



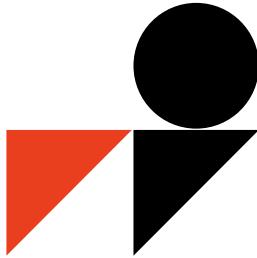
Covid-19, Stocks and Online Behaviors: a Time Series Analysis approach

Brocco Mattia
De Luca Chiara
Gianfrate Flavia



Goal of the project

Analyzing Time Series Data to investigate the effects of the pandemic on Stocks and Google Searches.



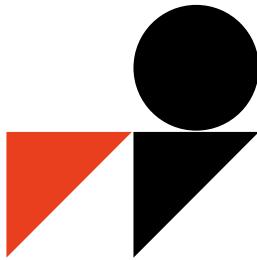
Research Questions

1. How the pandemic period has changed online behaviors?
2. Is there any relation between behavior (google trends) and Stocks during Covid-19?





Netflix, Amazon and Zoom. WHY?



- Some of the most used platforms during Covid-19 Lockdown.
- Give us informations about online behavior on shopping (Amazon), entertainment (Netflix) and social interactions (Zoom).

Stocks and Google Trends. WHY?

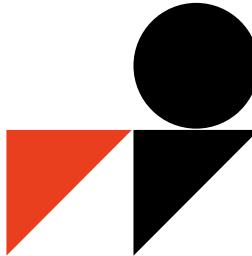
- Provide us informations with about how Covid-19 impacts on both macro-level (Stocks) and micro-level (Google Trends).





Data

Weekly Time Series from December 2017 to December 2022.



Three Companies: Netflix, Amazon, Zoom



Stocks



Google Trends

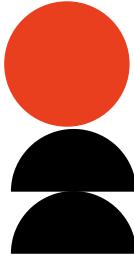


- Time Series of ADJ Close.
- NASDAQ. Currency in USD.
- Stocks:
Netflix, Inc. (NFLX),
Amazon.com, Inc. (AMZN),
Zoom Video Communications,
Inc. (ZM)

Source: Yahoo Finance

- Time Series of Google Trend Index. It measures the popularity of top search queries in Google Search. (Index with Range 0-100)
- Keywords: Netflix, Zoom, Amazon

Source: Google Trends

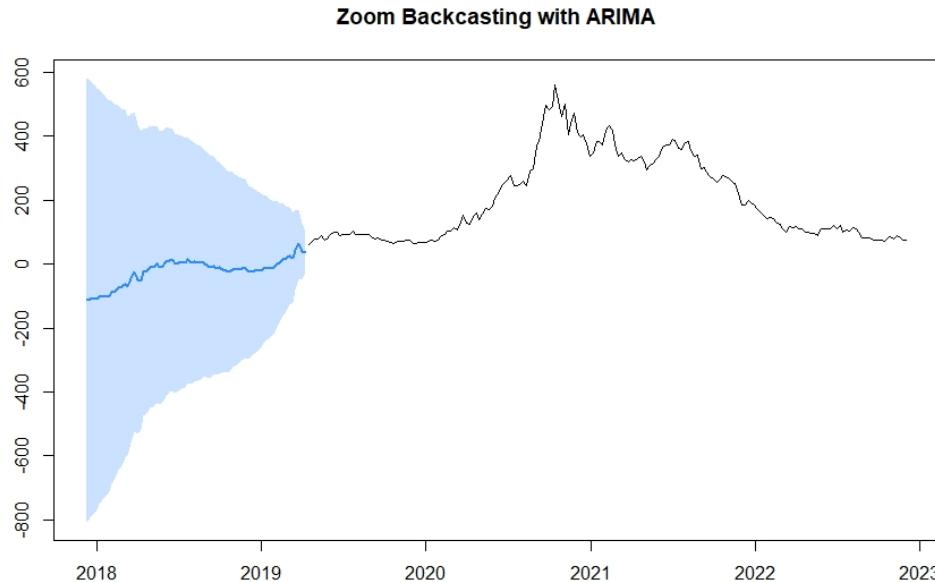




Data Preparation

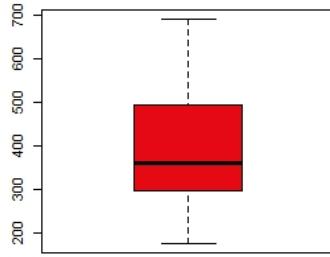
Acquire, combine and organize data to make them usable for the analysis.

