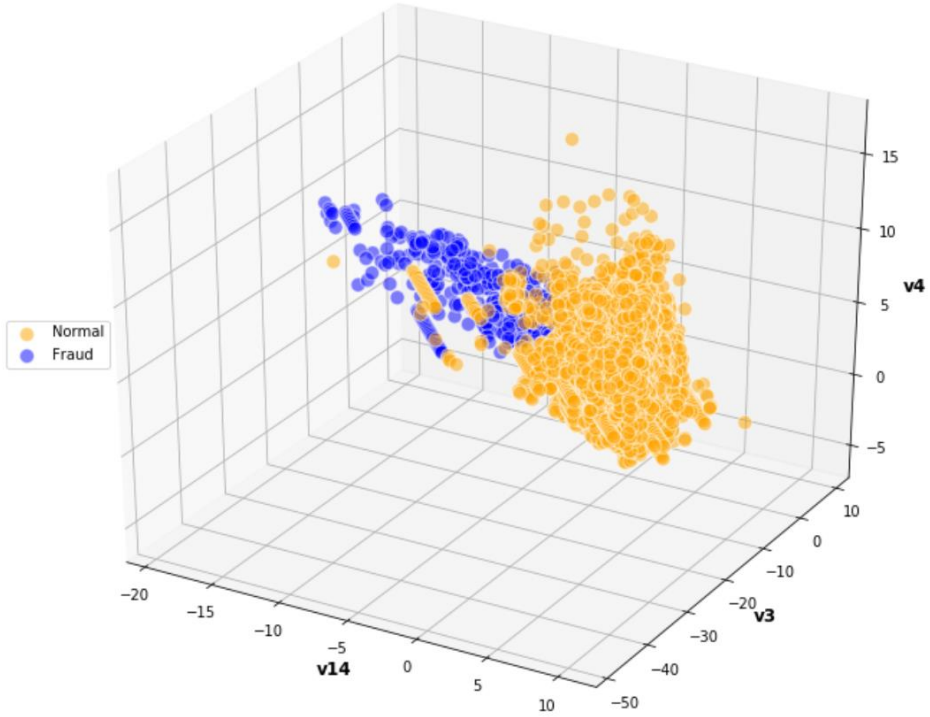
Visualization





3D Scatter plots also show most normal transactions are tightly grouped, although several are mixed with the fraud transaction. Conversely, some frauds are embedded with the large normal cluster.

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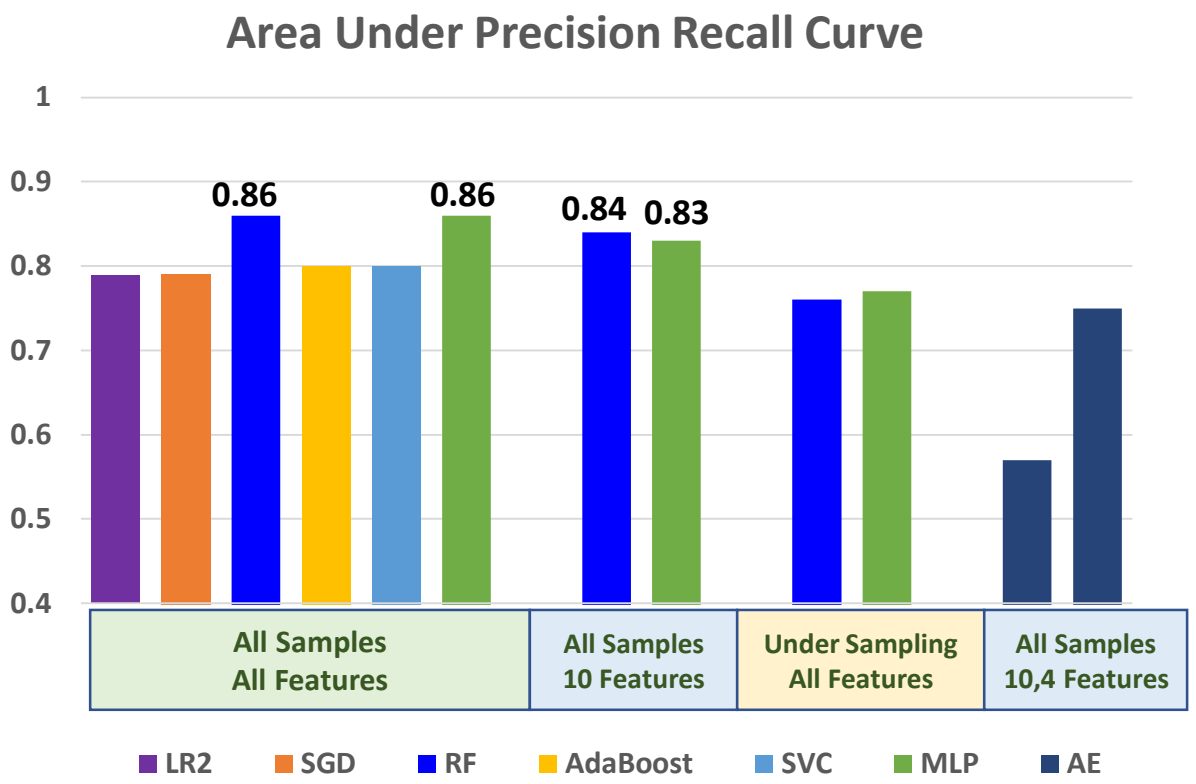
Model Results

Model	Application	Features	AU-PRC	TP	FP	FN
LR	All Samples	29	0.79	65	5	53
SGD	All Samples	29	0.79	83	7	35
RF	All Samples	29	0.86	92	4	26
SVC	All Samples	29	0.80	77	3	41
AdaBoost	All Samples	29	0.80	87	8	31
MLP	All Samples	29	0.86	95	6	23
RF	All Samples	10	0.84	90	4	28
MLP	All Samples	10	0.83	89	9	29
RF	Under Sampling	29	0.76	116	29,000	2
MLP	Under Sampling	29	0.77	118	22000	0
AE	All Samples	10	0.57	66	45	52
AE	All Samples	4	0.75	84	13	34



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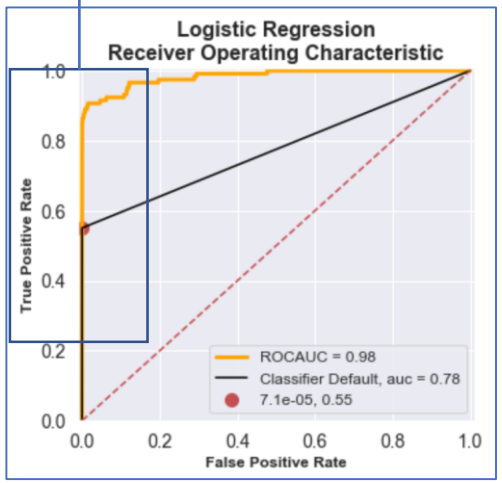
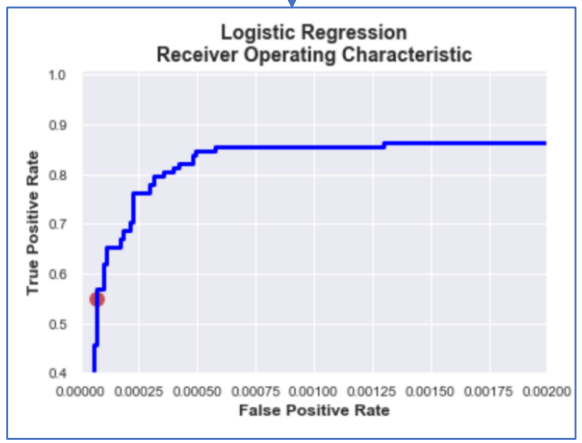
Results / Report

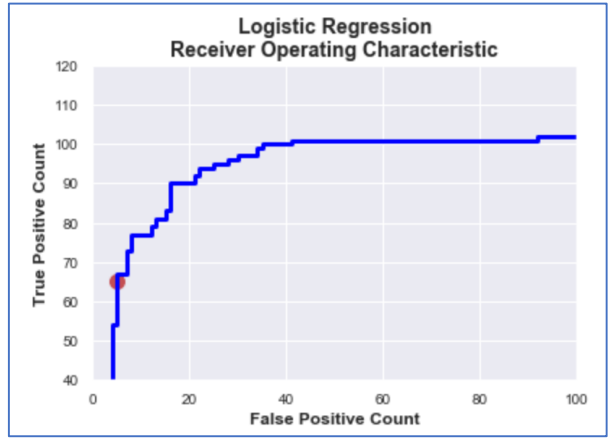


A FPR of 0.001 is 71. Zoom in on the ROC plot and see what happens when going to a higher True Positive Rate)

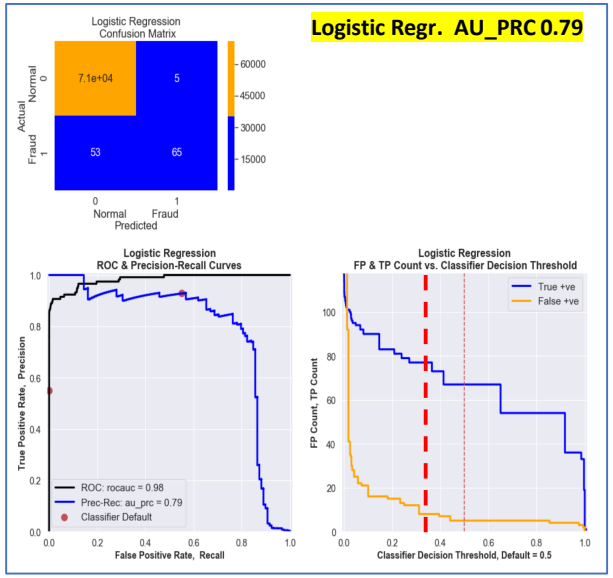


What does this mean in number of frauds identified & False Positives?

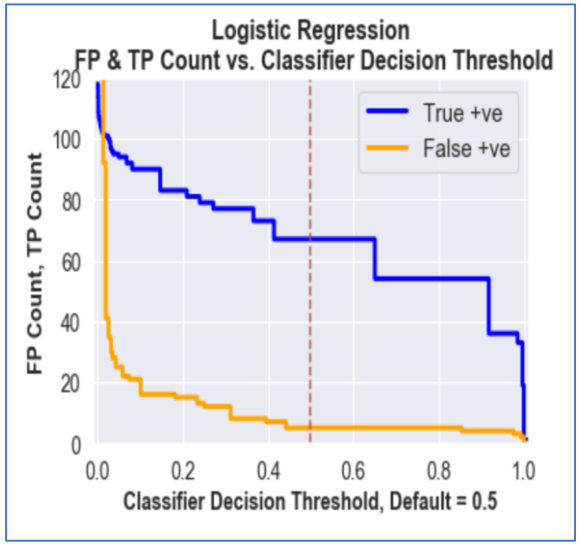
Multiply by P, & N



Logistic Regr. AU_PRC 0.79



Combine with the Precision-Recall Curve and Confusion Matrix for a single Report



What are the values of the thresholds at the steps in the plot? Plot FP count & TP count vs. the threshold values for each pair of FP/TP's.

