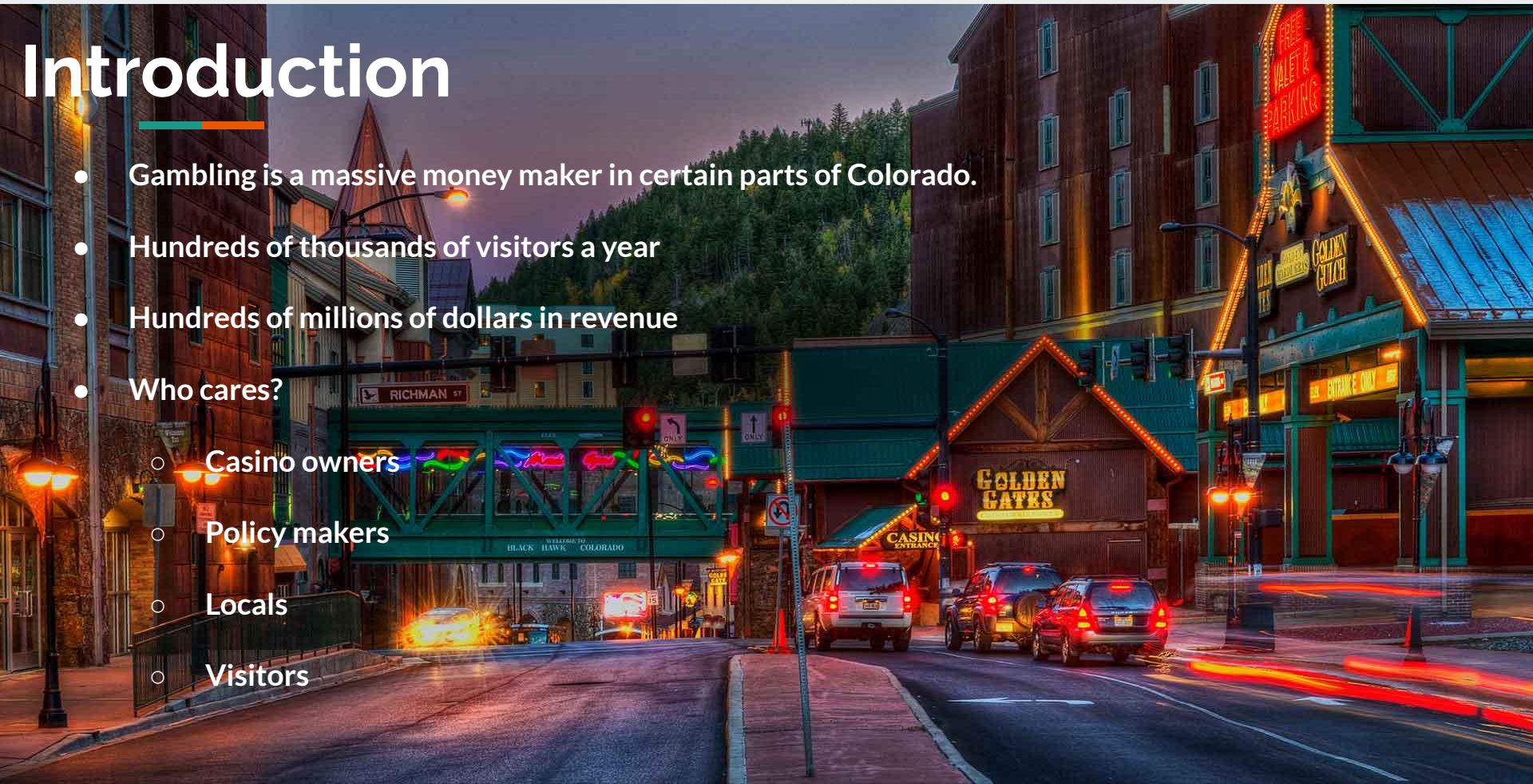# Casino Royale:

An exploration and analysis of the revenue generated by colorado casinos over the past decade

By:
Thomas Neal,
Cameron Mattson,
Hayes Vavpetic,
Michael Grodecki

Introduction

- Gambling is a massive money maker in certain parts of Colorado.

- Hundreds of thousands of visitors a year

- Hundreds of millions of dollars in revenue

- Who cares?
  - Casino owners
  - Policy makers
  - Locals
 - Visitors

Getting To Know Our Data

	2018-2019	Tax Year Basis	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
3	Statewide	Slots Total	12,712	12,696	12,656	12,651	12,714	12,677	12,589
4	Statewide	Coins In	917,443,891.01	869,552,971.45	875,178,070.08	803,604,172.48	765,419,891.32	815,403,816.57	749,180,736.04
5	Statewide	AGP	67,432,506.52	65,801,062.24	63,497,543.18	58,821,753.48	55,918,268.56	60,861,790.75	54,815,981.51
6	Statewide	Avg Daily AGP	171.12	167.19	167.24	151.77	146.61	154.87	140.46
7	Statewide	Hold %	7.35%	7.57%	7.26%	7.32%	7.31%	7.46%	7.32%
8									
9	Statewide	1¢ Slots	7,256	7,243	7,215	7,184	7,274	7,230	7,166
10	Statewide	Coins In	384,196,540.84	370,061,287.50	375,120,409.66	336,628,052.06	320,970,457.80	344,449,488.08	311,204,802.87
11	Statewide	AGP	37,382,700.40	35,997,873.94	36,130,223.74	32,205,477.40	31,113,933.15	33,457,142.40	29,944,481.30
12	Statewide	Avg Daily AGP	166.19	160.32	166.92	146.33	142.58	149.28	134.80
13	Statewide	Hold %	9.73%	9.73%	9.63%	9.57%	9.69%	9.71%	9.62%
14									
15	Statewide	5¢ Slots	360	364	364	366	364	359	350
16	Statewide	Coins In	21,952,785.34	21,139,750.48	22,415,130.31	21,396,932.38	19,705,868.80	21,322,272.65	19,344,480.41
17	Statewide	AGP	1,618,949.29	1,579,140.18	1,572,731.96	1,470,670.33	1,278,709.61	1,493,229.12	1,226,652.95
18	Statewide	Avg Daily AGP	145.07	139.95	144.02	131.16	117.10	134.17	113.06
19	Statewide	Hold %	7.37%	7.47%	7.02%	6.87%	6.49%	7.00%	6.34%
20									
21	Statewide	10¢ Slots	60	59	59	58	56	55	56
22	Statewide	Coins In	9,584,688.80	8,070,617.40	7,490,146.00	6,620,281.60	7,004,441.60	6,656,797.00	6,874,998.70
23	Statewide	AGP	360,904.73	401,022.22	457,239.62	268,676.13	368,082.96	386,184.83	388,507.30
24	Statewide	Avg Daily AGP	194.03	219.26	258.33	151.20	219.10	226.50	223.79
25	Statewide	Hold %	3.77%	4.97%	6.10%	4.06%	5.25%	5.80%	5.65%