Important step: same time window Zoom Backcasting

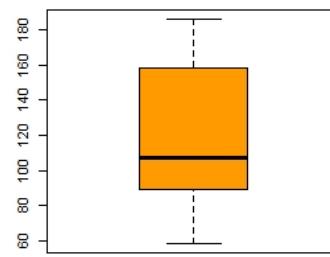


EDA - Boxplots

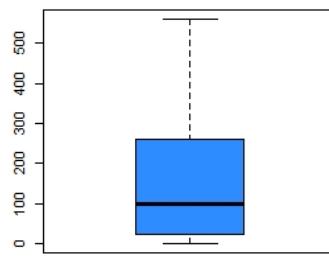
Netflix Stocks



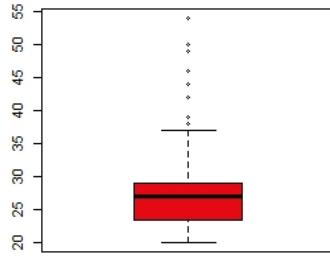
Amazon Stocks



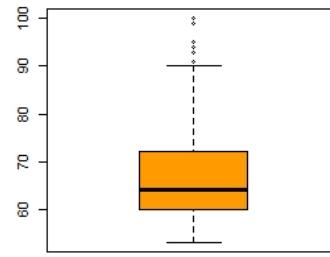
Zoom Stocks



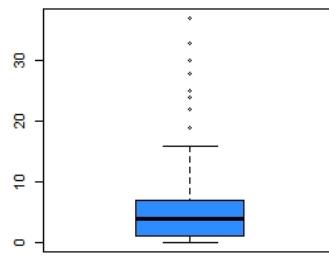
Netflix Trends



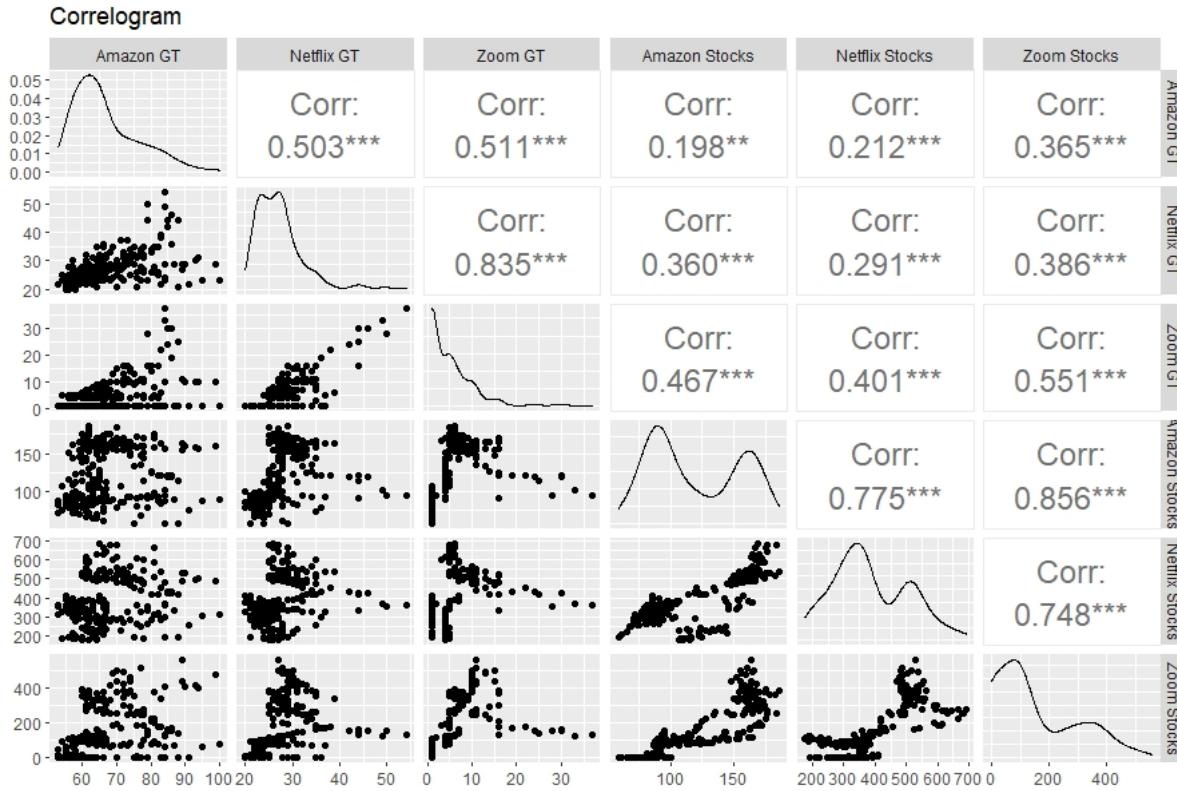
Amazon Trends



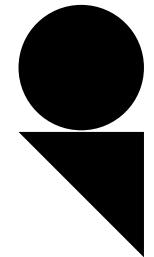
Zoom Trends



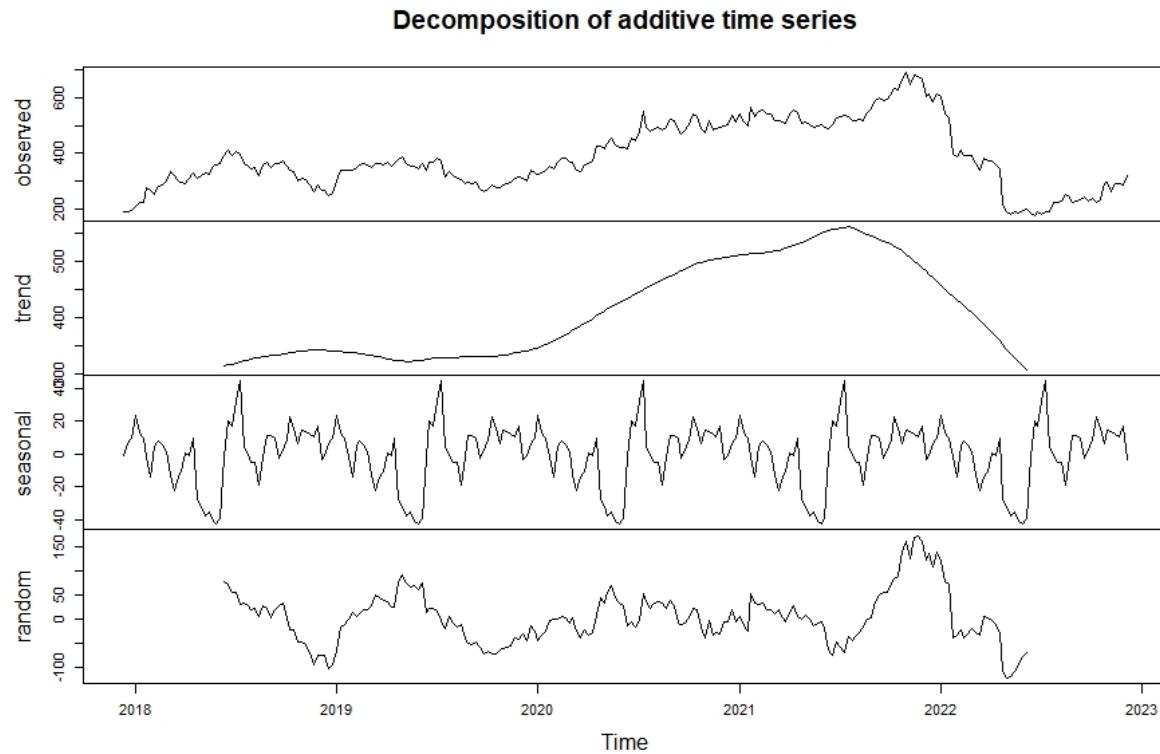
EDA - Correlogram



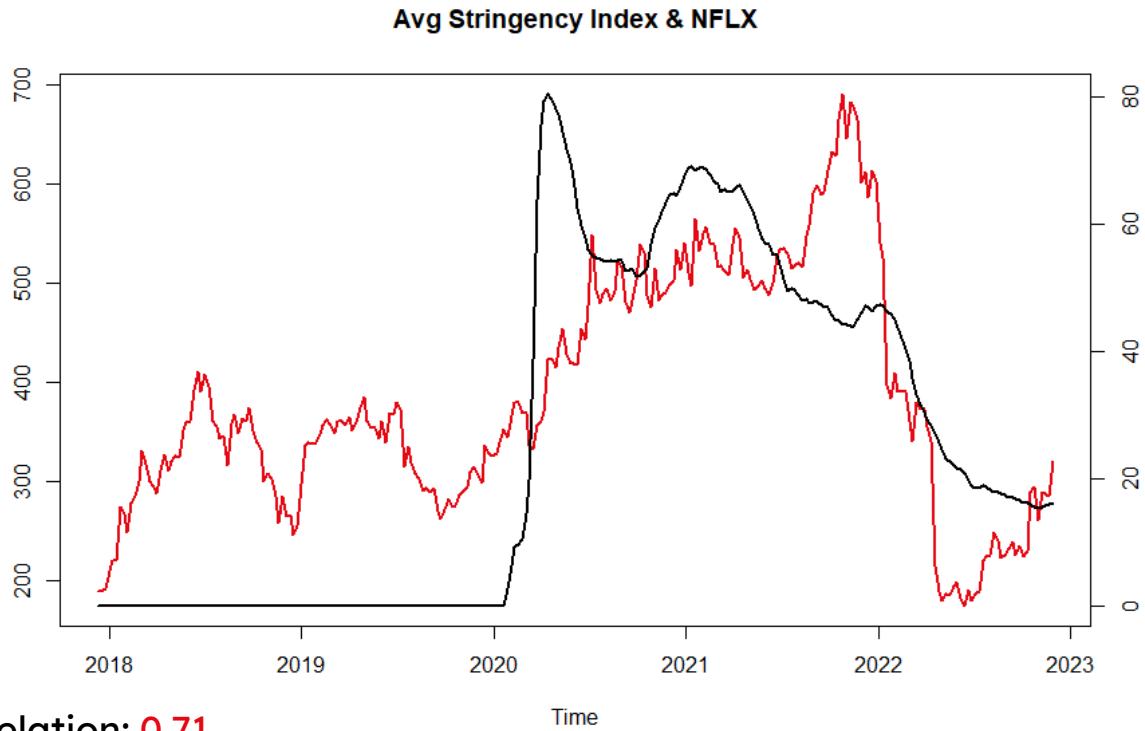
NETFLIX



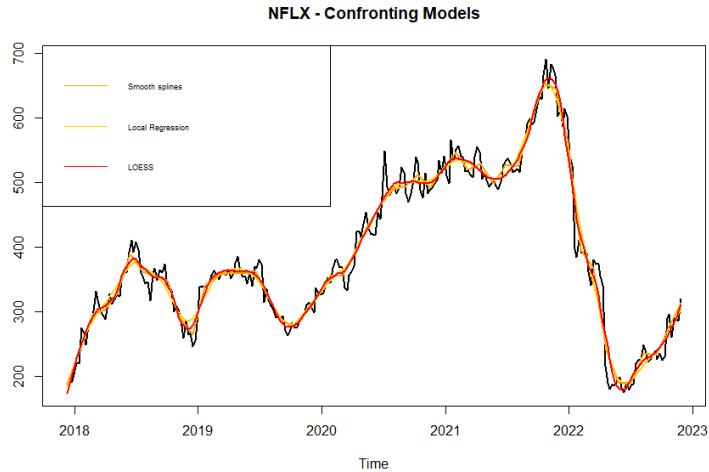
NFLX - Decomposition



NFLX - Relation with the pandemic