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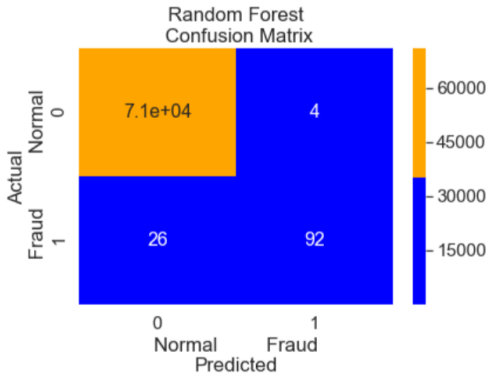
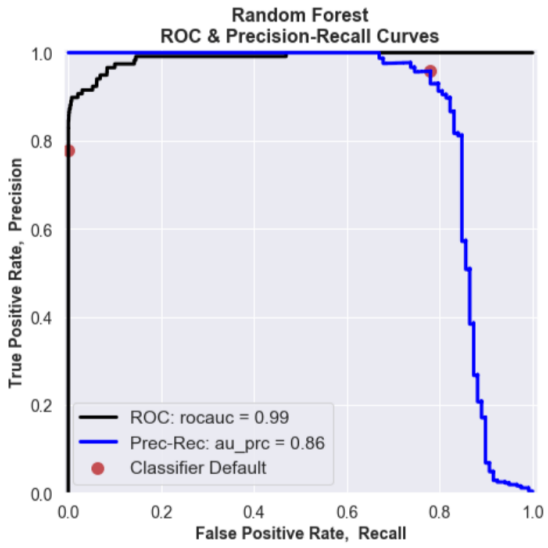
Random Forest & MLP Trained on 29 Features

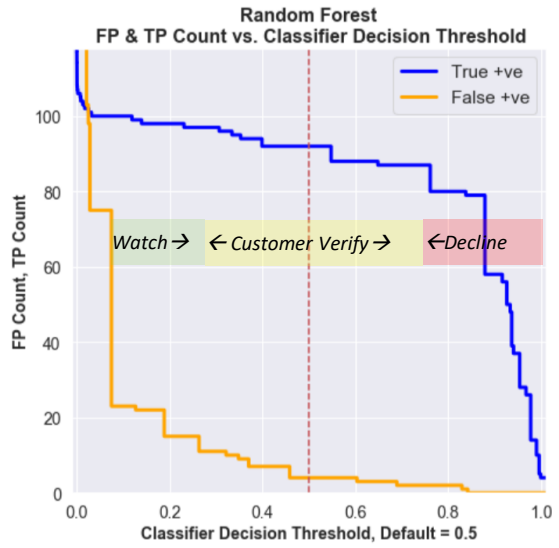
RFC AU_PRC 0.86



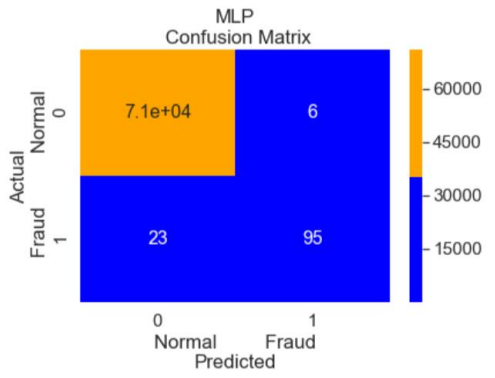
Best AU-PRC

Could segment decision threshold into decline, customer verify, watch list

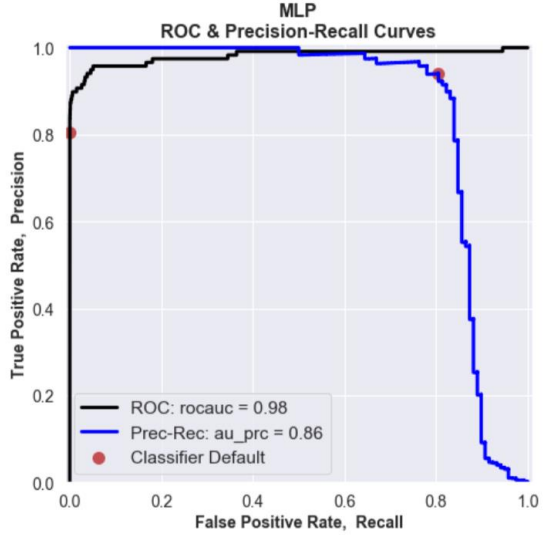


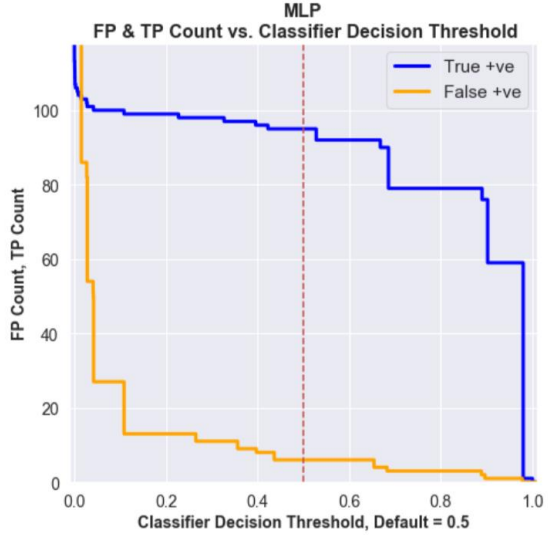


MLP AU_PRC 0.86



Best AU-PRC





** 29 Features are: Amount + Feature v1 to v28*

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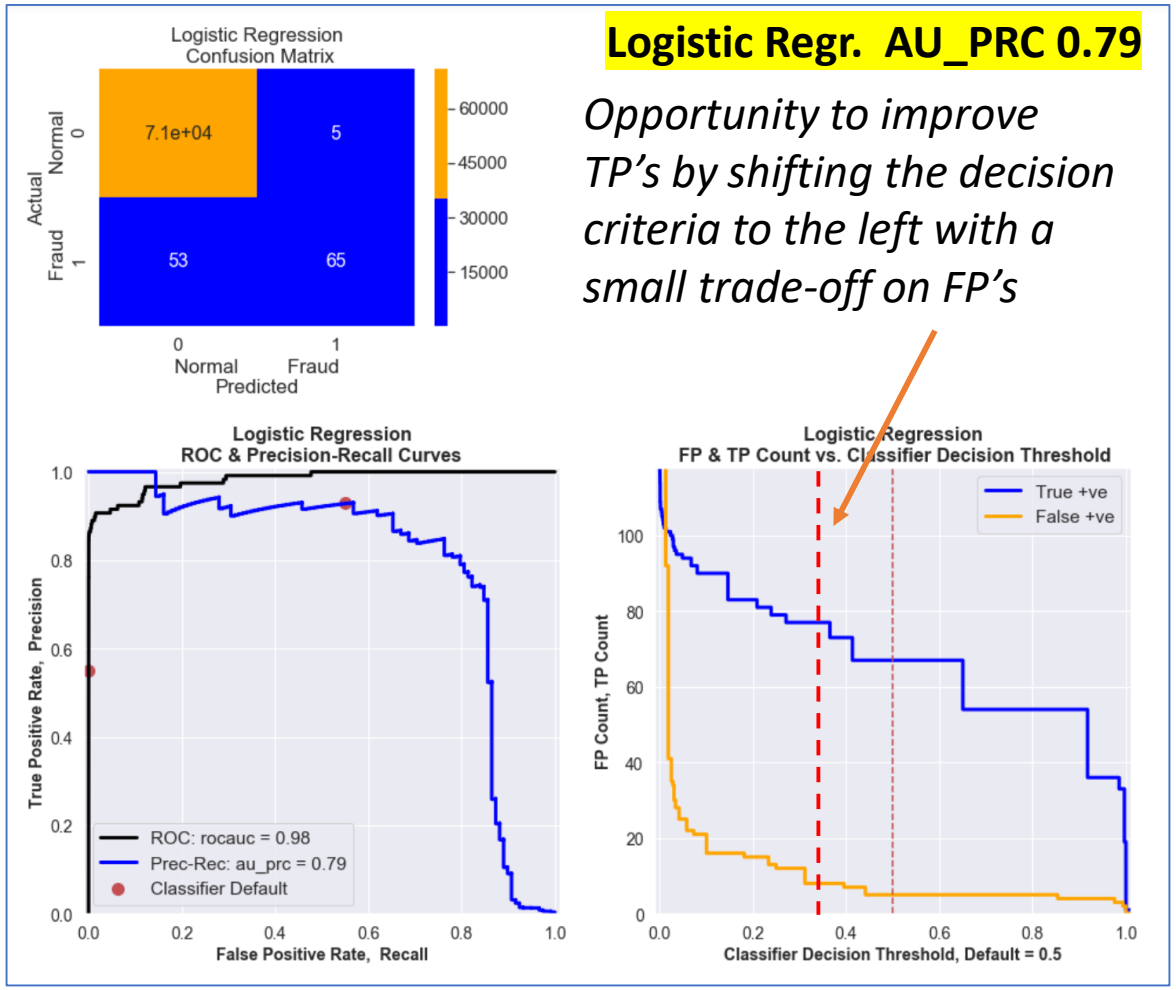
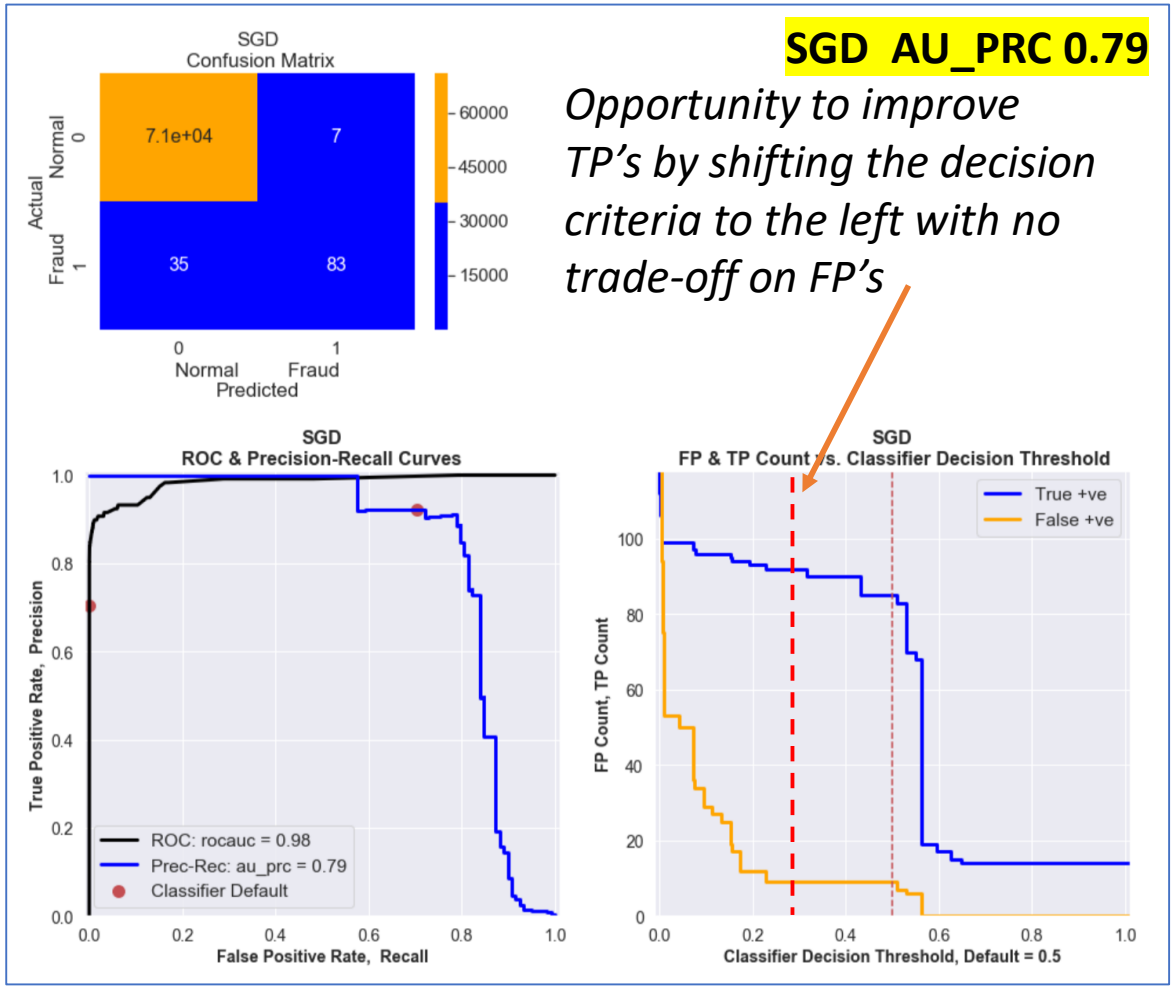
Logistic Regression & SGD Trained on 29 Features





