Workshop (FTSE Index 2018)

```
df.market_value.plot(figsize=(20,5))
plt.title("Prices", size = 24)
plt.show()
```


```
[31] df.returns.plot(figsize=(20,5))
     plt.title("Returns", size = 24)
     plt.show()
```

The DF-Test

```
[7]  sts.adfuller(df.market_value) # prices are non-stationary (p value >5%)
```

```
(-1.9041551418836864,
 0.33010893277028336,
 6,
 5014,
 {'1%': -3.4316548765428174,
  '5%': -2.8621166146845334,
  '10%': -2.5670769326348926},
 54854.15304507557)
```

ADF can test the stationary
H0: non-stationary
H1: stationary -> p-value less than 5%
prices: do not reject H0
returns: reject H0, accept H1

Using Returns

```
[10] df['returns'] = df.market_value.pct_change(1).mul(100)
     df = df.iloc[1:]
```

```
[11] sts.adfuller(df.returns) # returns are stationary (p value < 5%)
```

```
(-12.790332603910013,
 7.099523586679258e-24,
 32,
 4986,
 {'1%': -3.43166220814716,
  '5%': -2.862119853748156,
  '10%': -2.567078656914853},
 15690.778602127362)
```

mean is stationary
variance is non-stationary

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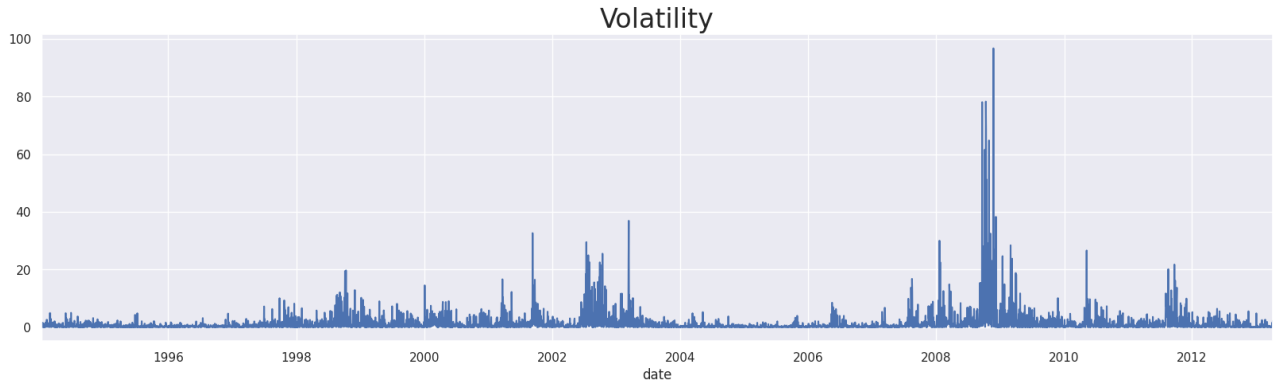
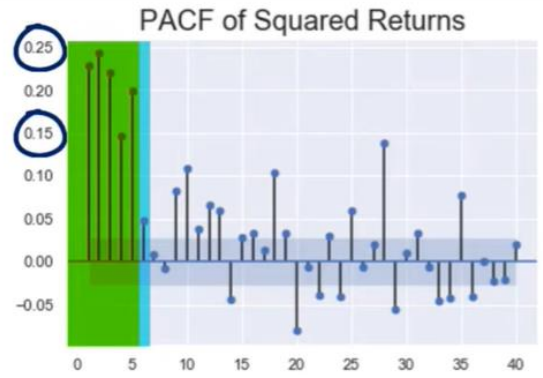
```
[32] df.sq_returns.plot(figsize=(20,5))
     plt.title("Volatility", size = 24)
     plt.show()
```




```
In [12]: sgt.plot_pacf(df.sq_returns[1:], lags = 40, alpha = 0.05, zero = False , method = ('ols'))
         plt.title("PACF of Squared Returns", size = 20)
         plt.show()
```



There tend to be short-term trends in variance

Clustering means below

High Variation → High Variation

Low Variation → Low Variation

The arch_model() Method

Questions:

1. Analyse the results of Arch (1) model – see next page. Try higher order Arch models to get the best model (using AIC/BIC)

2. Analyse the results of Garch (1, 1) model – see next page. Try higher order Garch models to get the best model (using AIC/BIC)