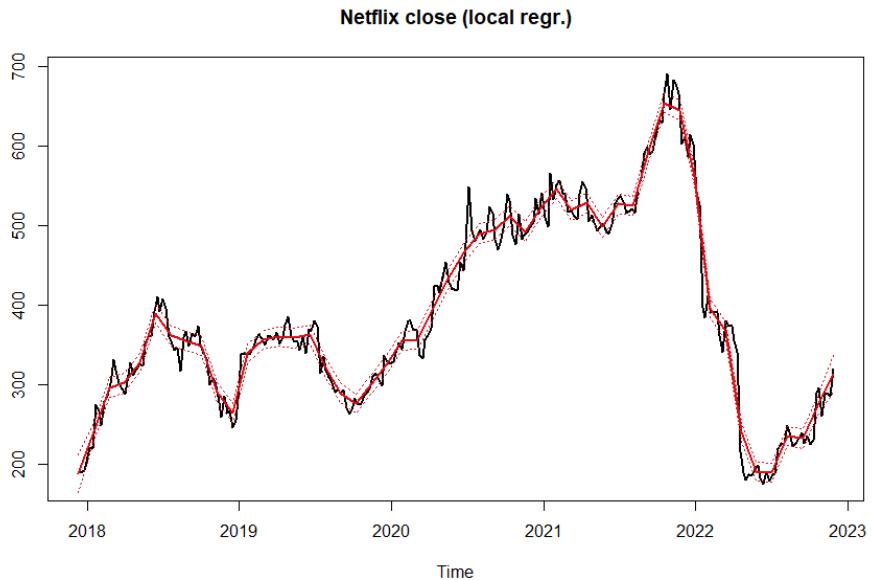


NFLX - Non parametric modelling



	Loess	Loc. Regr.	Spline
RMSE	19.498	19.002	21.485
MAPE	4.2%	3.9%	4.6%

NFLX - Non parametric modelling



Financial Events

- Birth of Disney+ (2019)
- Squid Game Release (9/2021)
- ESG Commitment (2022)

Other Events

- COVID-19 (2020)
- Rise/loss of subscribers (2020-2022)

Summary

Susceptible to Covid, Competitors trend and number of users

NFLX - TSLM

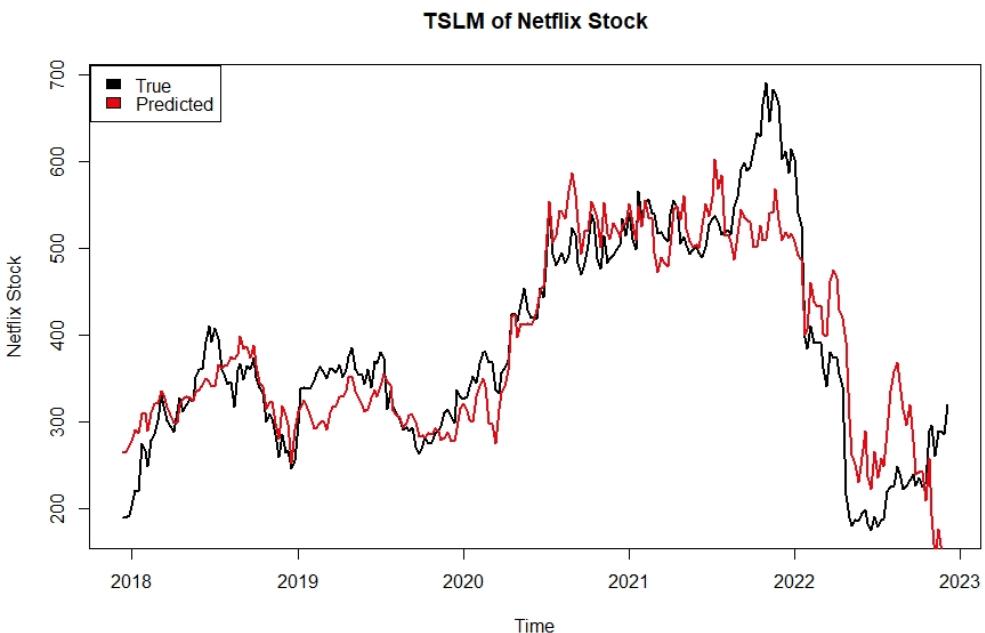
Predictor	p-value
Intercept	0.6815
Trend	< 2e-16 ***
Amazon stock	< 2e-16 ***
Netflix Trends	0.0269 *

Adjusted R-squared: 0.80

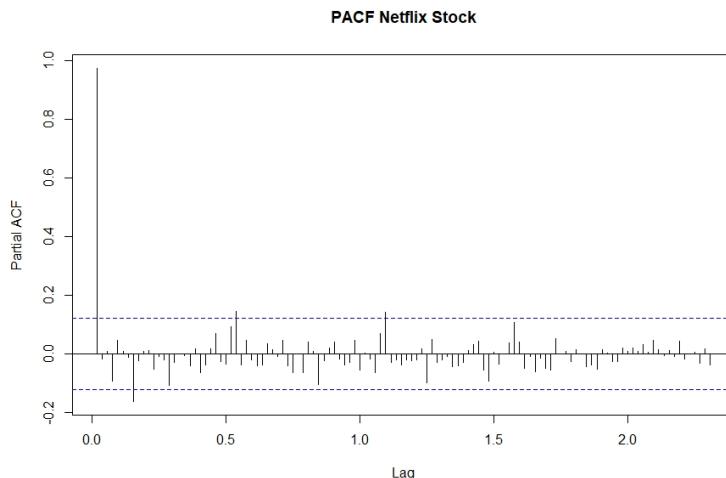
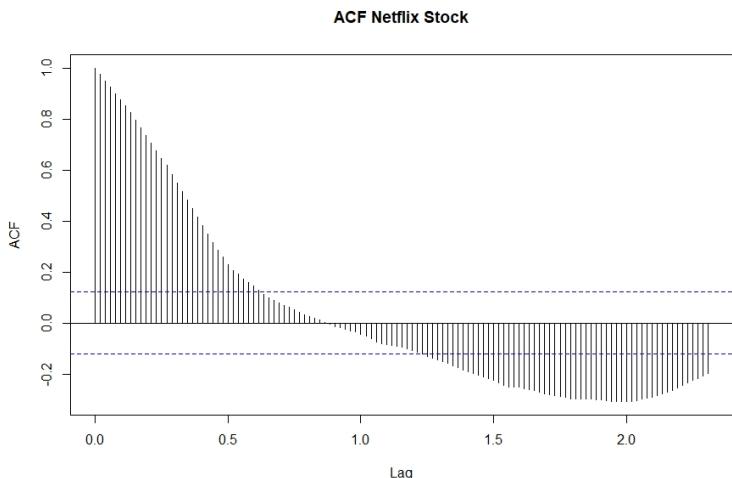
RMSE: 54.16