** 29 Features are: Amount + Feature v1 to v28*

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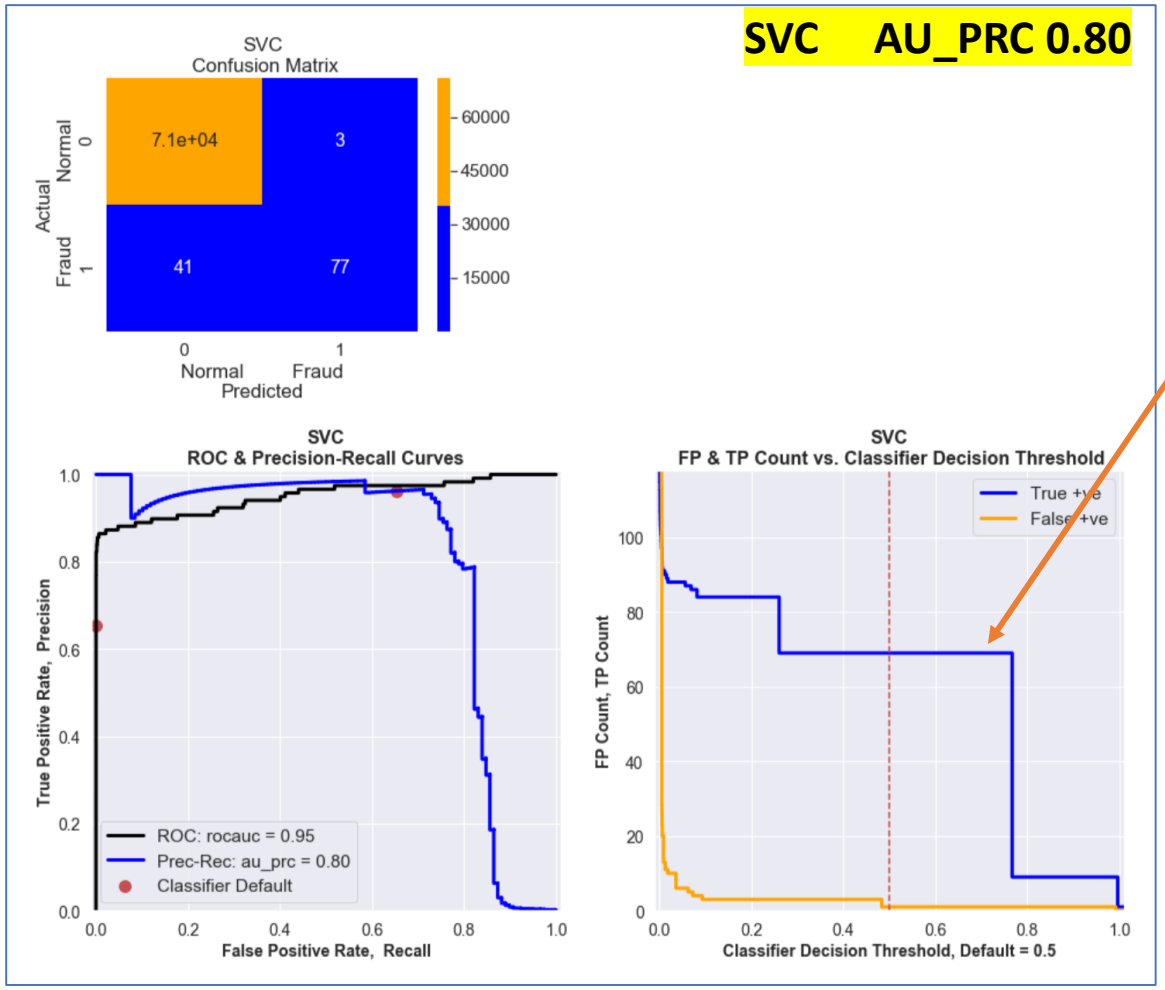
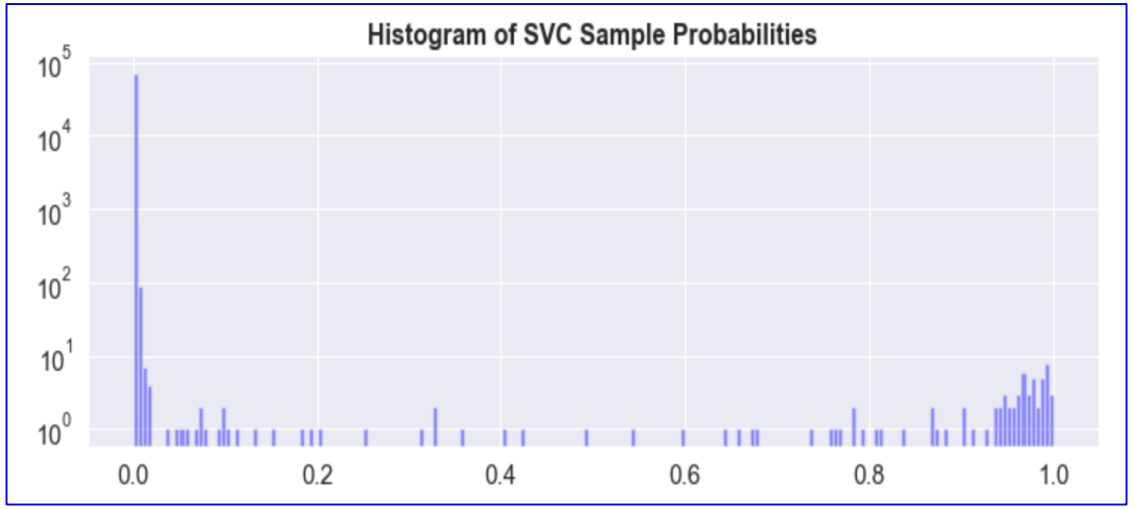
SVC Trained on 29 Features

SVC AU_PRC 0.80



Sample probabilities are heavily weighted towards 0 and 1 which flattens the True Positive curve making it insensitive to changing decision thresholds and likely consistent with new datasets.



** 29 Features are: Amount + Feature v1 to v28*

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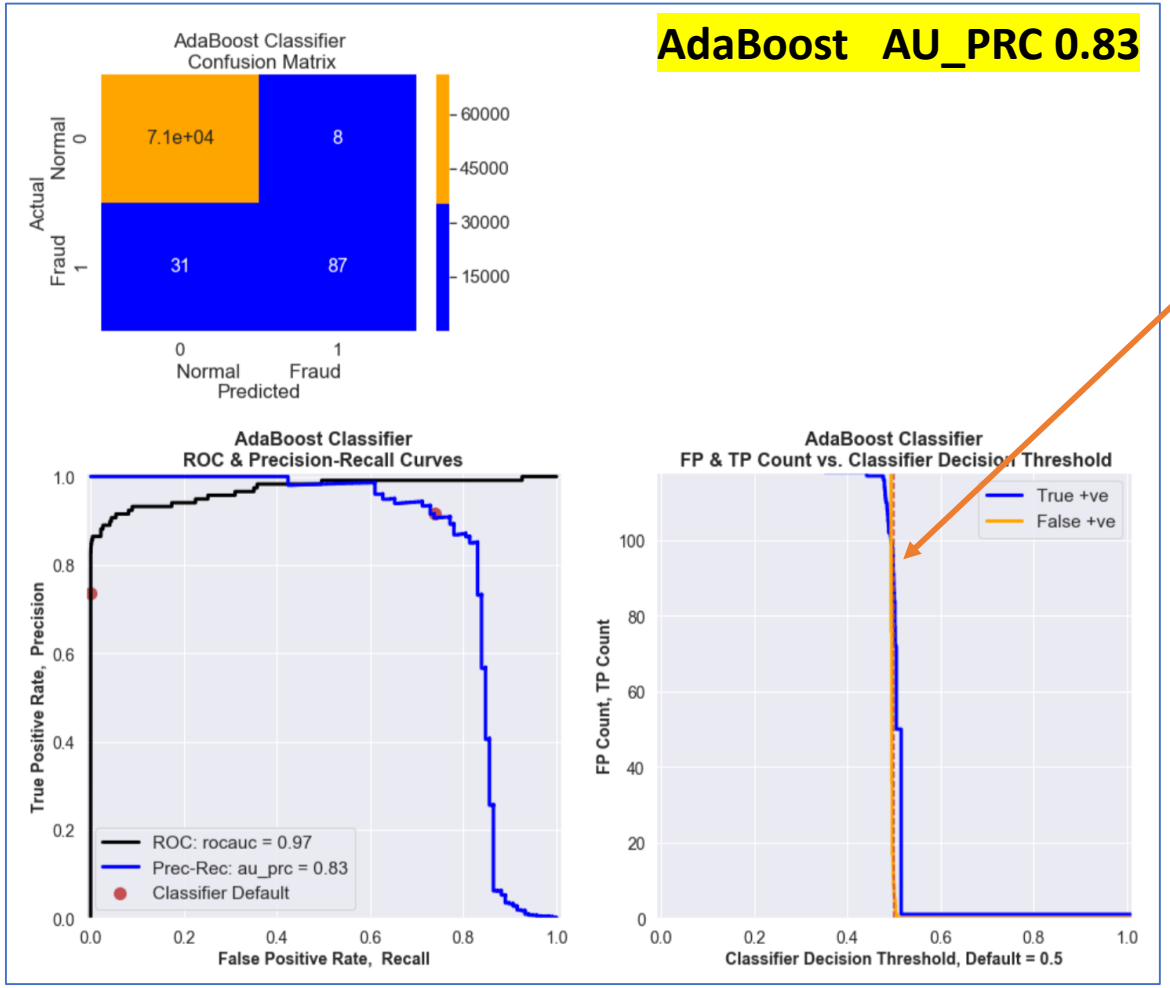
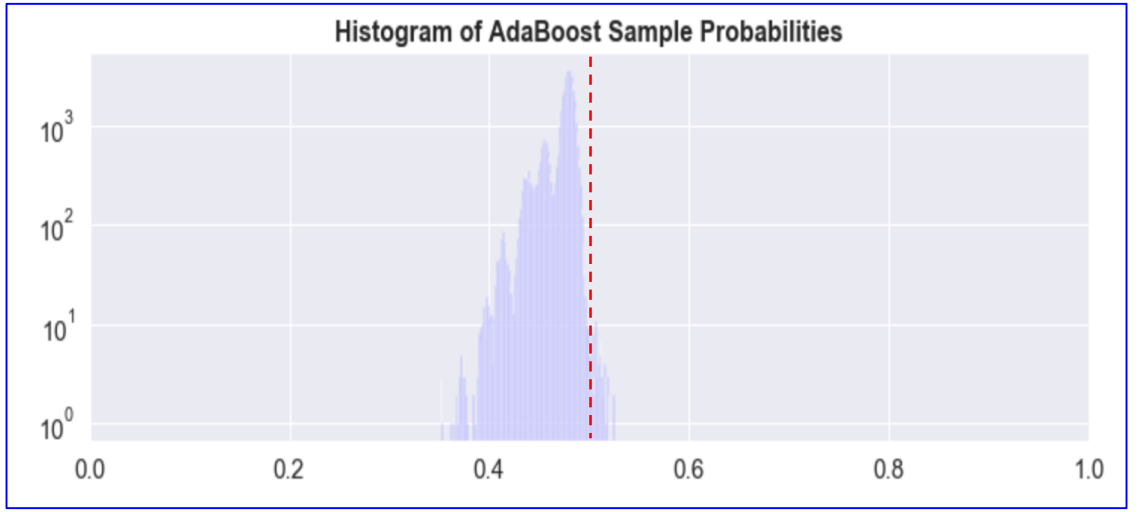
AdaBoost Trained on 29 Features