Data Preprocessing

- **Step 1: Importing**

- **Step 2: Cleaning/Organizing**

- **Step 3: Saving**
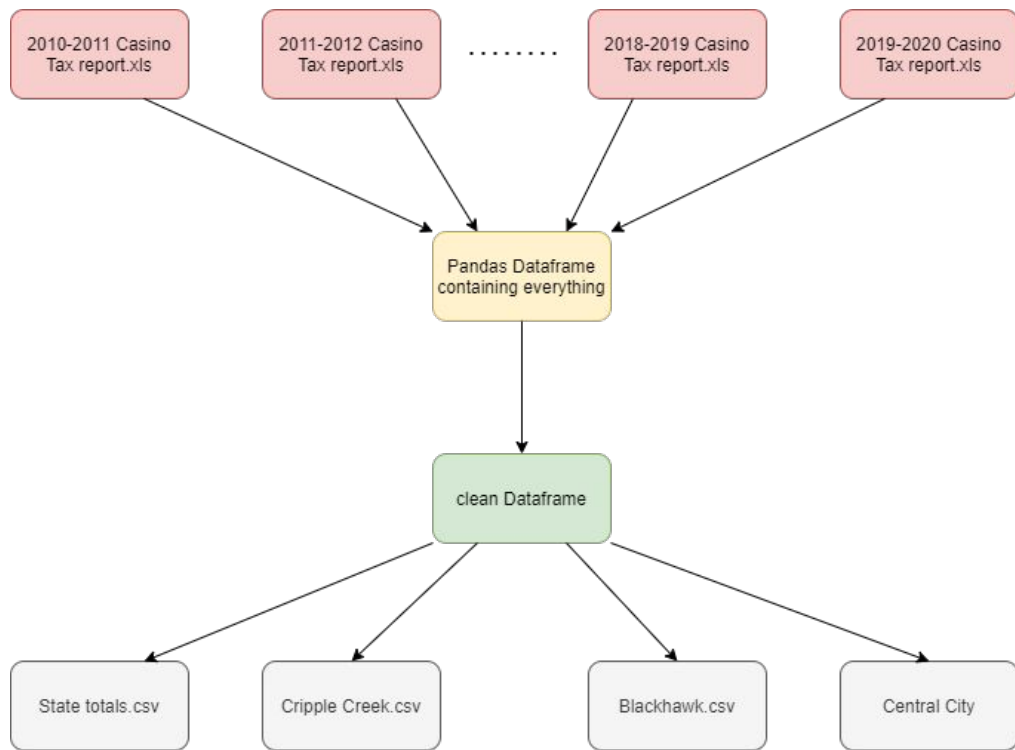
Tools

We plan on using different python libraries to help us clean, manipulate and display data

- Pandas
  - Read in the CSV files, clean the data and create the corresponding dataframes
- Numpy
  - Slice the data into different frames allowing for new approaches to analysis
- Matplotlib
  - Create all the graphs

- Scipy.stats
  - Concatenate arrays
- Scikit-learn
  - Run linear regression models and k-means clustering
- Tensorflow library
  - Data population and model building

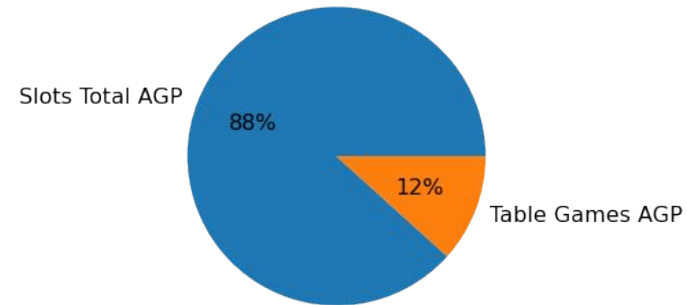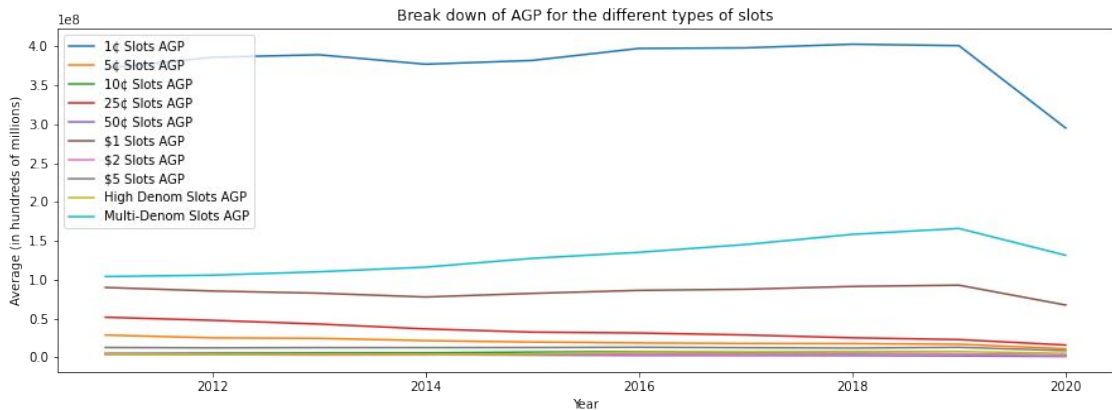|	A	B	C	D	E	F	G	H
1		Slots Total	Slots Total Coins In	Slots Total AGP	Slots Total Avg Daily AGP	Slots Total Hold %	1¢ Slots	1¢ Slots Coins In
2	JULY 2010	15224	924881940.3	63485300.52	134.5187152	0.068641518	7860	356301572.6
3	AUGUST 2010	15182	900224419	60548129.6	128.6500771	0.067258928	7901	348697168.4
4	SEPTEMBER 2010	15189	859887596.9	59638919.56	130.8818214	0.069356646	7925	343153004.8
5	OCTOBER 2010	15067	859014005	58207468.91	124.6207133	0.067760792	7944	344664840.2
6	NOVEMBER 2010	14572	745499907.1	50949581.25	116.7515865	0.068342841	7830	299836649.7
7	DECEMBER 2010	14194	740211154.5	51507997.2	117.2643768	0.069585546	7541	293791168.2
8	JANUARY 2011	14367	781224517.6	53065324.29	119.2482089	0.067925831	7789	314066660.2
9	FEBRUARY 2011	14303	738530651.4	51589059.54	128.8167805	0.069853647	7828	307567563.3
10	MARCH 2011	14081	851830451.4	59112001.56	135.7743918	0.069394093	7753	347335399
11	APRIL 2011	14071	826837715.7	57182308.32	135.4613705	0.069157837	7783	336517922.6
12	MAY 2011	14082	848486244.8	58930584.95	134.9940783	0.069453789	7763	344668590
13	JUNE 2011	14116	787685609	54289501.77	128.1985023	0.068922805	7820	318558747.2
14	TOTAL 2011	174448	9864314213	678506177.5	128.6893793	0.068783918	93737	3955159286
15	JULY 2011	14490	909189345.3	64031026.65	150.8083443	0.070426504	8034	371835070.2
16	AUGUST 2011	14573	842883016.2	58311877.52	131.7664676	0.06918146	8128	343478018.9
17	SEPTEMBER 2011	14668	823434356.6	58243996.93	132.3606875	0.070733018	8203	338767406.5
18	OCTOBER 2011	14563	807798801.1	55770084.33	123.6343462	0.069039573	8140	333714890.5
19	NOVEMBER 2011	14633	742951764.1	52178939.82	119.0597734	0.070231935	8186	307436286.7
20	DECEMBER 2011	14565	708232197.2	50383348.15	111.9484426	0.07113959	8220	293464738.7
21	JANUARY 2012	14549	779495207.9	52660755.88	116.7595065	0.067557511	8186	319462068.2
22	FEBRUARY 2012	14557	768157019.2	53877680.79	128.0675697	0.07013889	8204	327578622.3

Initially Proposed Work

- Exploration!