AIC: 2823.67

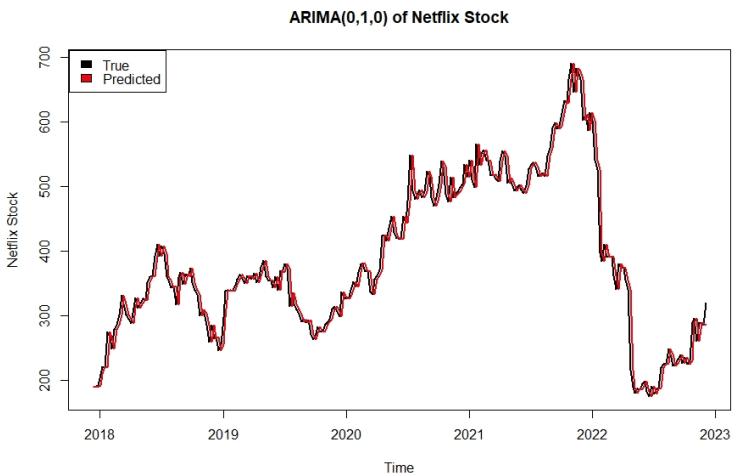
MAPE: 12.1%



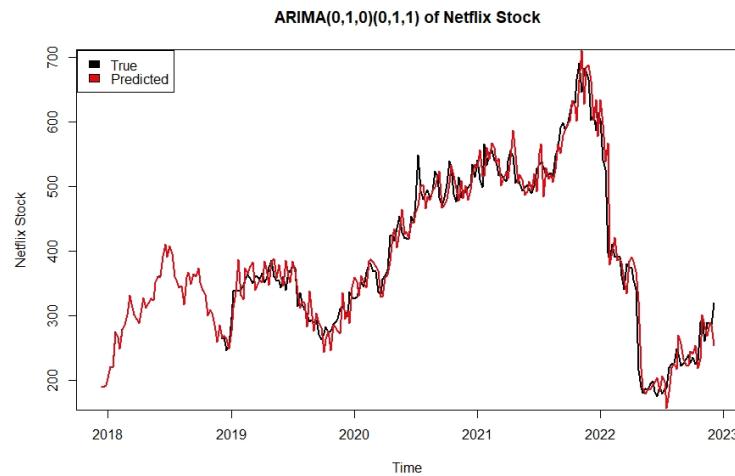
NFLX - Autocorrelations



NFLX – Auto ARIMA



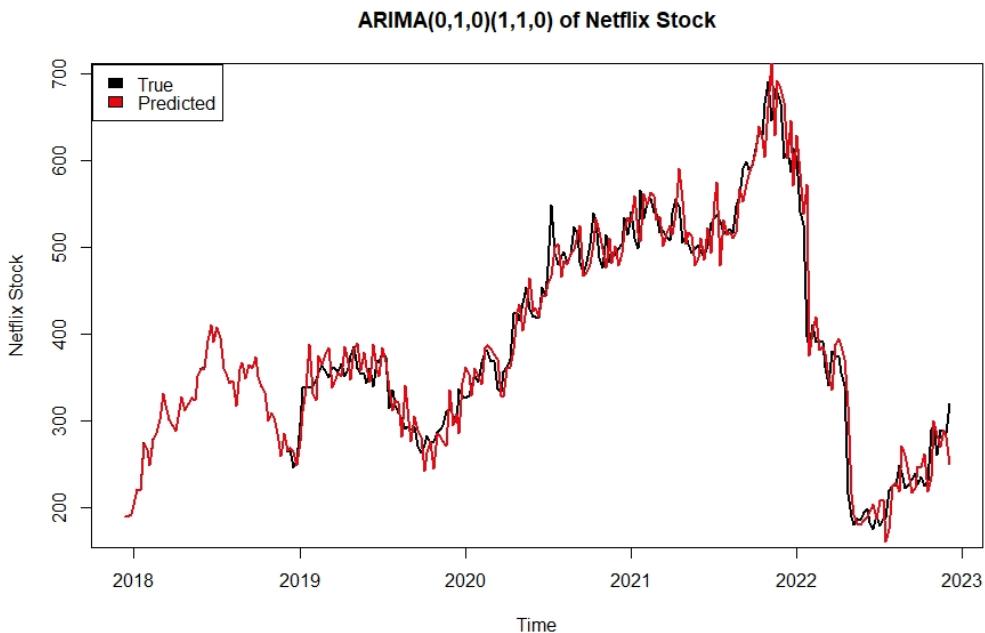
RMSE: 23.41
AIC: 2371.26
MAPE: 4.42%



RMSE: 24.84
AIC: 1985.96
MAPE: 4.25%

NFLX - SARIMA(0,1,0)(1,1,0)

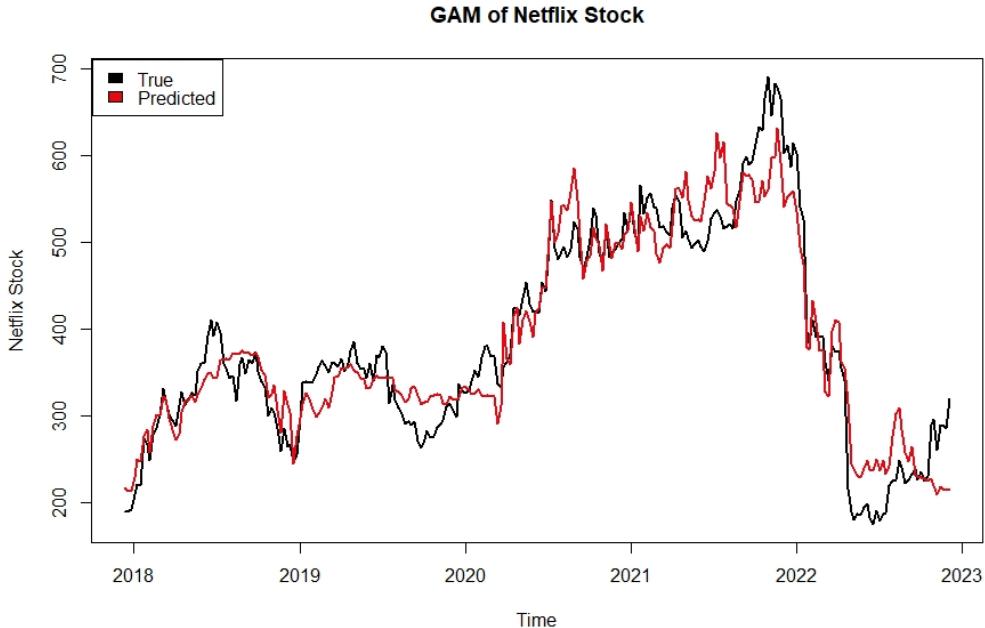
RMSE: 25.78
AIC: 1992.83
MAPE: 4.46%



NFLX - GAM

$$\text{NFLX} \sim \text{lo}(tt) + \text{lo}(AMZN) + \text{lo}(ZM) + \text{lo}(ZoomGT)$$