AdaBoost AU_PRC 0.83



Sample probabilities are heavily weighted towards 0.5 which steepens the True Positive curve making it overly sensitive to changing decision thresholds and possibly inconsistent with new datasets.



** 29 Features are: Amount + Feature v1 to v28*

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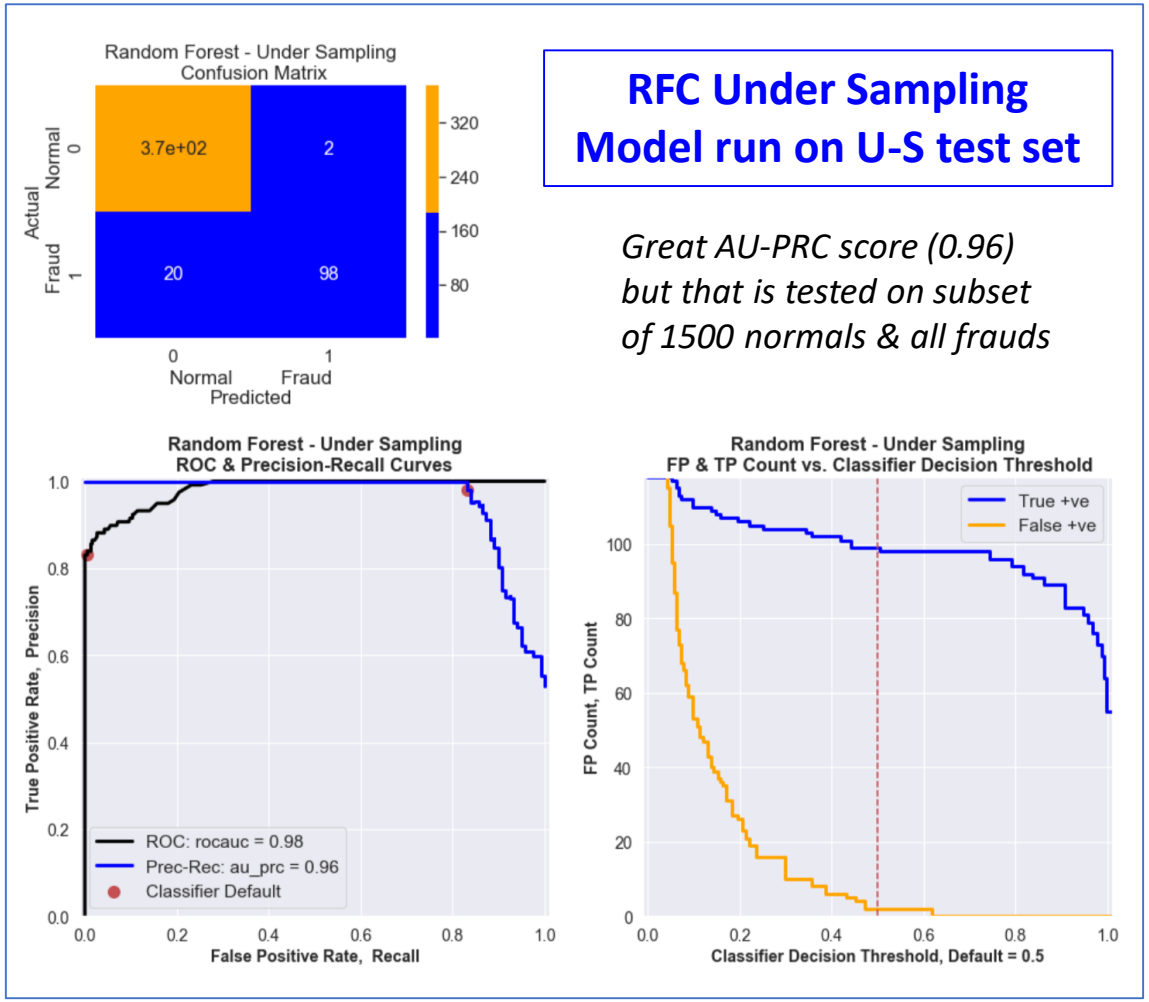
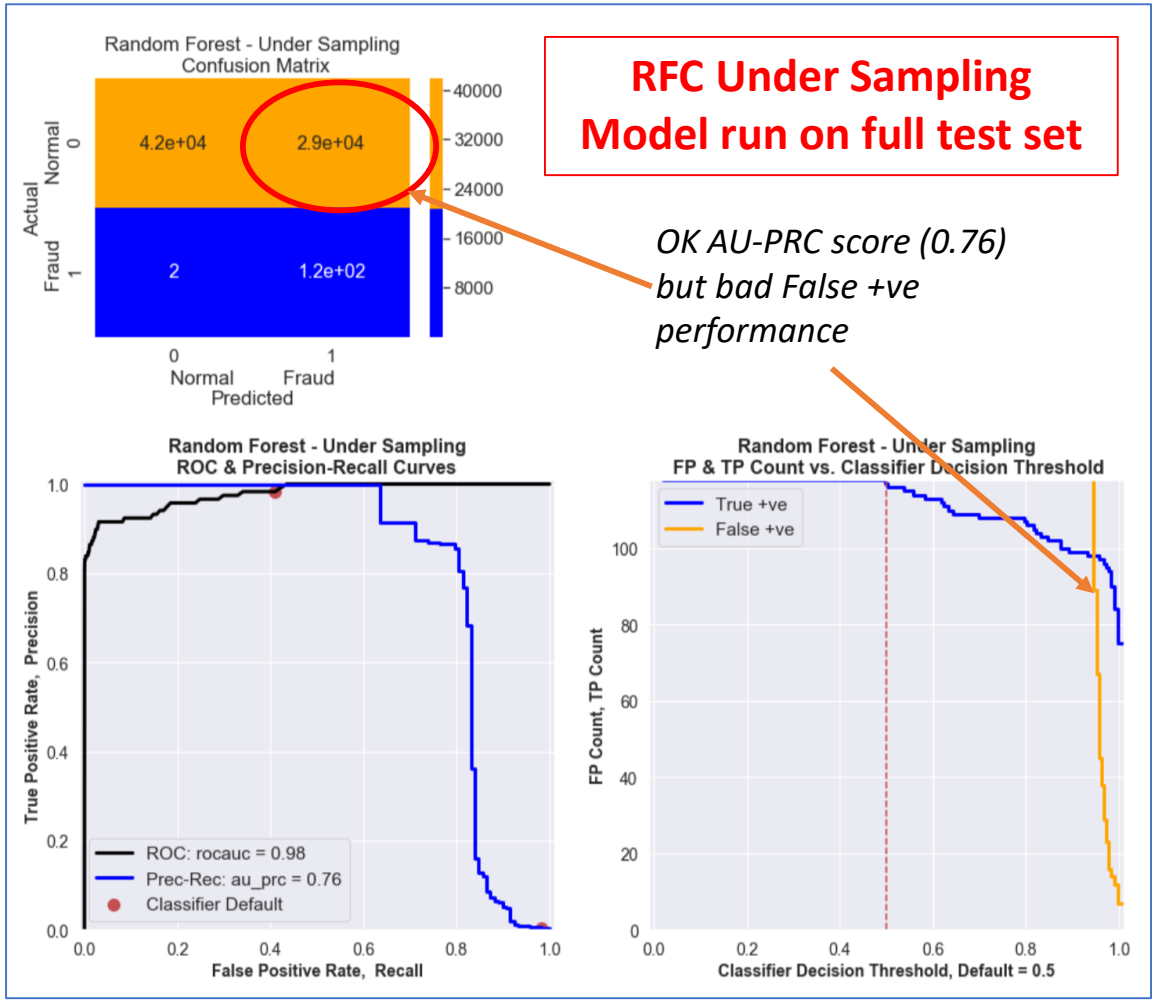
Random Forest on Under Sample Dataset





Model trained on U-S train set & tested on U-S test set →

Then Model tested on original test set (this is target test).