  - Tons of interesting trends that can be visualized using graphs.

  - Different graphs can show similar trends.

- Analysis!

  - Countless fun questions to explore!

  - Clustering

 - Associations
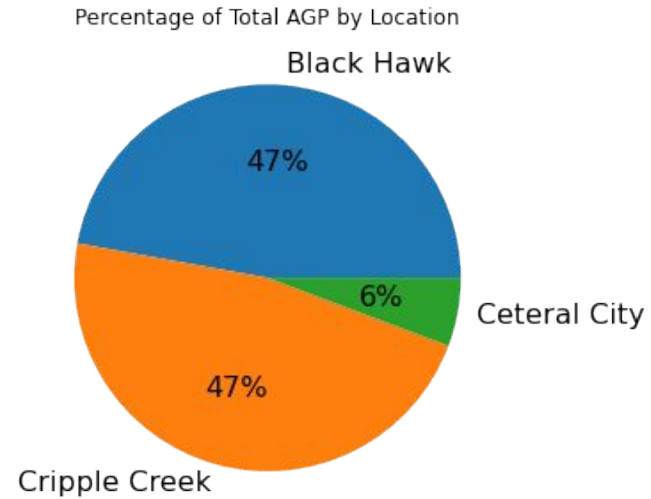
  - Regressions

Exploration!

Total AGP for the past 10 years compaired to Slots AGP and table games AGP

Monthly AGP for Total, Slots, and Table Games
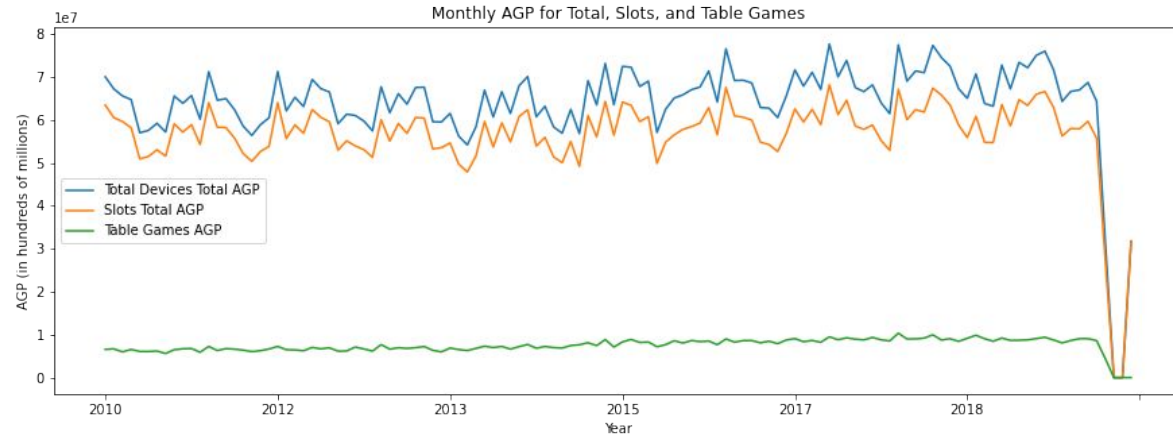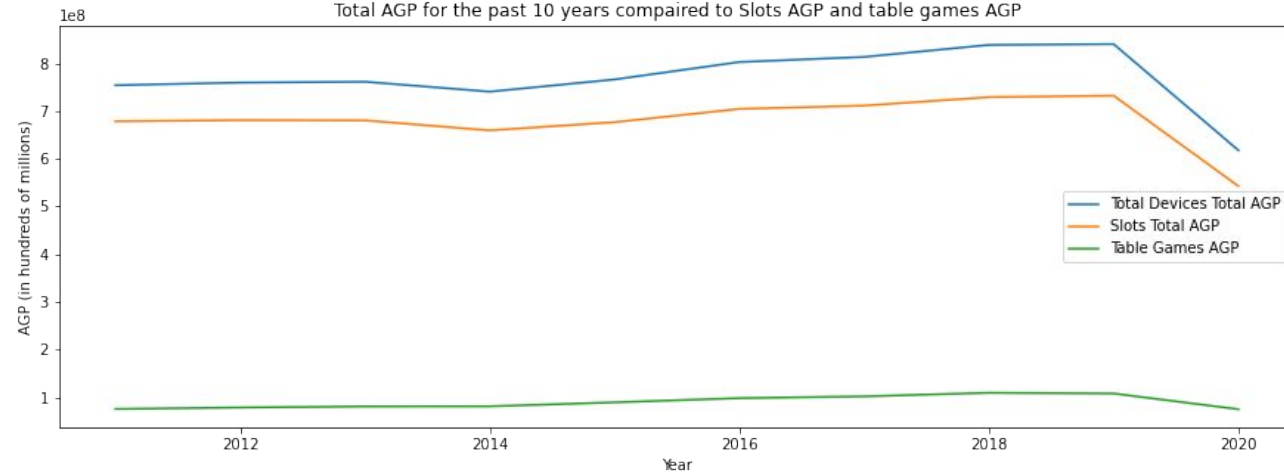
Percentage of AGP for Slots vs Table Games