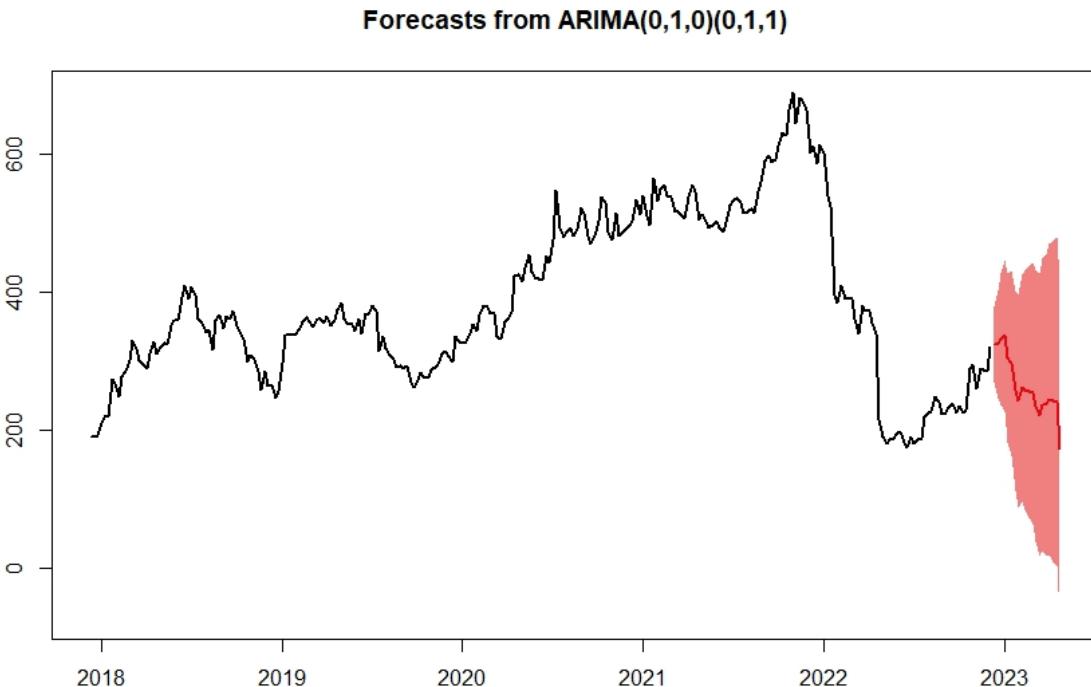
RMSE: 37.96
AIC: 2663.05
MAPE: 8.44%



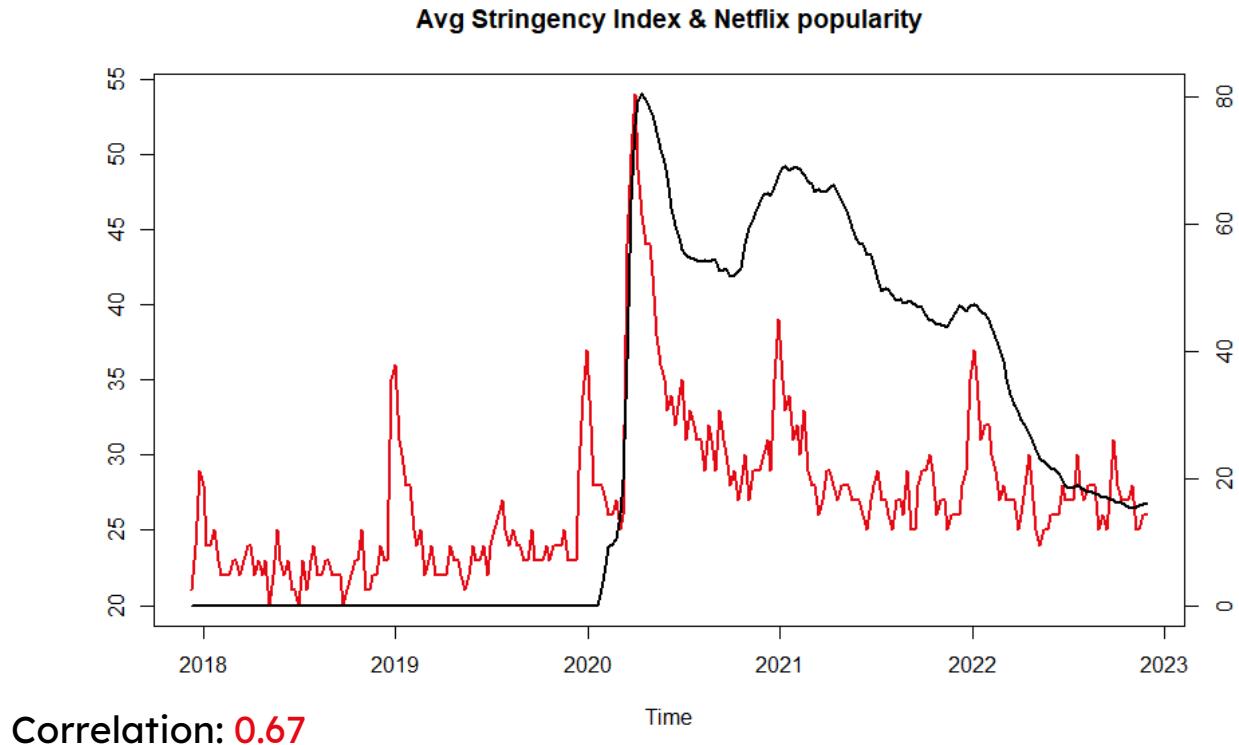
NFLX - Summary

Model	AIC	RMSE	MAPE
TSLM	2823.67	54.16	12.06%
ARIMA(4,1,0)	2373.54	23.15	4.42%
auto.ARIMA(0,1,0)	2371.26	23.41	4.42%
auto.ARIMA(0,1,0)(0,1,1)	1985.96	24.84	4.25%
SARIMA(0,1,0)(1,1,0)	1992.83	25.78	4.46%
GAM	2663.05	37.96	8.44%