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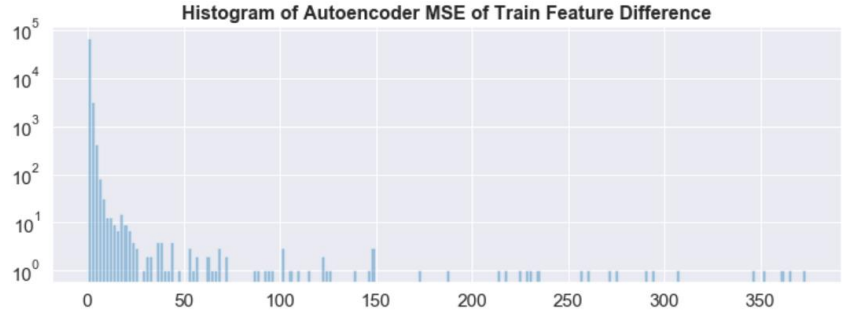
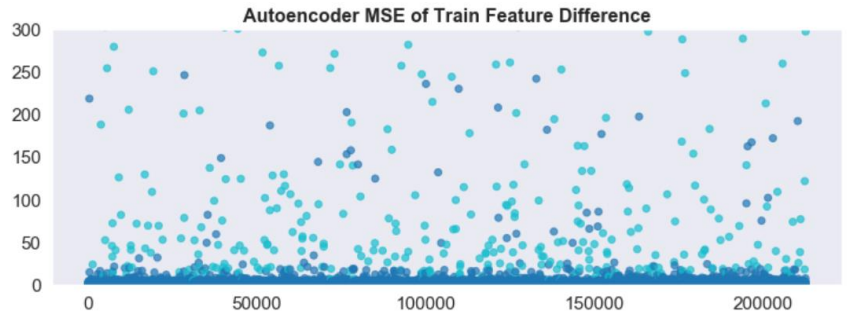
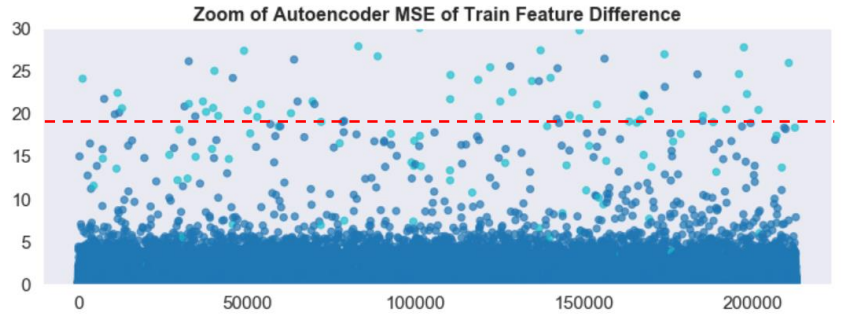
Autoencoders

MSE stats for train set: min 0.0003, max 373.4034, mean 0.7072, std 5.2781

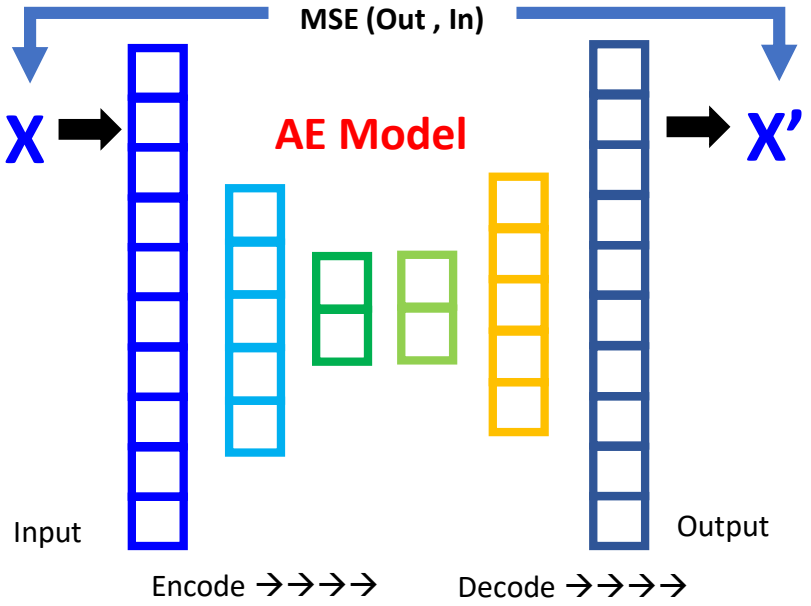






- Train model on Normal data only. Test with Normal & Fraud.
- Model is not trained on Fraud.
  → Fraud samples will have greater error on reconstruction.

Set the 50% T/F decision threshold here where the occurrences are approximately equal, dominated by fraud above, and dominated by normal below



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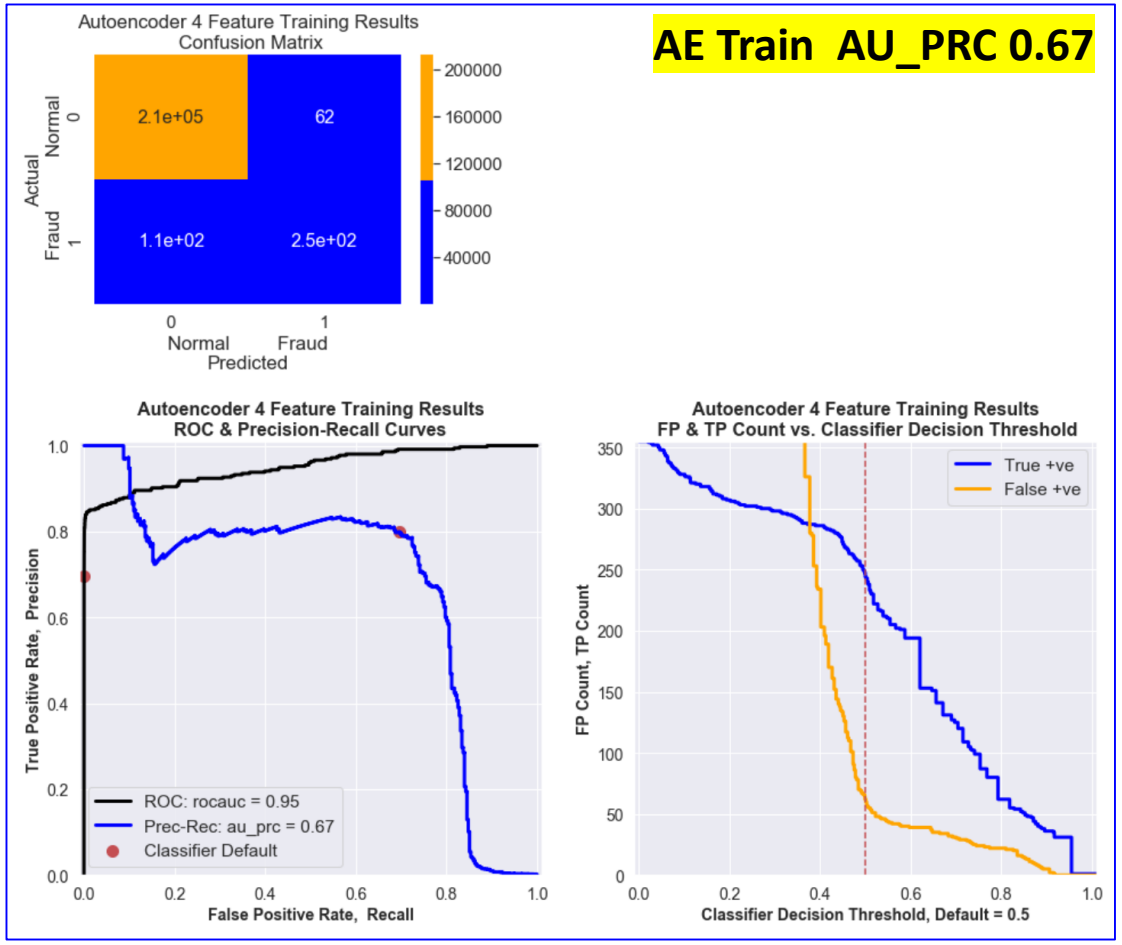
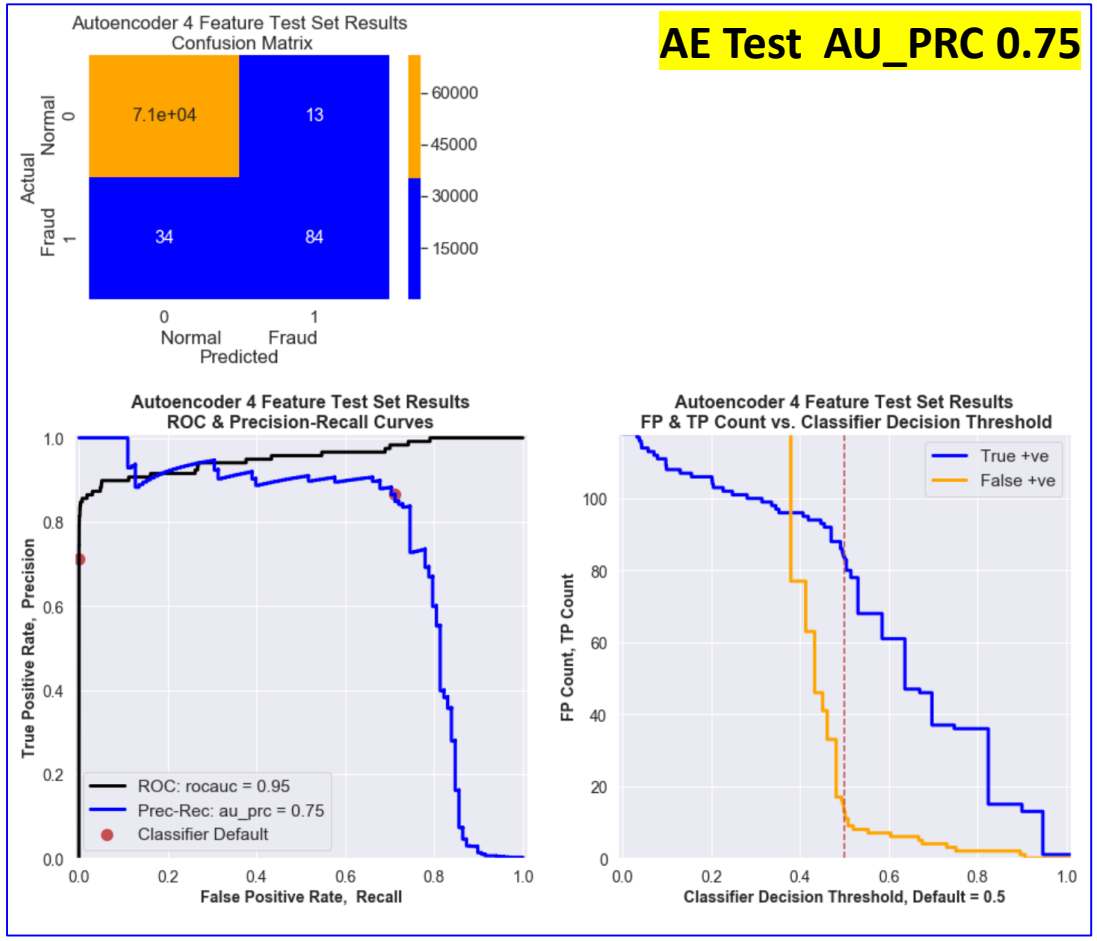
Autoencoders – 4 Features





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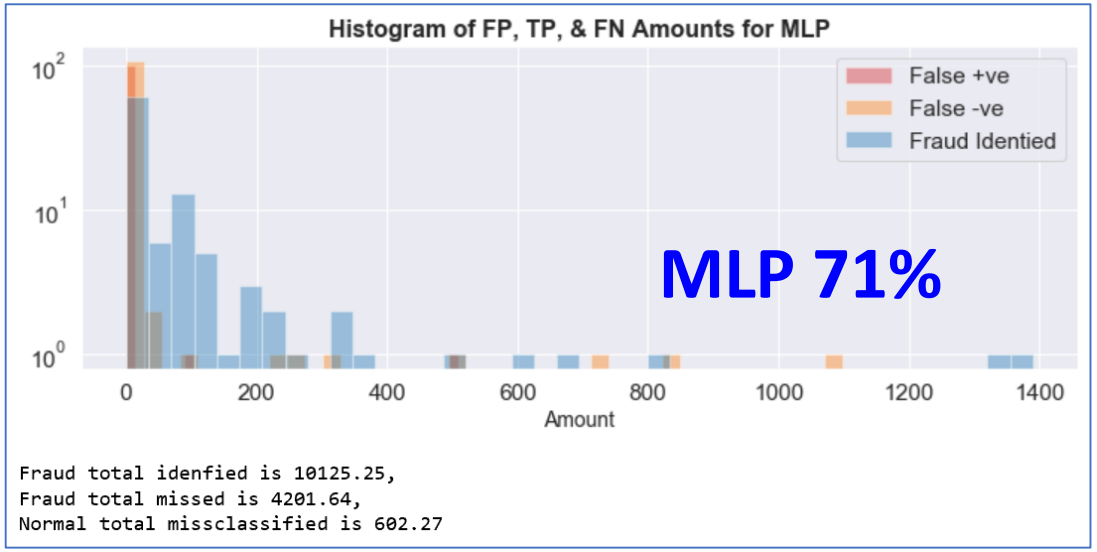
Fraud Value Identified