Break down of AGP for the different types of slots

Percentage of AGP for Different types of Slots vs Table Games

Break down of AGP for the different types of table games
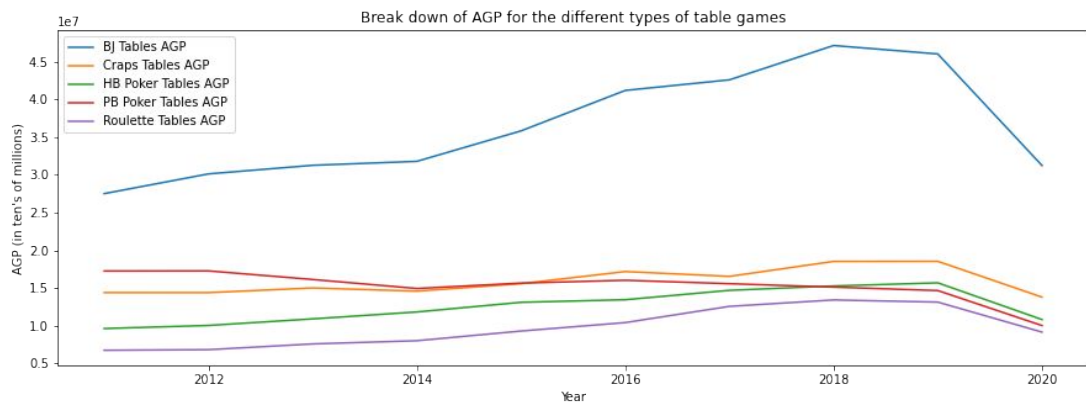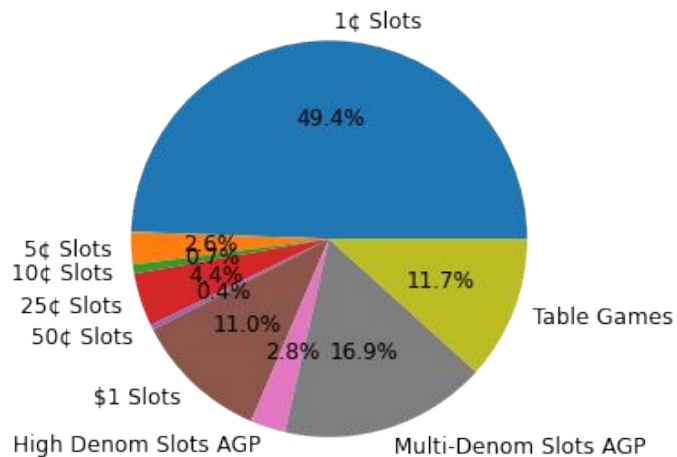
Revised Proposed Work

- New Trends
  - Seasonal trends
  - Locational trends
- Analysis
  - Linear regression
 - Supervised learning - Neural Network

