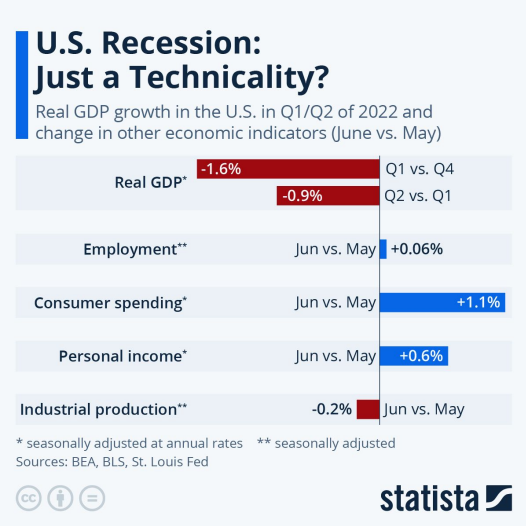
GDP-Based Recession Indicator Index

an analysis of the historical trends of
recession in the U.S. economy based on GDP

Problem Statement and Overview:

Can we anticipate recession for the U.S. economy?

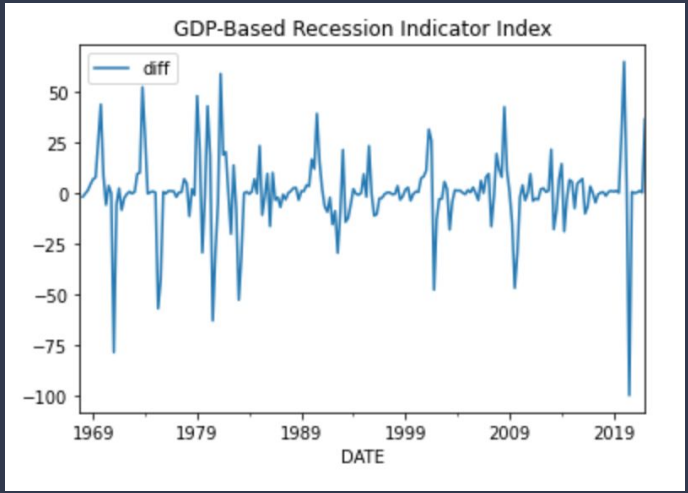
- How can we model this data in order to predict future periods of economic recession in the United States?
  - Given a direct perspective on the nature of the fluctuation of the United States' economic status, is it possible to program an algorithm for learning the timeline of economic recession and extending that timeline to future recessions?



"Real GDP growth in the U.S. Q1/Q2 of 2022 and change in other economic indicators (June vs. May)."

(Bucholz, 2022)

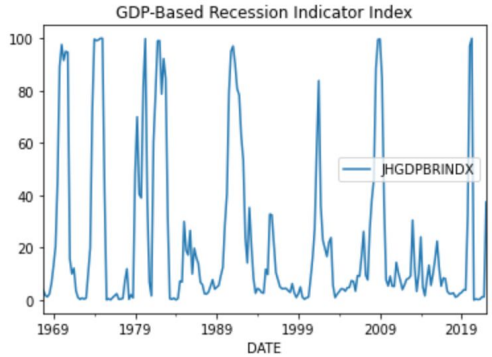
Exploring the Data



Target Variable: JHGDPBRINDX
Raw Data available here

- Index values calculated quarterly using the probability of a state of recession based on differences between recession & expansion

```
RangeIndex: 218 entries, 0 to 217
Data columns (total 2 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   DATE          218 non-null    object
 1   JHGDPBRINDX   218 non-null    float64
dtypes: float64(1), object(1)
memory usage: 3.5+ KB
```



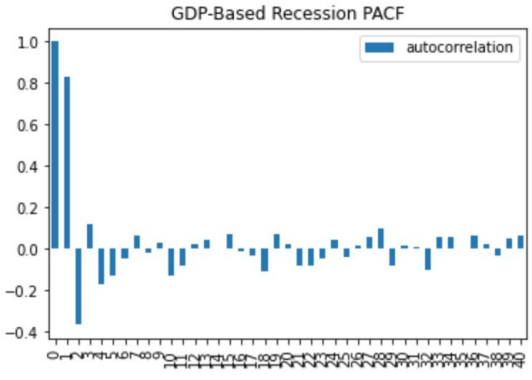
	DATE	JHGDPBRINDX
0	1967-10-01	3.834800
1	1968-01-01	1.761400
2	1968-04-01	1.212700
3	1968-07-01	2.300900
4	1968-10-01	6.333800
5	1969-01-01	12.950100
6	1969-04-01	20.460500
7	1969-07-01	45.702800
8	1969-10-01	89.228200
9	1970-01-01	97.605670
10	1970-04-01	91.584250
11	1970-07-01	94.995510
12	1970-10-01	94.655470
13	1971-01-01	15.872900
14	1971-04-01	10.011500
15	1971-07-01	12.151800