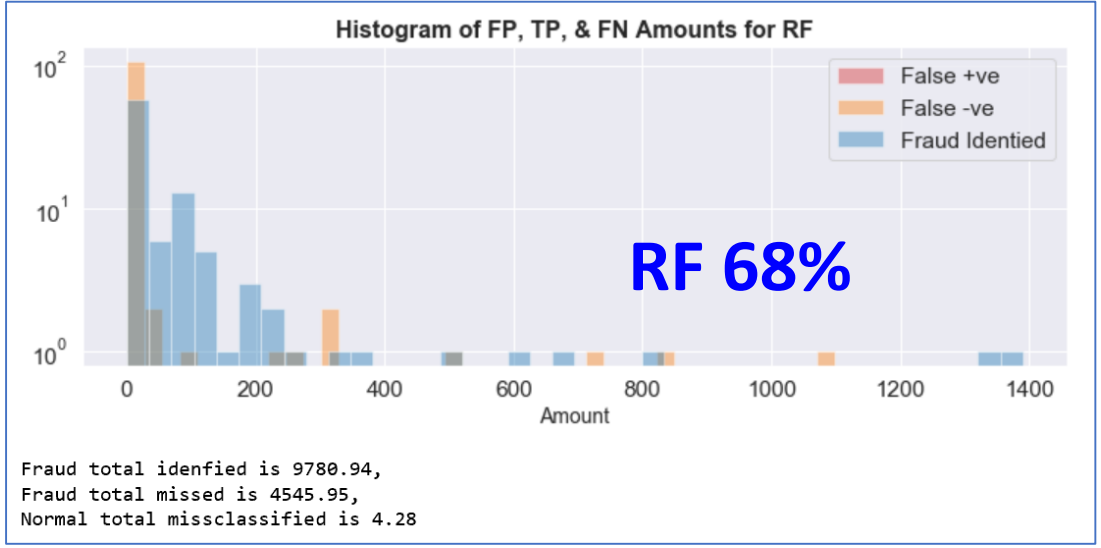
95 Frauds & 71% of value*

6 FP's – 4% of the Fraud value



92 Frauds & 68% of value*

4 FP's – .03% of the Fraud value



*** Results of amounts will vary with new data as TP's and FP's will have different amounts**

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Future Work

- Further refinement by optimizing more parameters.
- Investigate a hybrid classifier by combining multiple classifiers.

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Conclusions

- Random Forest & MLP provided the best scores identifying about 80% of the fraudulent transaction while maintaining a low false positive rate.

- Performance degraded when features were dropped except for the Autoencoder model which improved with fewer more distinct features.

- In extremely underbalanced datasets there is a lot of information in the lowest fraction of the False Positive Rate.

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Questions

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Additional Charts

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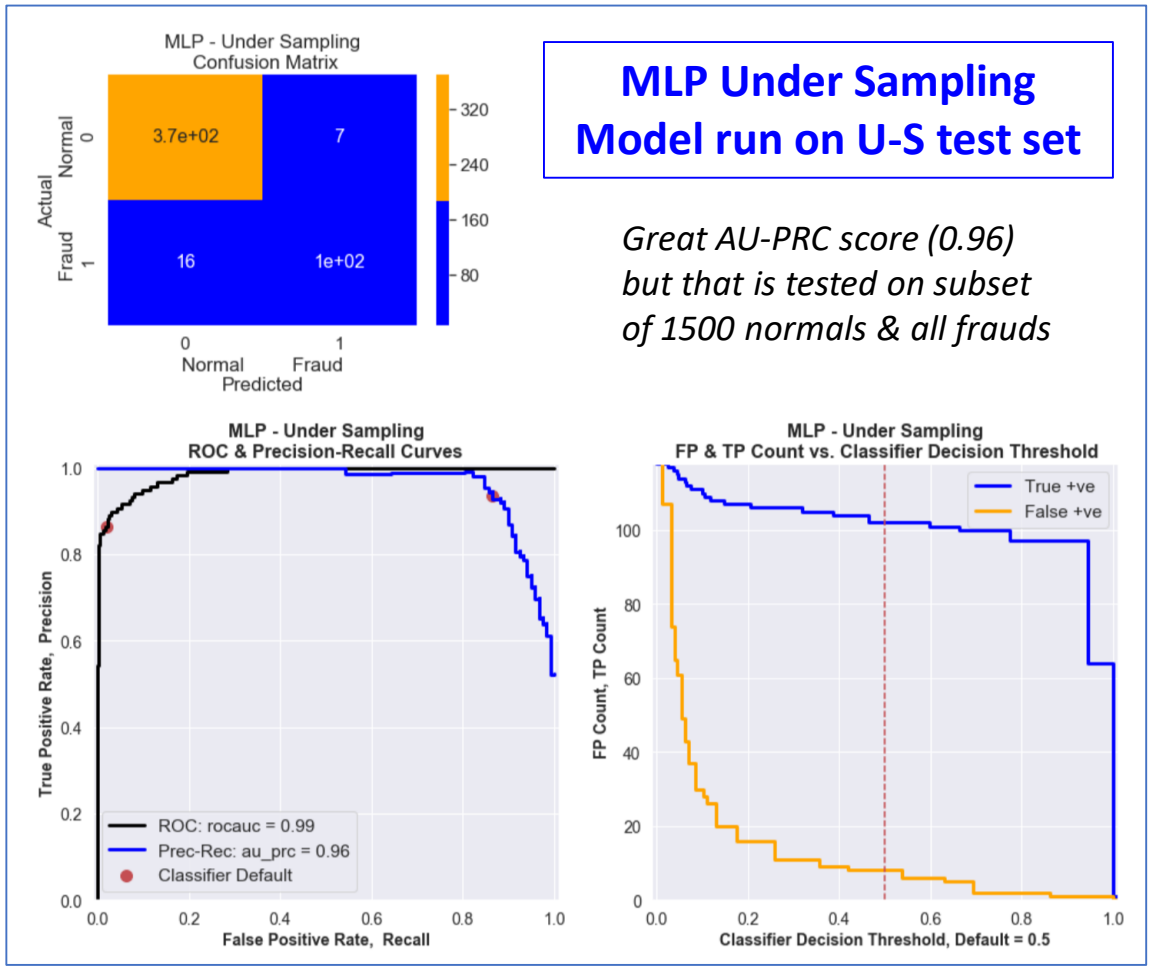
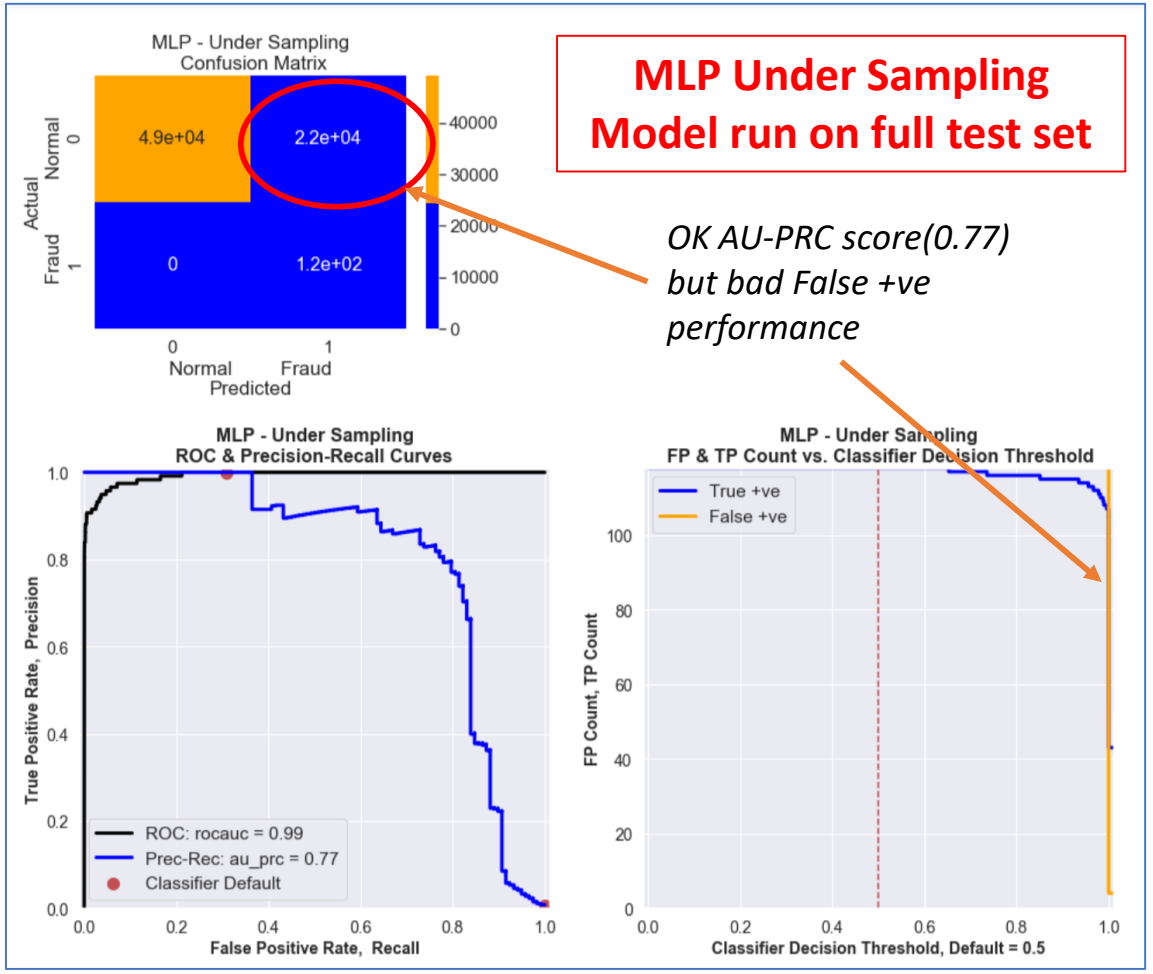
MLP on Under Sample Dataset after Optimization