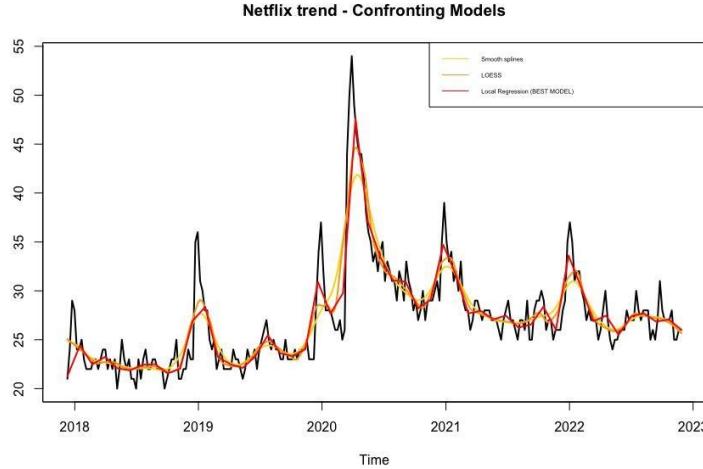
NFLX - Forecasting



Netflix GT - Relation with the pandemic

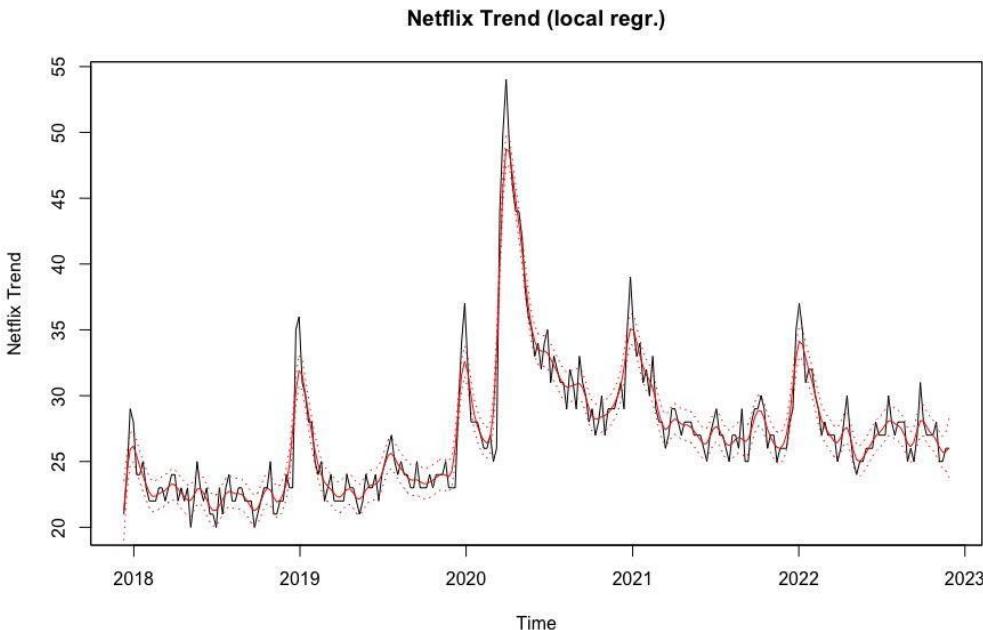


Netflix GT - Non parametric modelling



	Loess	Loc. Regr.	Spline
RMSE	2.479	1.34	2.527
MAPE	5%	3.2%	5.7%

Netflix GT - Non parametric modelling



Recurrent Events

- Christmas
- Netflix Series Release

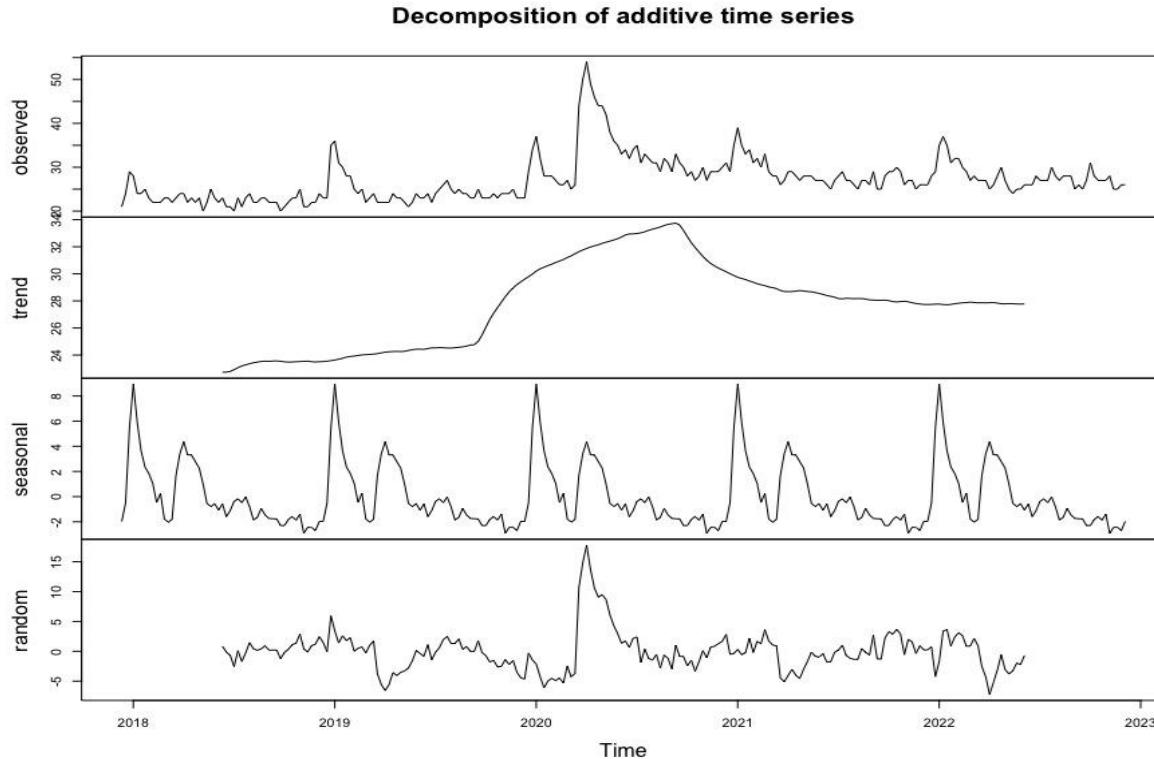
Significant Events

- COVID-19 (2020)
- Loss of subscribers
(from 2020)

Summary

Susceptibility to Netflix Releases and number of users

Netflix GT - Decomposition



Netflix GT - TSLM

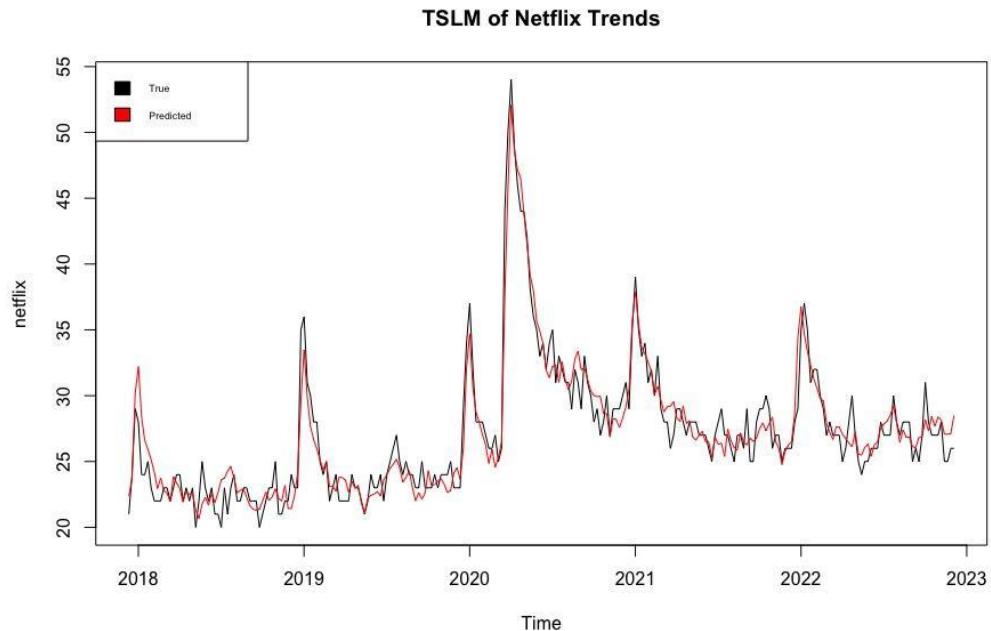
Predictor	p-value
Intercept	0.036 *
Trend	4.38e-11 ***
Amazon stock	0.003285 **
Seasonality	< 2e-16 ***
Netflix Stock	0.000382 ***
Zoom Stock	0.000235 ***
Zoom Trends	< 2e-16 ***
Amazon Trends	3.18e-05 ***

Adjusted R-squared: 0.89

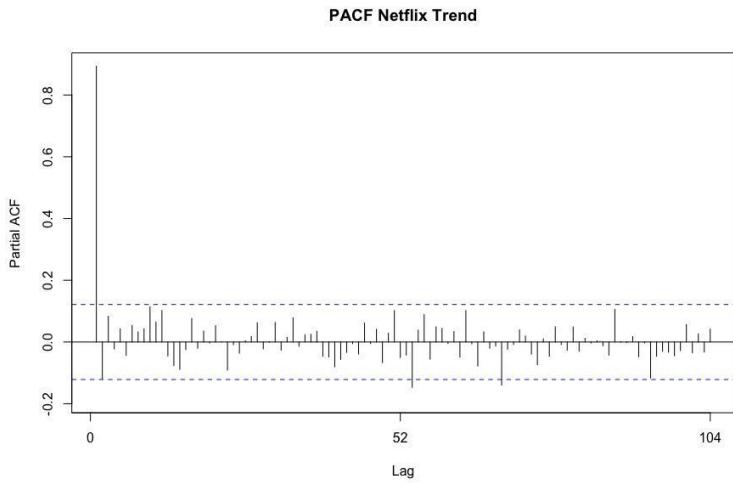
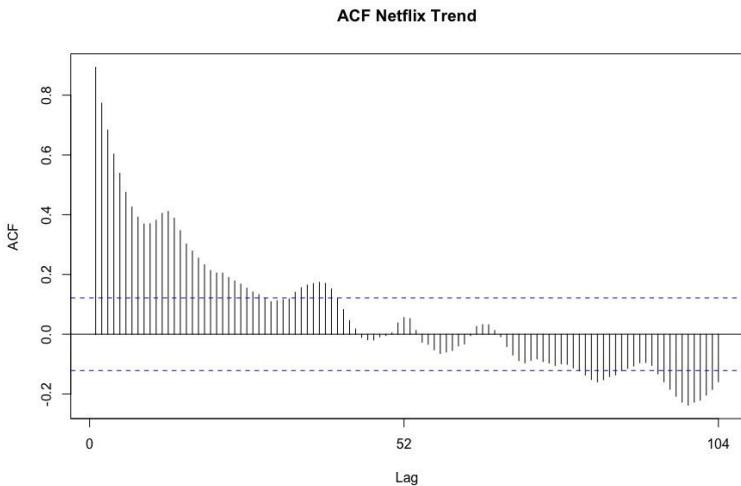
RMSE: 1.58