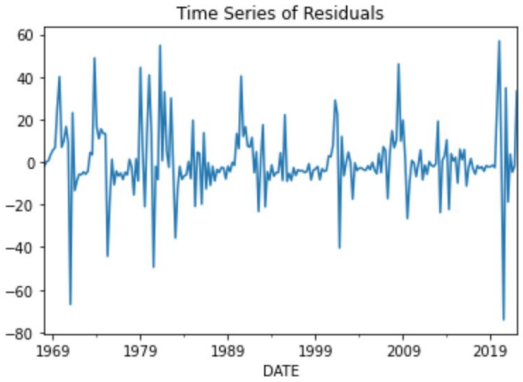
Visualizing the Data

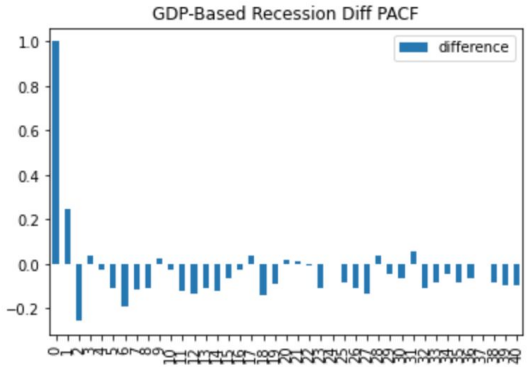
Plots:

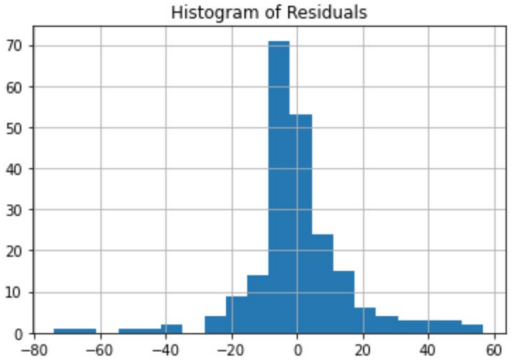
- Autocorrelation in the Data
- Residuals of best-performing ARIMA model (2,1,2)

Notice an element of periodicity in the dataset, which is supported by the fluctuation in residuals over time.









ARIMA Model Results

Dep. Variable:	D.JHGDPBRINDX	No. Observations:	217
Model:	ARIMA(2, 1, 2)	Log Likelihood	-913.174
Method:	css-mle	S.D. of innovations	16.125
Date:	Thu, 22 Sep 2022	AIC	1838.348
Time:	03:07:15	BIC	1858.628
Sample:	01-01-1968 - 01-01-2022	HQIC	1846.541

	coef	std err	z	P>|z|	[0.025	0.975]
const	-0.0878	0.078	-1.125	0.261	-0.241	0.065
ar.L1.D.JHGDPBRINDX	0.7763	0.155	5.004	0.000	0.472	1.080
ar.L2.D.JHGDPBRINDX	-0.0812	0.140	-0.581	0.561	-0.355	0.193
ma.L1.D.JHGDPBRINDX	-0.5877	0.145	-4.048	0.000	-0.872	-0.303
ma.L2.D.JHGDPBRINDX	-0.4123	0.145	-2.848	0.004	-0.696	-0.129

Roots

	Real	Imaginary	Modulus	Frequency
AR.1	1.5346	+0.0000j	1.5346	0.0000
AR.2	8.0214	+0.0000j	8.0214	0.0000
MA.1	1.0000	+0.0000j	1.0000	0.0000
MA.2	-2.4255	+0.0000j	2.4255	0.5000

Residuals Description

count	217.000000
mean	0.315780
std	16.318489
min	-74.067235
25%	-5.680907
50%	-1.957440
75%	5.587355
max	56.882765

dtype: float64

```
Epoch 1/20
1/1 [==============================] - 0s 402ms/step - loss: 5.6394 - accuracy: 0.1481
Epoch 2/20
1/1 [==============================] - 0s 12ms/step - loss: 10080115.0000 - accuracy: 0.8519
Epoch 3/20
1/1 [==============================] - 0s 12ms/step - loss: 1488949376.0000 - accuracy: 0.1481
Epoch 4/20
1/1 [==============================] - 0s 16ms/step - loss: 17.1986 - accuracy: 0.8519
Epoch 5/20
1/1 [==============================] - 0s 10ms/step - loss: 3.7108 - accuracy: 0.8519
Epoch 6/20
1/1 [==============================] - 0s 11ms/step - loss: 3.2718 - accuracy: 0.8519
Epoch 7/20
1/1 [==============================] - 0s 13ms/step - loss: 2.8329 - accuracy: 0.8519
Epoch 8/20
1/1 [==============================] - 0s 13ms/step - loss: 2.3939 - accuracy: 0.8519
Epoch 9/20
1/1 [==============================] - 0s 14ms/step - loss: 1.9550 - accuracy: 0.8519
Epoch 10/20
1/1 [==============================] - 0s 14ms/step - loss: 1.5161 - accuracy: 0.8519
Epoch 11/20
1/1 [==============================] - 0s 13ms/step - loss: 1.0779 - accuracy: 0.8519
Epoch 12/20
1/1 [==============================] - 0s 14ms/step - loss: 0.6535 - accuracy: 0.8519
Epoch 13/20
1/1 [==============================] - 0s 14ms/step - loss: 0.4206 - accuracy: 0.8519
Epoch 14/20
1/1 [==============================] - 0s 21ms/step - loss: 0.4221 - accuracy: 0.8519
Epoch 15/20
1/1 [==============================] - 0s 14ms/step - loss: 0.4249 - accuracy: 0.8519
Epoch 16/20
1/1 [==============================] - 0s 15ms/step - loss: 0.4337 - accuracy: 0.8519
Epoch 17/20
1/1 [==============================] - 0s 27ms/step - loss: 0.4417 - accuracy: 0.8519
Epoch 18/20
1/1 [==============================] - 0s 16ms/step - loss: 0.4819 - accuracy: 0.8519
Epoch 19/20
1/1 [==============================] - 0s 13ms/step - loss: 0.4639 - accuracy: 0.8519
Epoch 20/20
1/1 [==============================] - 0s 17ms/step - loss: 0.5453 - accuracy: 0.8519
Test score: 0.5012971758842468
Test accuracy: 0.8048780560493469
```