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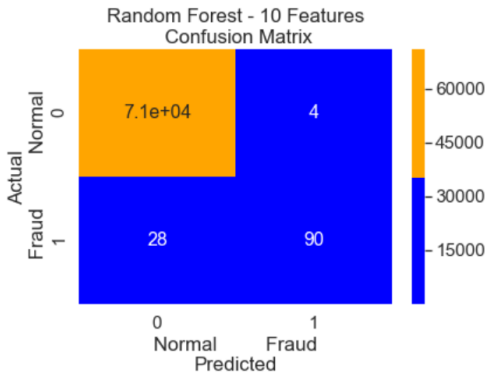
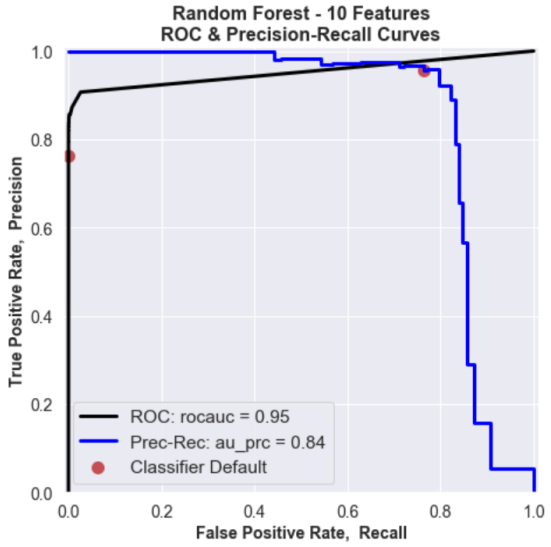
RoboGarden Bootcamp

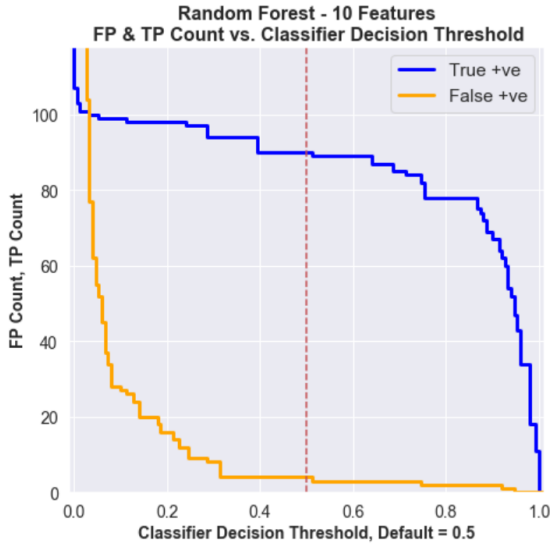
Random Forest & MLP Trained on 10 Features

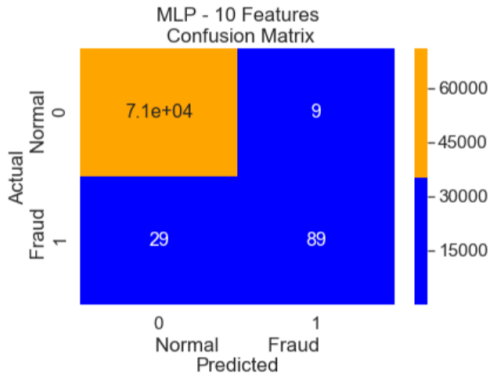


RFC 10 Features AU_PRC 0.84

2% lower AU-PRC Score than when trained on 29 Features

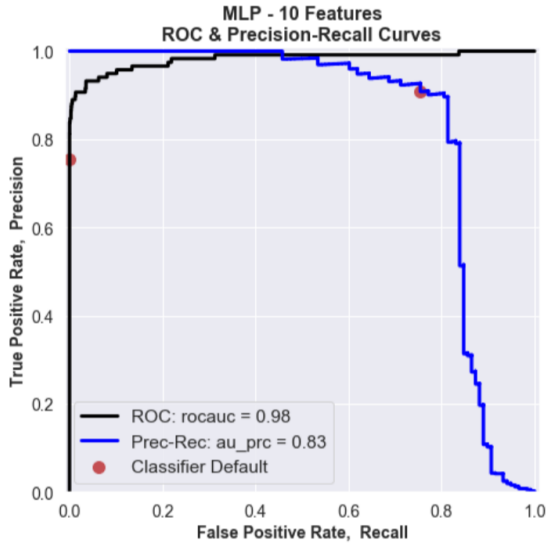


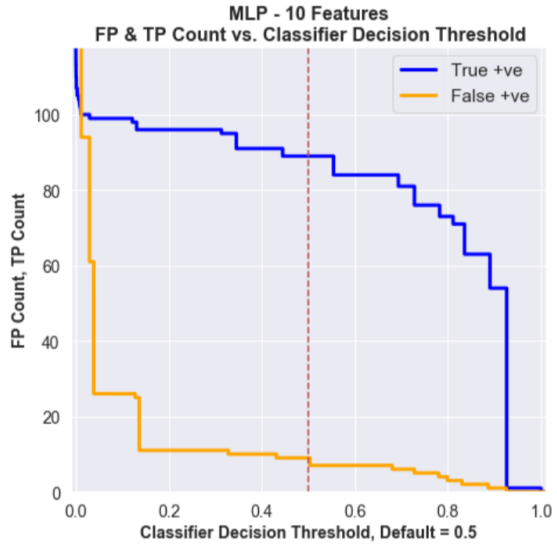




MLP 10 Features AU_PRC 0.83

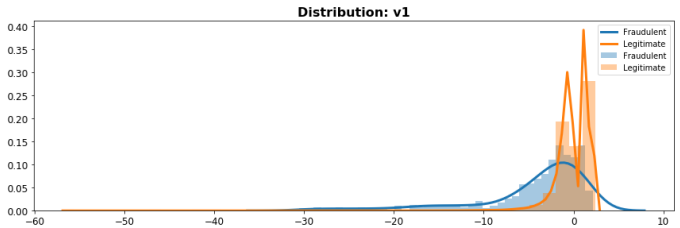
3% lower AU-PRC Score than when trained on 29 Features

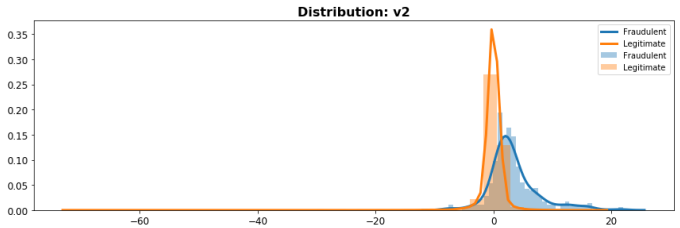


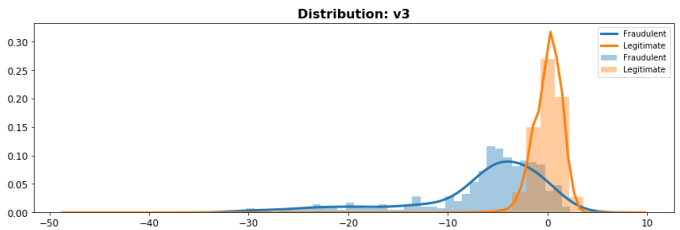


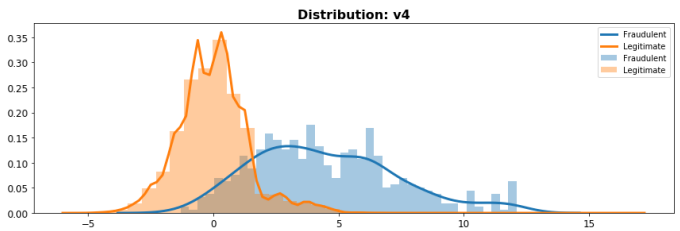
** 10 Features are Features v3, v4, v7, v9, v10, v11, v12, v14, v16, & v17*