Percentage of Total AGP by Location

Seasonal Trends

Monthly Average AGP Grouped by Season

Clusters for AGP vs. Coins In for all Slot Machines

AGP vs. Coins In for all Slot Machines

Slot AGP vs. Coins In
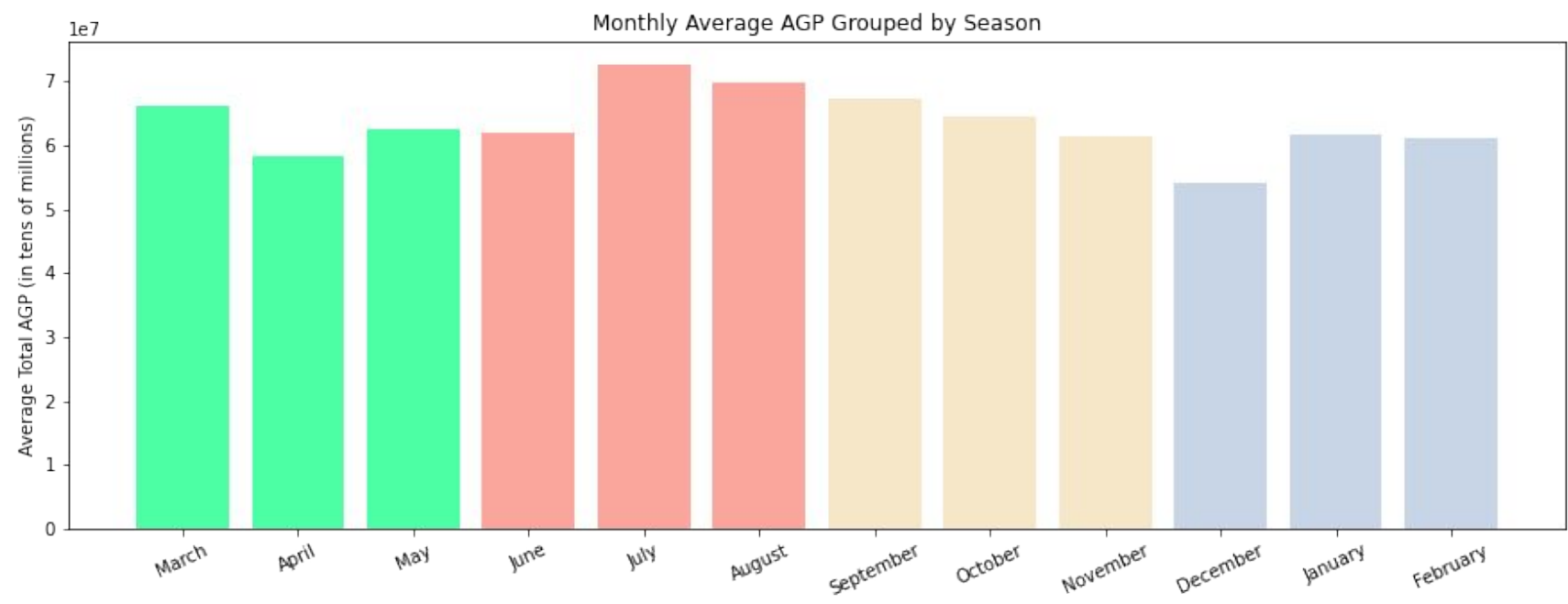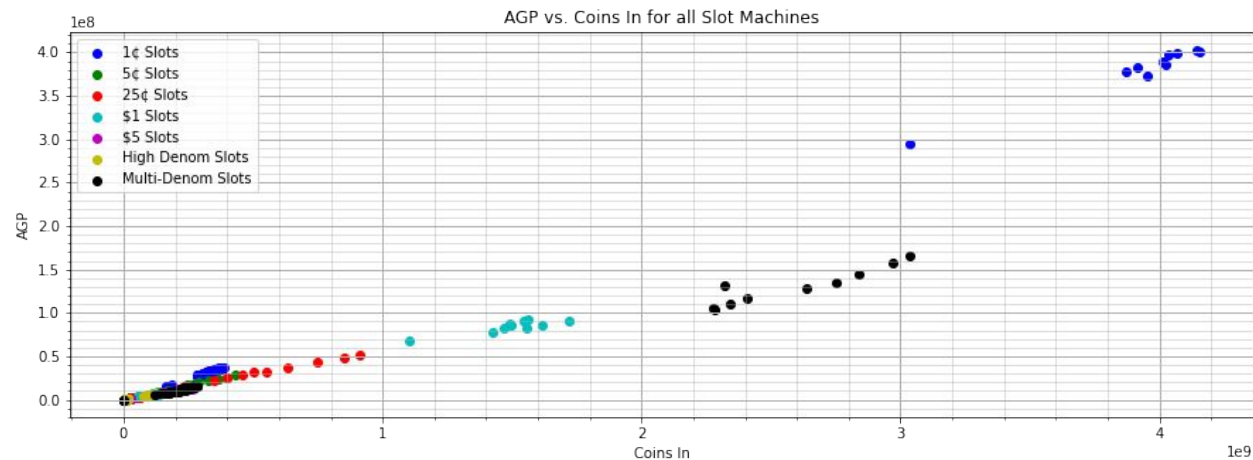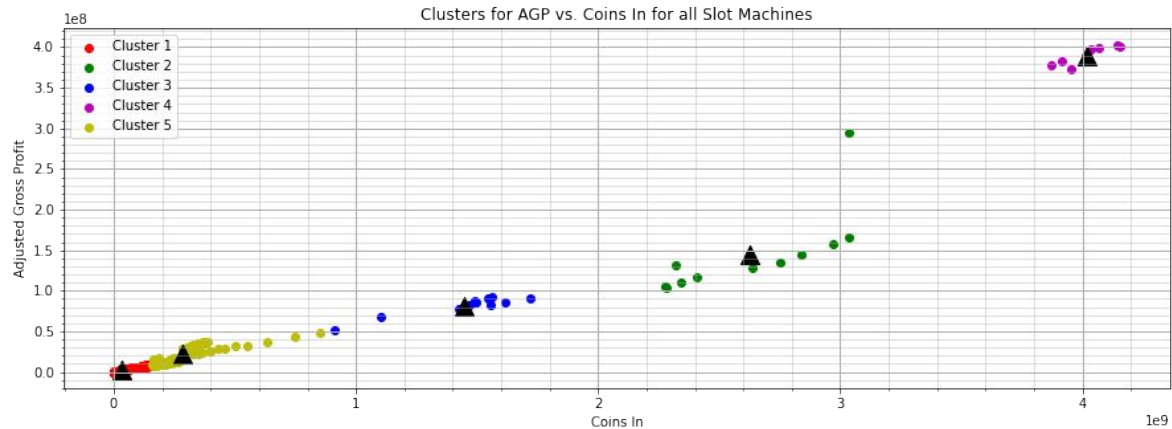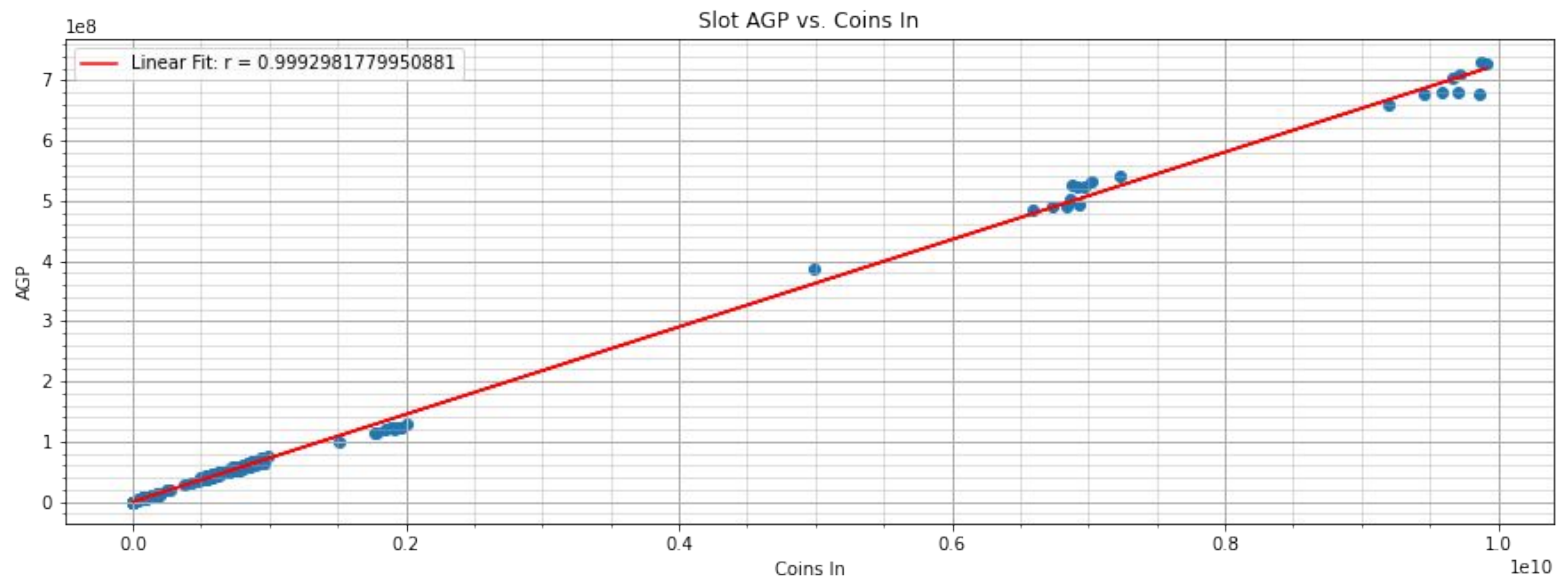
Multi-Class Classification with NN and SoftMax Function