AIC: 1081.25

MAPE: 4.2%

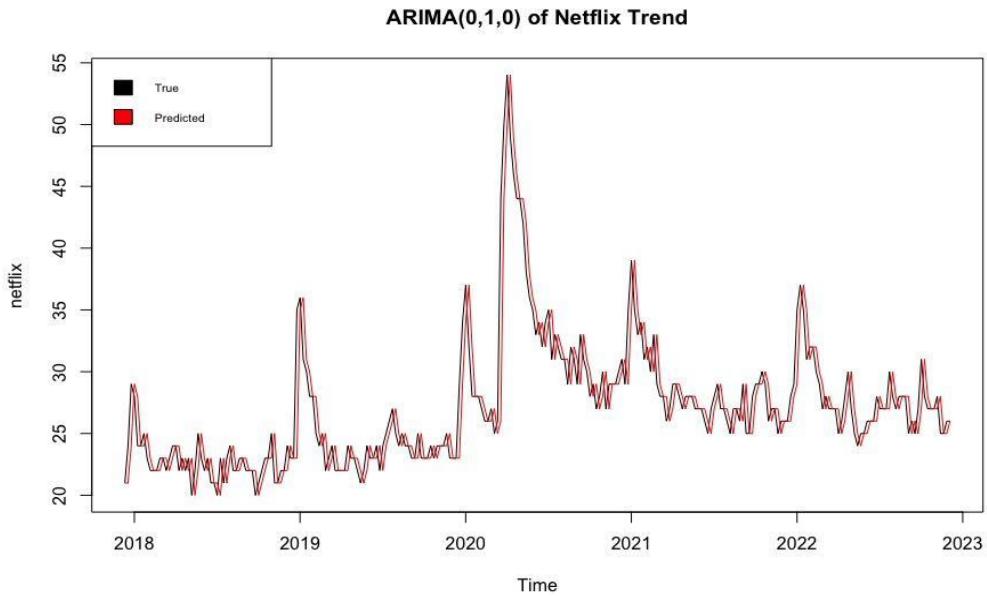


Netflix GT - Autocorrelations



Netflix GT - auto.ARIMA

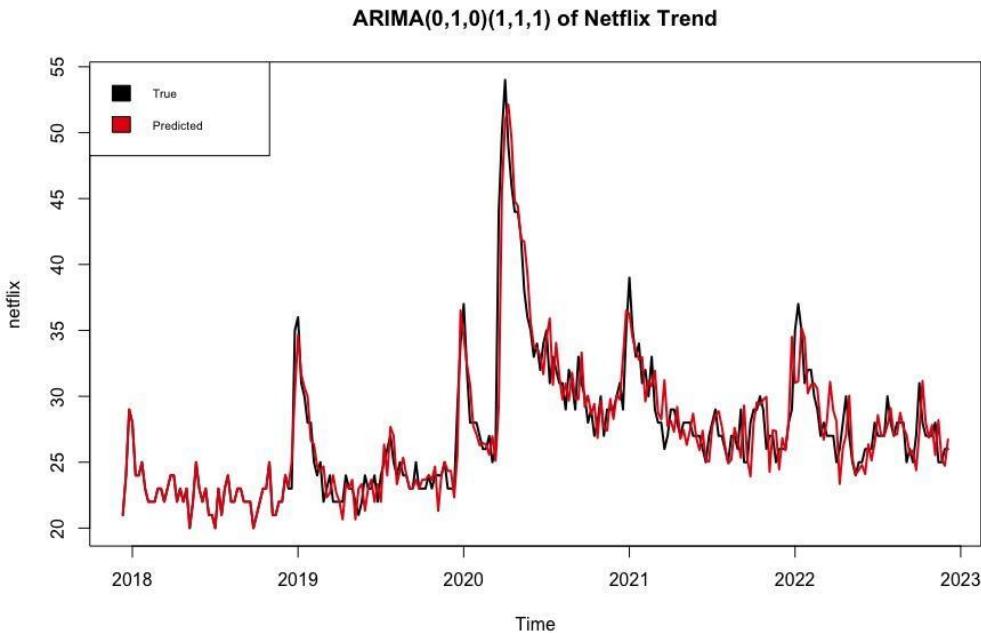
RMSE: 2.3607
AIC: 1182.957
MAPE: 5.4%



Translated Series → Lack of Seasonality in the model!

Netflix GT - SARIMA(0,1,0)(1,1,1)

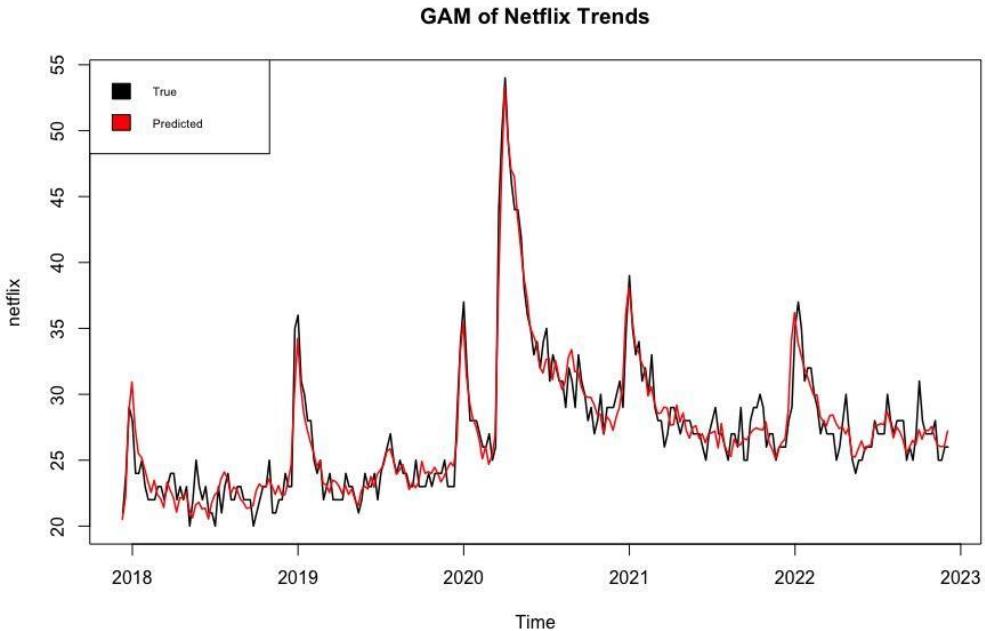
RMSE: 1.9172
AIC: 1002.251
MAPE: 4.12%



Netflix GT - GAM

NFLX ~ seas+lo(tt)+lo(NetflixStock)+lo(ZoomStock)+lo(ZoomTrend)+lo(AmazonTrend)