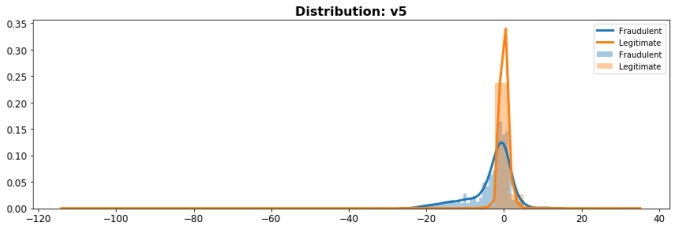
RoboGarden Bootcamp Visualization

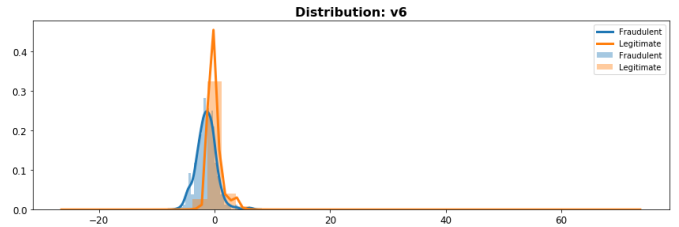


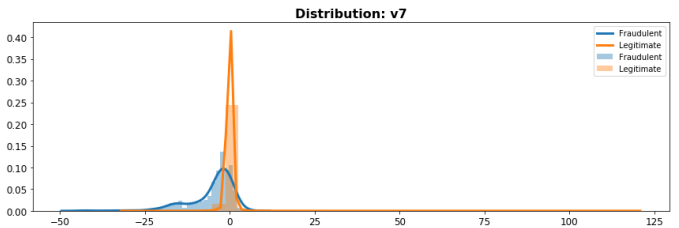


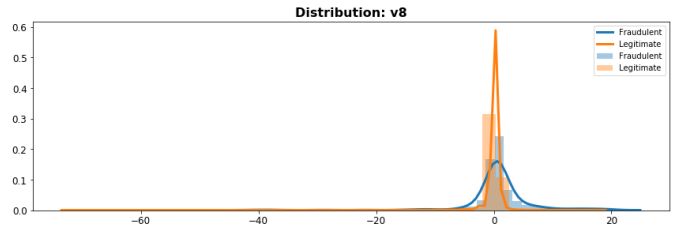


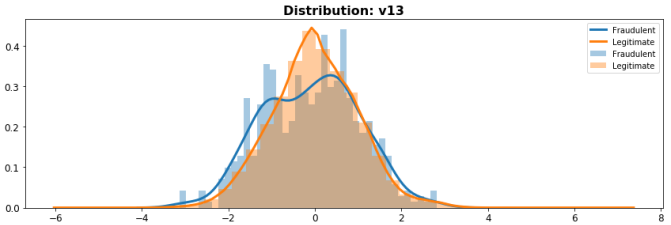


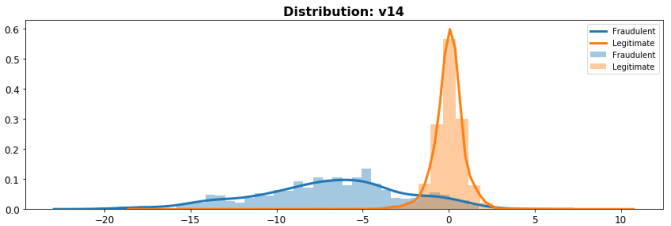


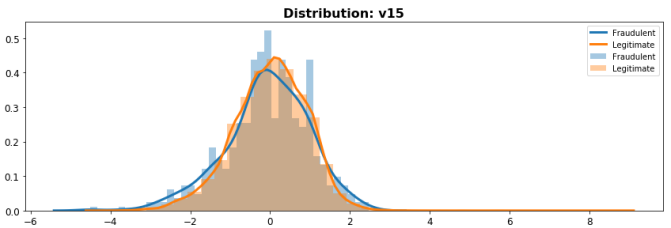


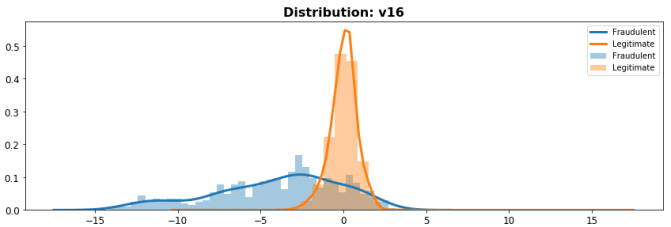




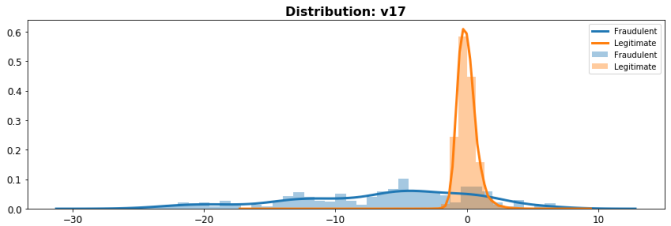


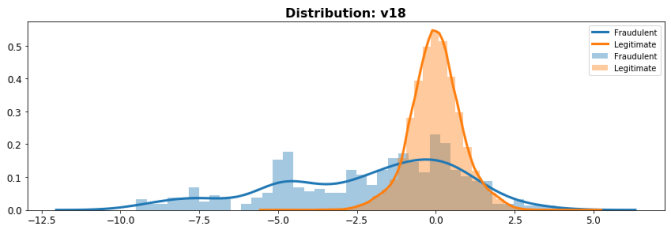


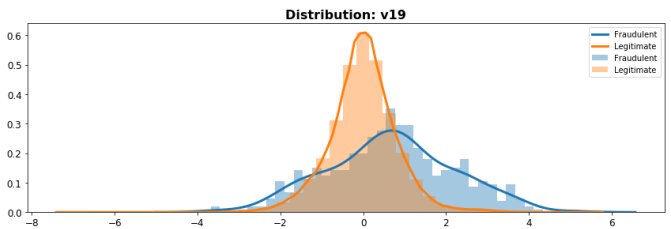


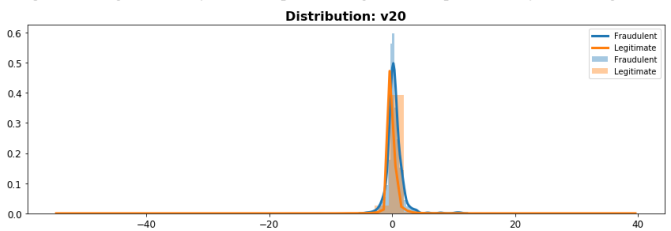


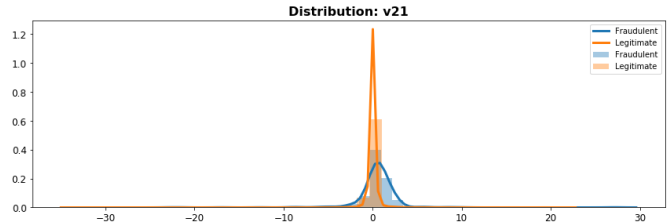
RoboGarden Bootcamp Visualization

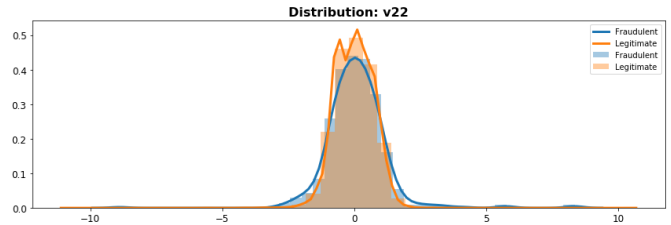


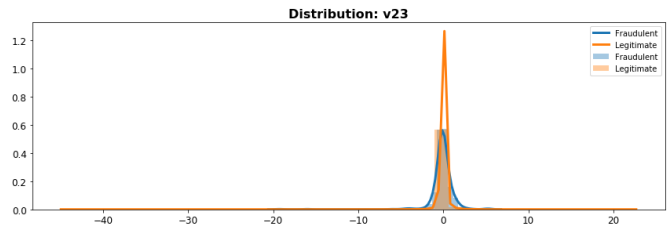


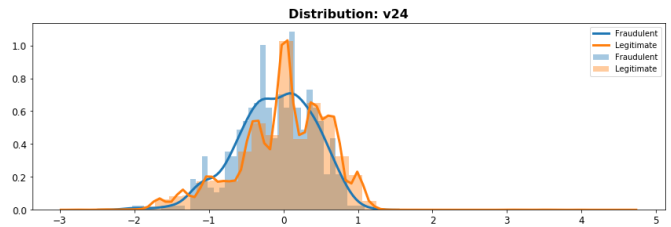


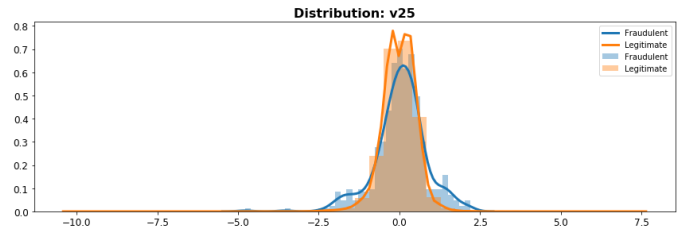


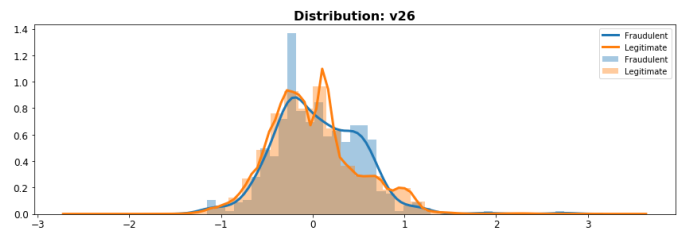


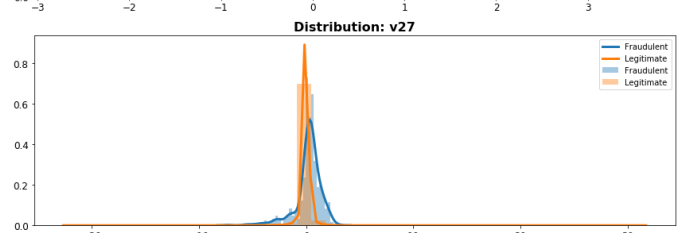


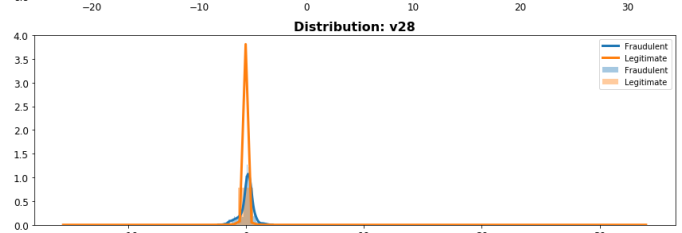












RoboGarden Bootcamp
Data Cleaning – Examples of Duplicates

	time	v1	v2	v3	v4	v5	v6	v7	v8	v9	...	v21	v22	v23	
13560	24050	1.216761	0.698963	-0.137686	2.527629	0.618533	-0.314776	0.486486	-0.303207	0.330209	...	-0.200891	-0.448693	-0.226691	-0.
13561	24050	-0.841458	0.918286	1.504540	-0.521650	1.046457	-0.714847	0.855367	-0.089329	0.533366	...	0.029330	0.180174	-0.290965	-0.
13562	24050	0.783460	-0.766538	1.331255	1.812482	-0.929991	1.318111	-0.979965	0.472786	2.619051	...	0.027365	0.410787	-0.294227	-0.
13563	24050	0.783460	-0.766538	1.331255	1.812482	-0.929991	1.318111	-0.979965	0.472786	2.619051	...	0.027365	0.410787	-0.294227	-0.
13564	24050	0.783460	-0.766538	1.331255	1.812482	-0.929991	1.318111	-0.979965	0.472786	2.619051	...	0.027365	0.410787	-0.294227	-0.
13565	24050	0.783460	-0.766538	1.331255	1.812482	-0.929991	1.318111	-0.979965	0.472786	2.619051	...	0.027365	0.410787	-0.294227	-0.
13566	24052	0.019196	1.060485	2.078401	1.703168	-0.332444	-0.210411	0.065809	-0.106047	0.782455	...	-0.095117	0.090776	0.000921	0.
13567	24052	1.124959	-0.283011	0.454480	0.910154	-0.616918	-0.344330	-0.297557	-0.024893	2.232117	...	-0.472669	-1.231524	-0.007479	-0.
13568	24053	-0.254508	1.082387	-0.593772	-0.109728	3.051428	3.289752	0.430333	0.595560	0.318167	...	-0.055309	-0.054035	-0.247829	0.
13569	24053	-0.802007	0.283655	1.559359	-0.032721	0.952904	0.032269	0.046522	0.159000	0.352412	...	0.084018	0.397200	-0.028074	-0.

v6	v7	v8	v9	...	v21	v22	v23	v24	v25	v26	v27	v28	amount	class
-0.928678	0.344191	0.262082	-1.143424	...	0.179758	0.290998	-0.346720	0.435099	0.564471	-0.200885	-0.038164	-0.057133	5.00	False
5.760059	-18.750889	-37.353443	-0.391540	...	27.202839	-8.887017	5.303607	-0.639435	0.263203	-0.108877	1.269566	0.939407	1.00	True
5.760059	-18.750889	-37.353443	-0.391540	...	27.202839	-8.887017	5.303607	-0.639435	0.263203	-0.108877	1.269566	0.939407	1.00	True
5.760059	-18.750889	-37.353443	-0.391540	...	27.202839	-8.887017	5.303607	-0.639435	0.263203	-0.108877	1.269566	0.939407	1.00	True
5.760059	-18.750889	-37.353443	-0.391540	...	27.202839	-8.887017	5.303607	-0.639435	0.263203	-0.108877	1.269566	0.939407	1.00	True
5.760059	-18.750889	-37.353443	-0.391540	...	27.202839	-8.887017	5.303607	-0.639435	0.263203	-0.108877	1.269566	0.939407	1.00	True
5.760059	-18.750889	-37.353443	-0.391540	...	27.202839	-8.887017	5.303607	-0.639435	0.263203	-0.108877	1.269566	0.939407	1.00	True
3.183007	-0.499724	0.803819	-0.074543	...	-0.340246	-1.150620	0.091744	0.946327	0.368241	0.110198	-0.022594	0.024337	5.99	False
0.960209	0.338479	0.151942	-0.182027	...	0.191189	0.865940	-0.272396	-1.333896	-0.154556	-0.161314	0.215079	-0.099068	22.72	False
3.098005	-0.013022	0.649896	-0.465807	...	-0.043931	-0.258826	-0.189341	1.009328	0.998140	-0.266138	-0.009990	0.006402	14.90	False
-0.822682	0.633459	-0.335497	-1.189777	...	-0.002347	0.007407	-0.119860	0.403321	0.758846	0.065612	-0.034713	0.012673	7.53	False