$$\mathbf{z} = \begin{bmatrix} z_1 \\ z_2 \\ z_3 \\ \vdots \\ z_K \end{bmatrix} = \begin{bmatrix} \mathbf{w}_1^\top \\ \mathbf{w}_2^\top \\ \mathbf{w}_3^\top \\ \vdots \\ \mathbf{w}_K^\top \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ \vdots \\ x_n \end{bmatrix}$$

$z_j = \mathbf{w}_j^\top \cdot \mathbf{x}$

SoftMax

$\dfrac{e_1^z}{\sum_{k=1}^{K} e_k^z}$

$\dfrac{e_2^z}{\sum_{k=1}^{K} e_k^z}$

$\dfrac{e_3^z}{\sum_{k=1}^{K} e_k^z}$

$\dfrac{e_K^z}{\sum_{k=1}^{K} e_k^z}$

probabilities

green

blue

purple

red
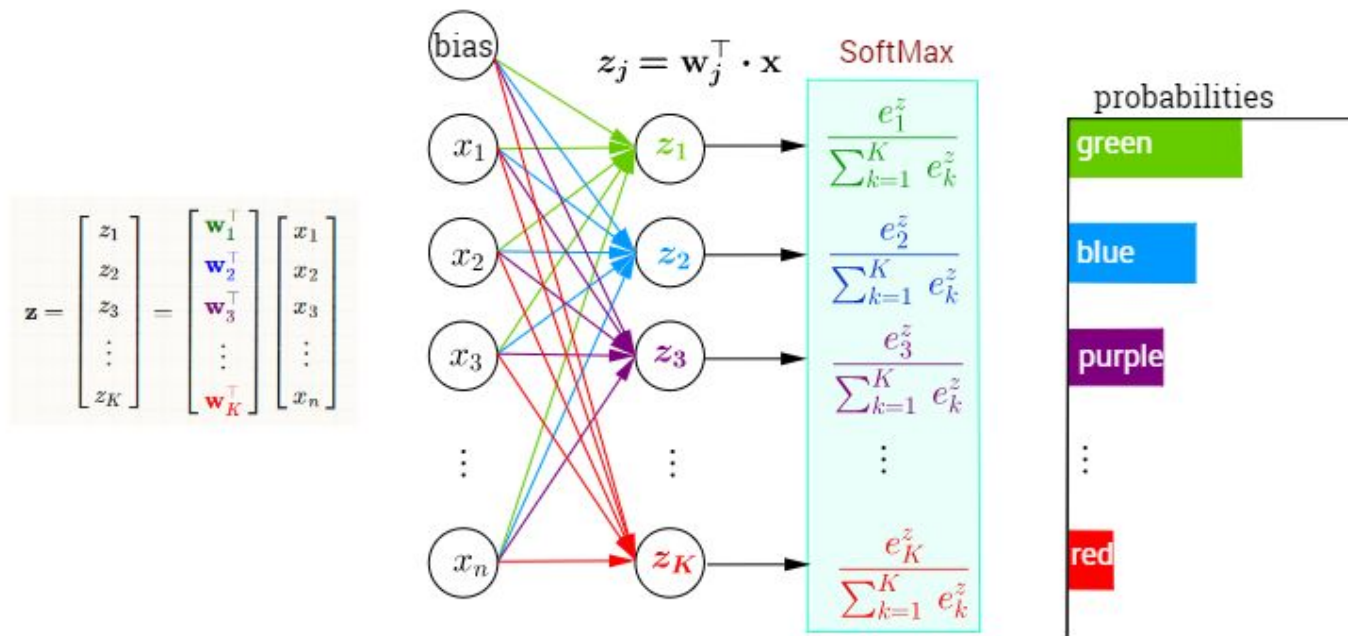
Categorical Cross-Entropy Loss: $L_{CCE} = -\sum_{i=1}^{n} y_i log(p_i)$