Results: ARIMA(2,1,2) | ANN with a batch size of 109 and a learning rate of 10.0

Time Series Analysis with ARIMA models: PACF yielded high values at 1 and 2	**Deep Learning with ANNs: (batch_size=109; optimizer=sgd_10, loss='categorical_crossentropy')**
Greatest log-likelihood	Test accuracy of about 80.5%
Lowest AIC score	Least amount of loss (after learning)
Approximately normal & periodic residuals ❏ Evidence of seasonality trend ❏ Slightly left-skewed - likely outliers	Trained to account for multiple conditions: ❏ Entered (or still in) a recession ❏ Either heading-towards or moving-out-of a recession (tracking intermediate periods) ❏ Exited (or still out of) a recession

Results: ARIMA(2,1,2) | ANN with a batch size of 109 and a learning rate of 10.0

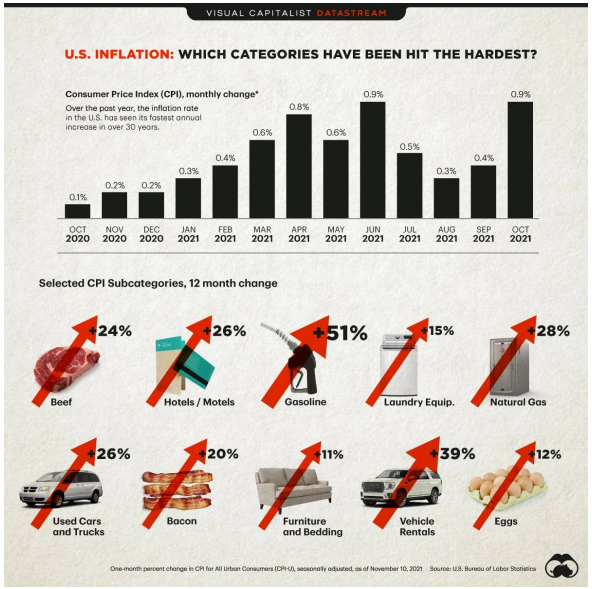
Inferences: Seasonality & Potential for Comparison with Other Factors

- Time Series Analysis with ARIMA modeling seems to more precisely describe the data
  - Likely due to the univariate relation between time and the target variable (GDP-Based Recession Indicator Index values)
  - There appears to be a strong likelihood of seasonality present in the dataset
    - One can see a continued trend resembling periodicity evident in each visualization representing the data
- Deep Learning with Artificial Neural Network models could lead to more comparable (and possibly more statistically significant) results if the data is correlated with additional relevant variables than time alone
  - There could be potential for greater insights produced through backpropagation after comparing this index with further time-related data on various other factors that impact the United States' economy
    - Perhaps then it may be possible to predict future periods of economic recession more confidently as well

Cultural Fit:

Recent Inflation and Historical Impact of Economic Recession

- Gas prices lately! Too high!
  - With inflation rates remaining high in the past few months, it is important to look at the evolution of phenomena like inflation and recession in order to plan for the coming economic quarters



(Routley, 2022)

Sources & Works Cited

Buchholz, Katharina. (2022, August 9). *U.S. Recession: Just a Technicality?* Statista Infographics. Retrieved September 30, 2022, from https://www.statista.com/chart/27944/us-gdp-and-indicators/

Hamilton, James. (2022, July 28). *GDP-Based Recession Indicator Index [JHGDPBRINDX]*. FRED, Federal Reserve Bank of St. Louis. Retrieved September 15, 2022, from https://fred.stlouisfed.org/series/JHGDPBRINDX

Routley, Nick. (2021, November 19). *U.S. Inflation: Which Categories Have Been Hit the Hardest?* Visual Capitalist. Retrieved September 30, 2022, from https://www.visualcapitalist.com/u-s-inflation-which-categories-have-been-hit-the-hardest/

Thank You!

Your time and attention are much appreciated.

Any questions, comments, concerns, or suggestions for discussion?