3. Which model is better – Arch or Garch?

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The Simple ARCH(1)

```
[37] model_arch_1 = arch_model(df.returns[1:], mean = "Constant", vol = "ARCH", p = 1)
     results_arch_1 = model_arch_1.fit()
     results_arch_1.summary()
```

```
Iteration:      1,   Func. Count:      5,   Neg. LLF: 29071.83486537579
Iteration:      2,   Func. Count:     13,   Neg. LLF: 12040.736044828116
Iteration:      3,   Func. Count:     20,   Neg. LLF: 7809.7227529035545
Iteration:      4,   Func. Count:     26,   Neg. LLF: 7660.088789376123
Iteration:      5,   Func. Count:     30,   Neg. LLF: 7660.088782040875
Iteration:      6,   Func. Count:     33,   Neg. LLF: 7660.088782040906
Optimization terminated successfully    (Exit mode 0)
            Current function value: 7660.088782040875
            Iterations: 6
            Function evaluations: 33
            Gradient evaluations: 6
```

Constant Mean - ARCH Model Results

Dep. Variable:	returns	**R-squared:**	0.000
Mean Model:	Constant Mean	**Adj. R-squared:**	0.000
Vol Model:	ARCH	**Log-Likelihood:**	-7660.09
Distribution:	Normal	**AIC:**	15326.2
Method:	Maximum Likelihood	**BIC:**	15345.7
		No. Observations:	5020
Date:	Thu, Feb 29 2024	**Df Residuals:**	5019
Time:	14:56:33	**Df Model:**	1

Mean Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
mu	0.0345	1.603e-02	2.151	3.147e-02	[3.063e-03,6.590e-02]

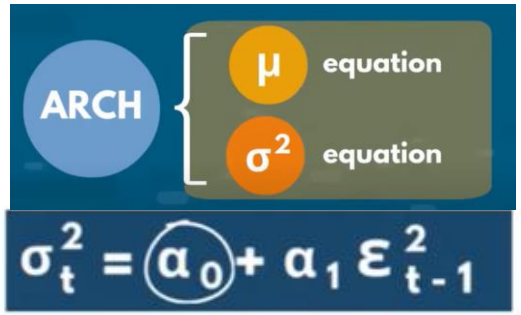
Volatility Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
lambda 0 **omega**	0.9206	4.309e-02	21.365	2.855e-101	[0.836, 1.005]
lambda 1 **alpha[1]**	0.3684	5.040e-02	7.310	2.673e-13	[0.270, 0.467]

mean equation

variance equation

p-value all significant



The Simple GARCH Model

```
[40] model_garch_1_1 = arch_model(df.returns[1:], mean = "Constant", vol = "GARCH", p = 1, q = 1)
     results_garch_1_1 = model_garch_1_1.fit(update_freq = 5)
     results_garch_1_1.summary()
```

```
Iteration:      5,   Func. Count:     35,   Neg. LLF: 7010.712887007633
Iteration:     10,   Func. Count:     64,   Neg. LLF: 6970.058478413694
Optimization terminated successfully    (Exit mode 0)
            Current function value: 6970.058366189882
            Iterations: 13
            Function evaluations: 78
            Gradient evaluations: 13
```

Constant Mean - GARCH Model Results

Dep. Variable:	returns	**R-squared:**	0.000
Mean Model:	Constant Mean	**Adj. R-squared:**	0.000
Vol Model:	GARCH	**Log-Likelihood:**	-6970.06
Distribution:	Normal	**AIC:**	13948.1
Method:	Maximum Likelihood	**BIC:**	13974.2
		No. Observations:	5020
Date:	Thu, Feb 29 2024	**Df Residuals:**	5019
Time:	14:58:06	**Df Model:**	1

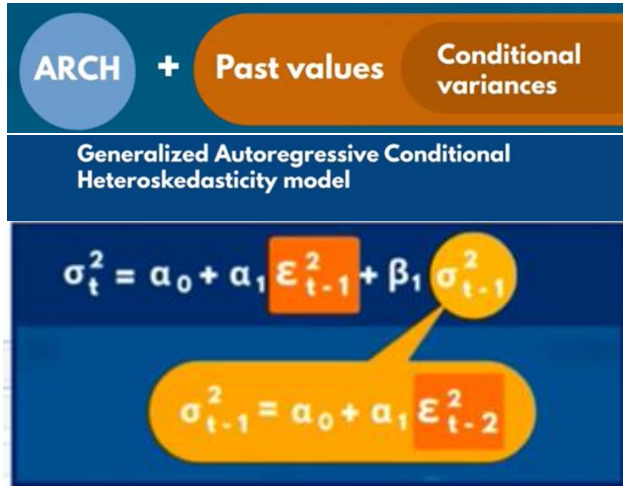
Mean Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
mu	0.0466	1.183e-02	3.939	8.187e-05	[2.342e-02,6.981e-02]

Volatility Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
omega	0.0109	3.004e-03	3.640	2.724e-04	[5.048e-03,1.682e-02]
alpha[1]	0.0835	1.071e-02	7.794	6.476e-15	[6.249e-02, 0.104]
beta[1]	0.9089	1.148e-02	79.168	0.000	[0.886, 0.931]

omega - lambda 0
alpha[1] - lambda 1
beta[1] - lambda 2



Keep in mind we are measuring and modelling volatility, rather than returns or prices