Softmax: $\sigma(z)_i = \dfrac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}}$

Categorical Cross-Entropy Loss vs. Epoch
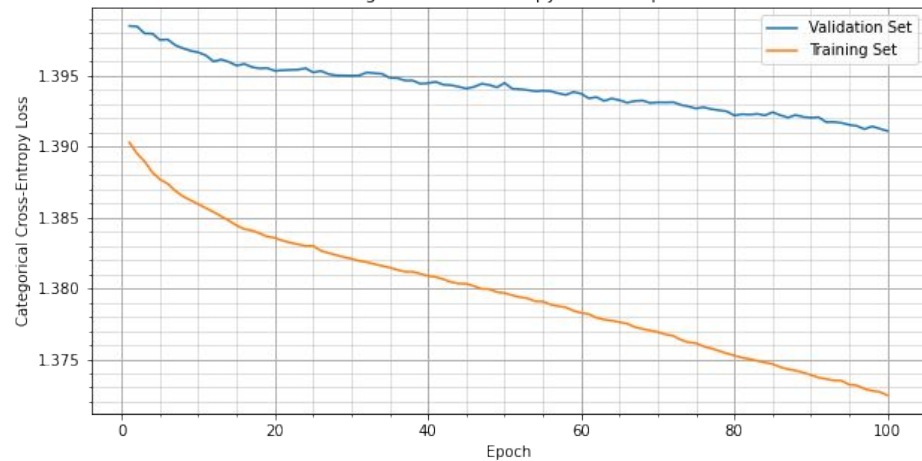
Categorical Accuracy vs. Epoch
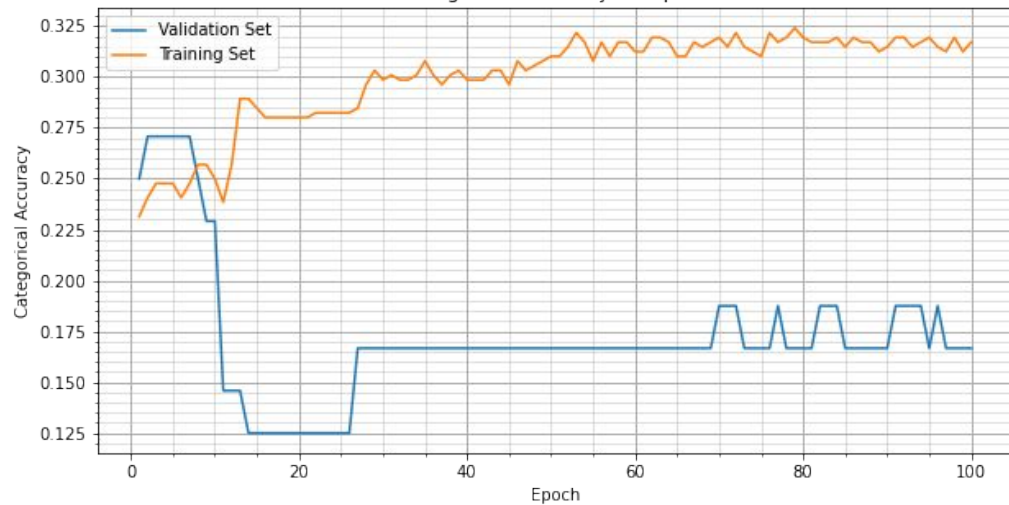
Categorical Cross-Entropy Loss vs. Epoch
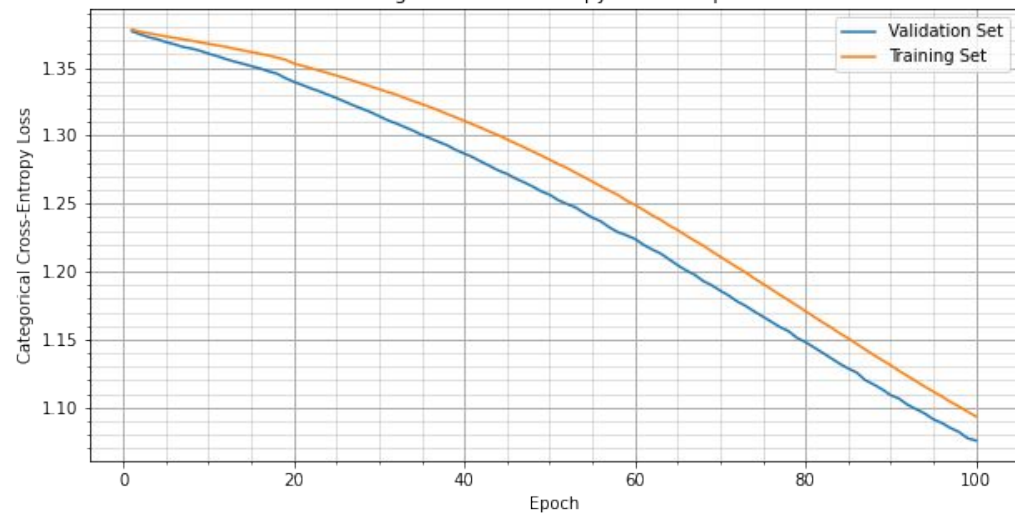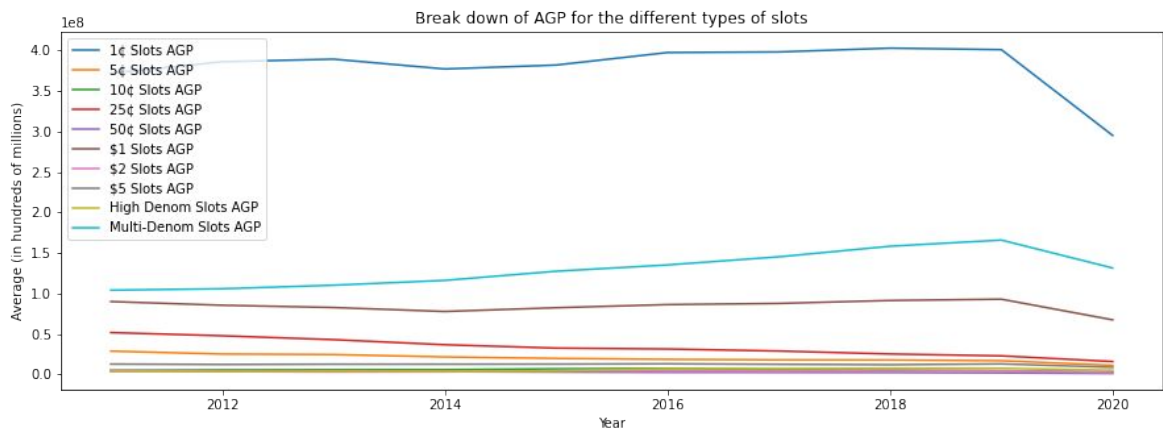
Categorical Accuracy vs. Epoch
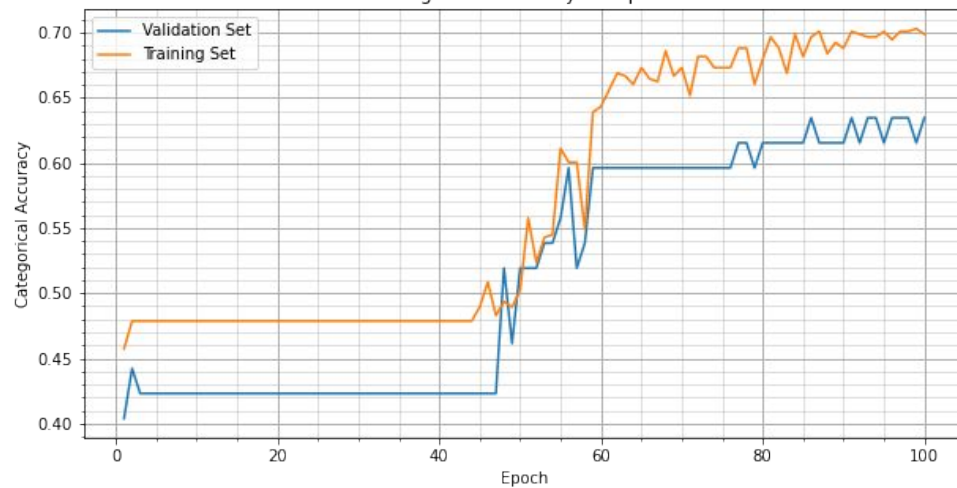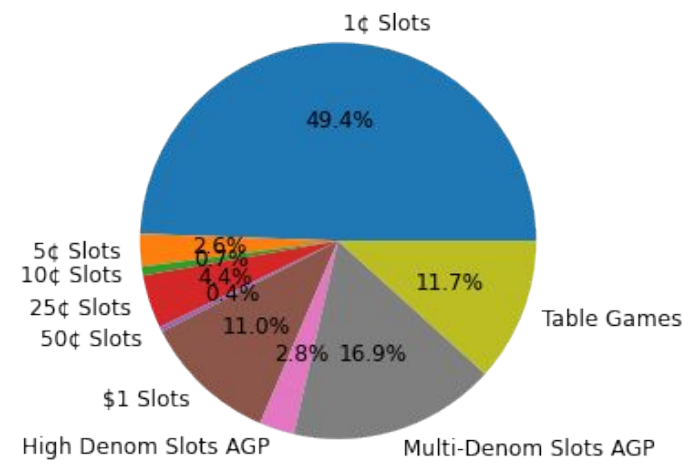
Conclusions Drawn

- **Four original groups of interest:**

  - **Casinos**
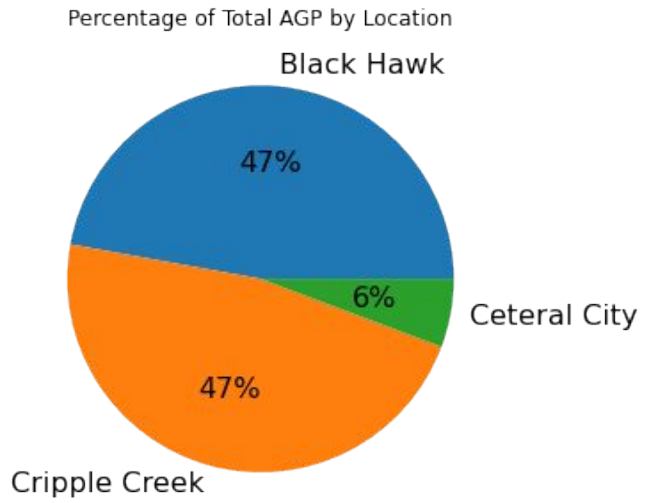
  - **Locals**

  - **Policy Makers**

  - **Visitors**

Conclusions Drawn: Casinos

Break down of AGP for the different types of slots

Percentage of AGP for Different types of Slots vs Table Games

Conclusions Drawn: Locals

Monthly Average AGP Grouped by Season

Percentage of Total AGP by Location
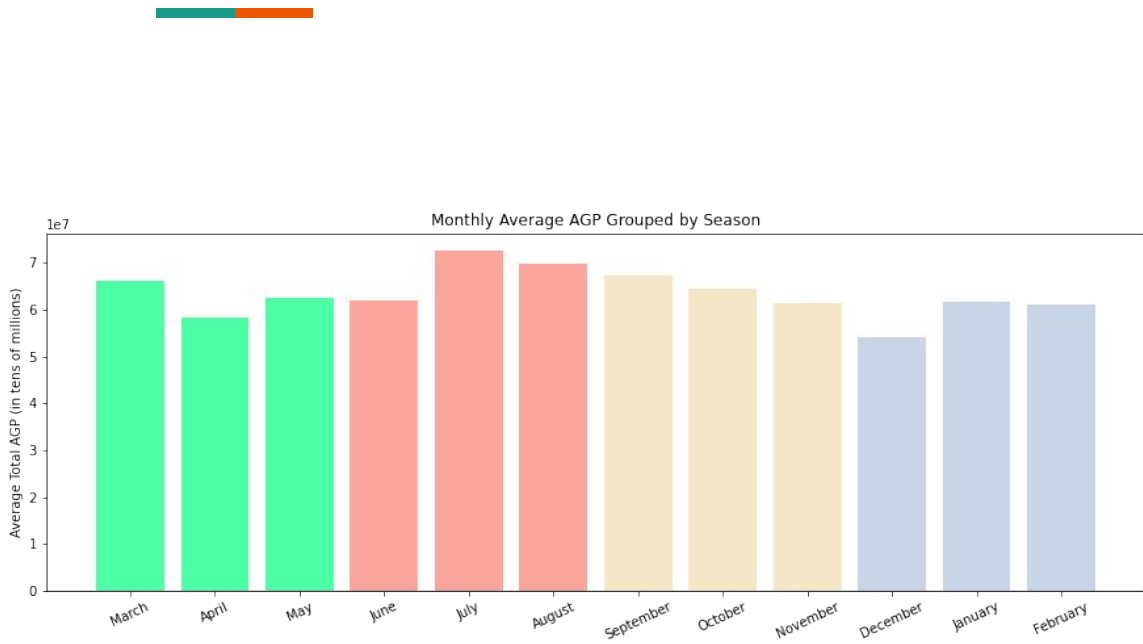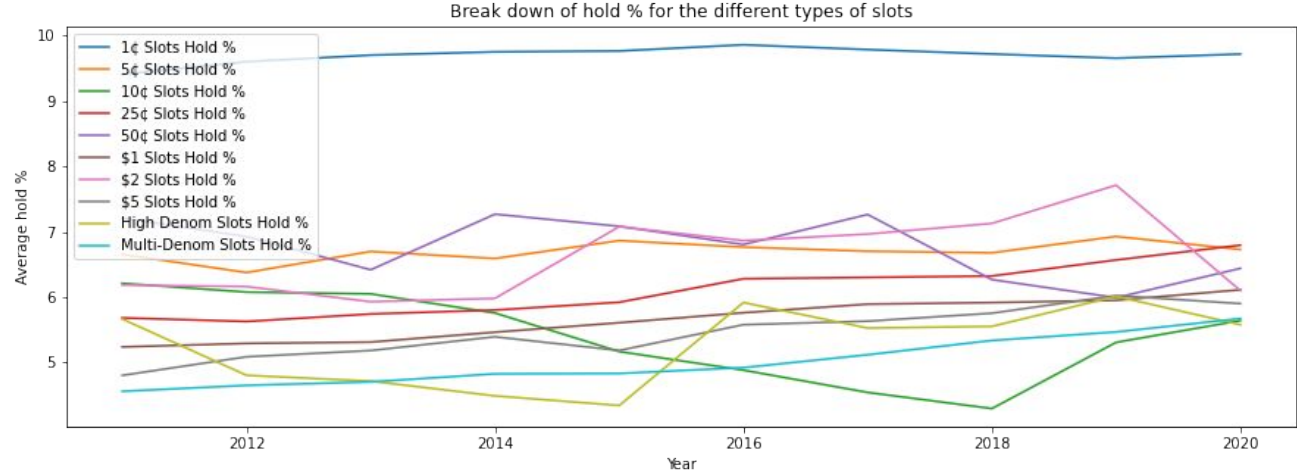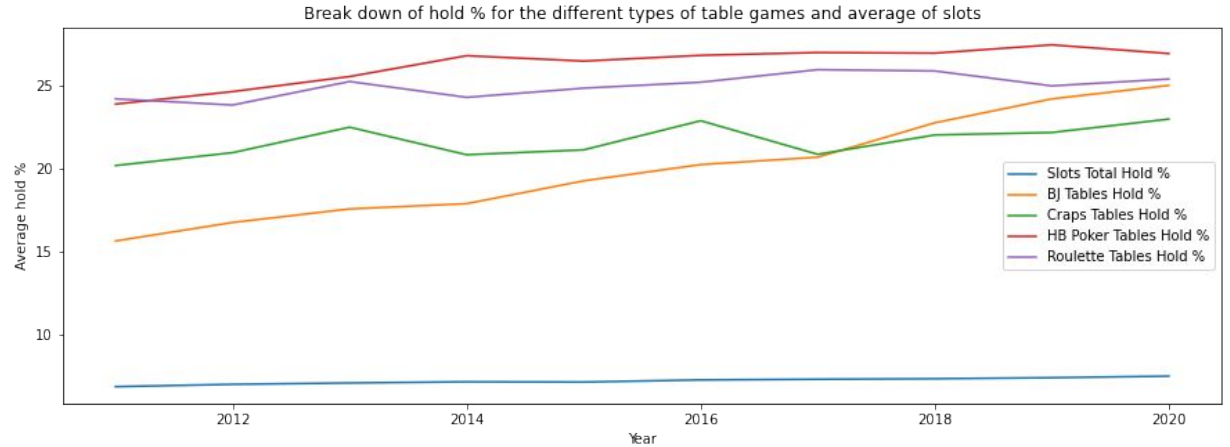
Policy Makers:

"By law, slot machines must pay out between 80 percent and 100 percent... with higher denominations paying out higher than lower denominations"

-Colorado Department of Revenue

Break down of hold % for the different types of table games and average of slots

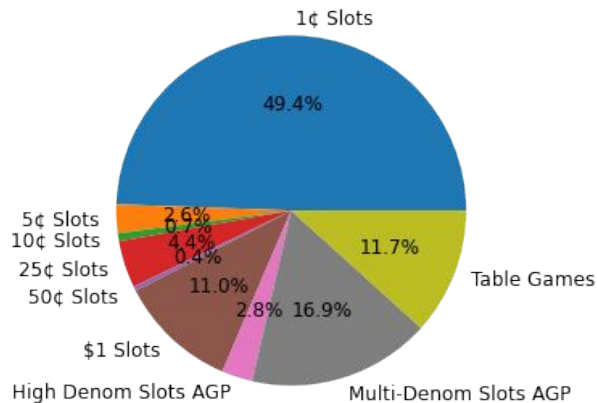Break down of hold % for the different types of slots

Conclusions Drawn: Visitors

Break down of hold % for the different types of table games and average of slots
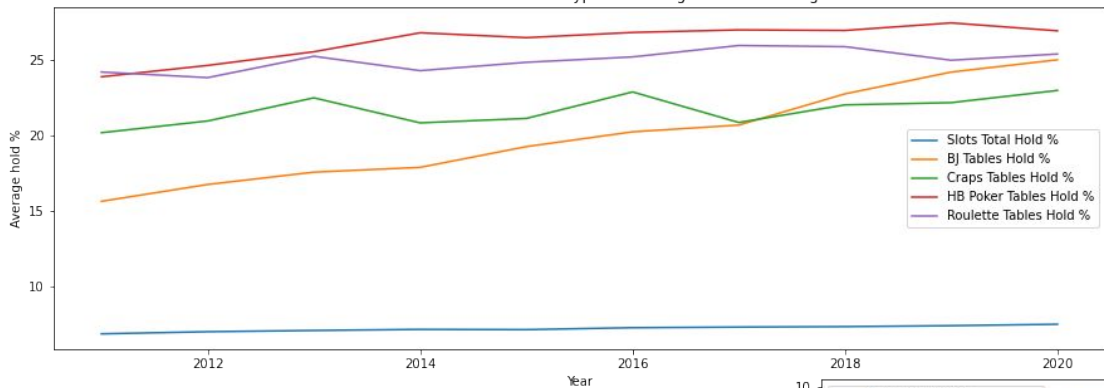
Percentage of AGP for Different types of Slots vs Table Games

- Best table game: Craps
- Best slot machine: 10 cent

Break down of hold % for the different types of slots