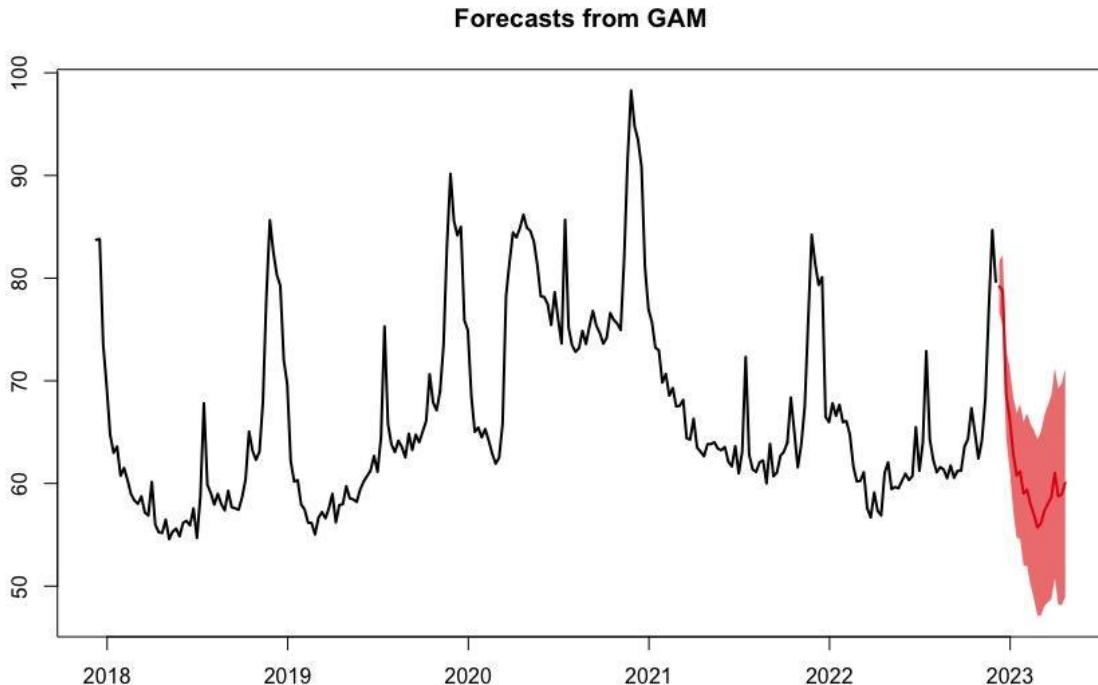
RMSE: 1.397
AIC: 1056.377
MAPE: 4%

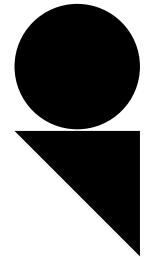


Netflix GT - Summary

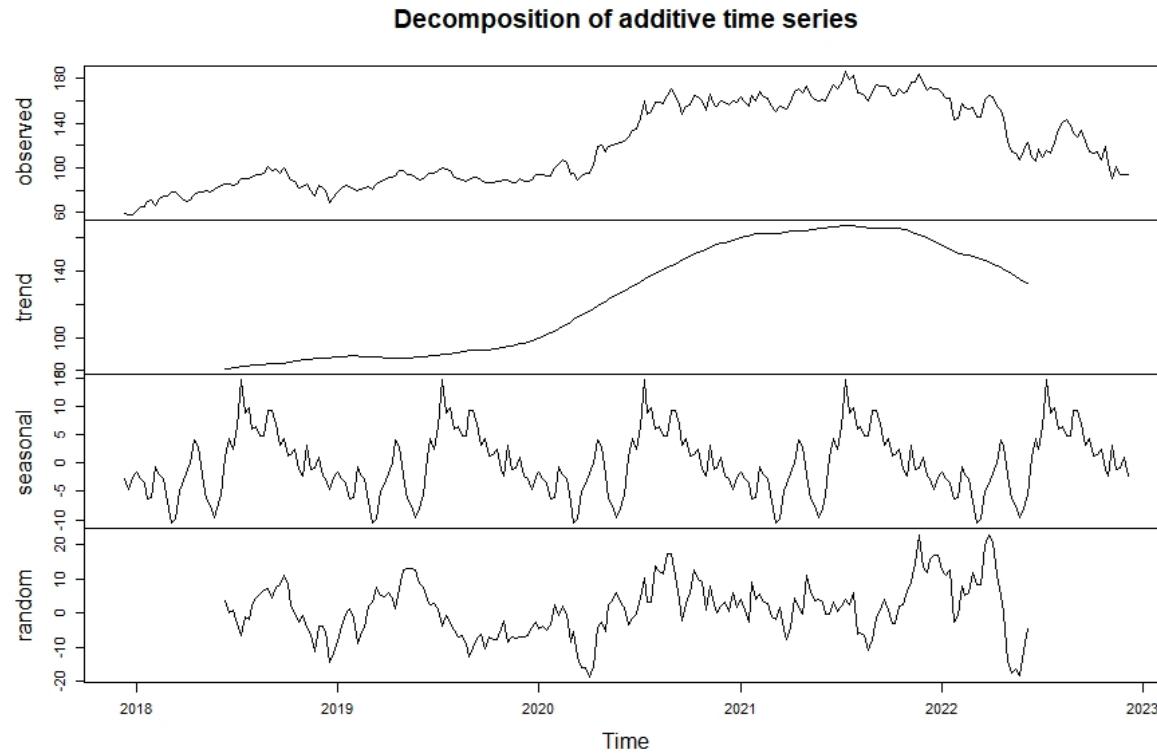
Model	AIC	RMSE	MAPE
TSLM	1081.25	1.58	4.2%
auto.ARIMA(0,1,0)	1182.957	2.36	5.4%
SARIMA(0,1,0)(1,1,1)	1002.251	1.9172	4.12%
GAM	1056.377	1.397	3.9%

Netflix GT - Forecasting

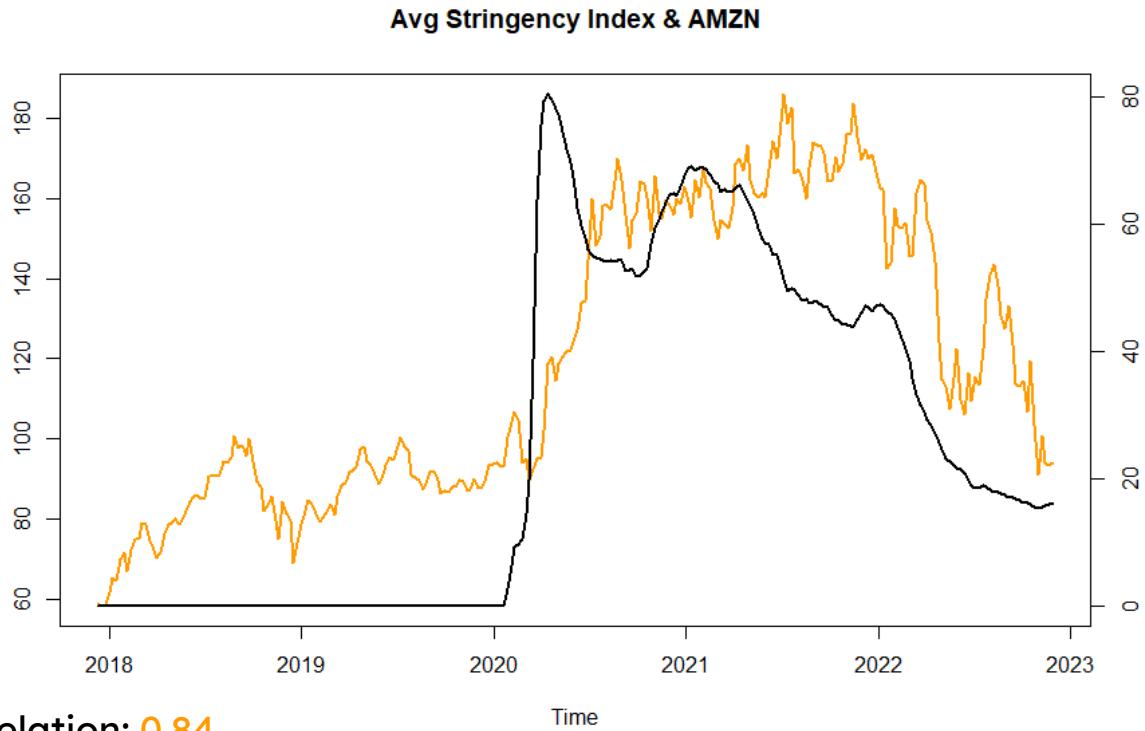




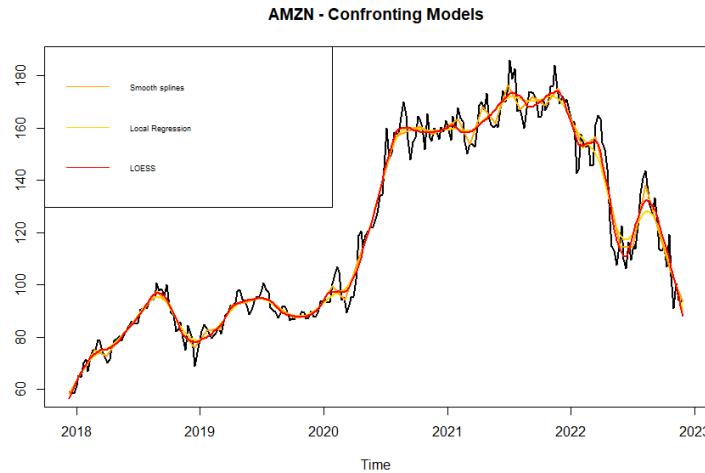
AMZN - Decomposition



AMZN - Relation with the pandemic

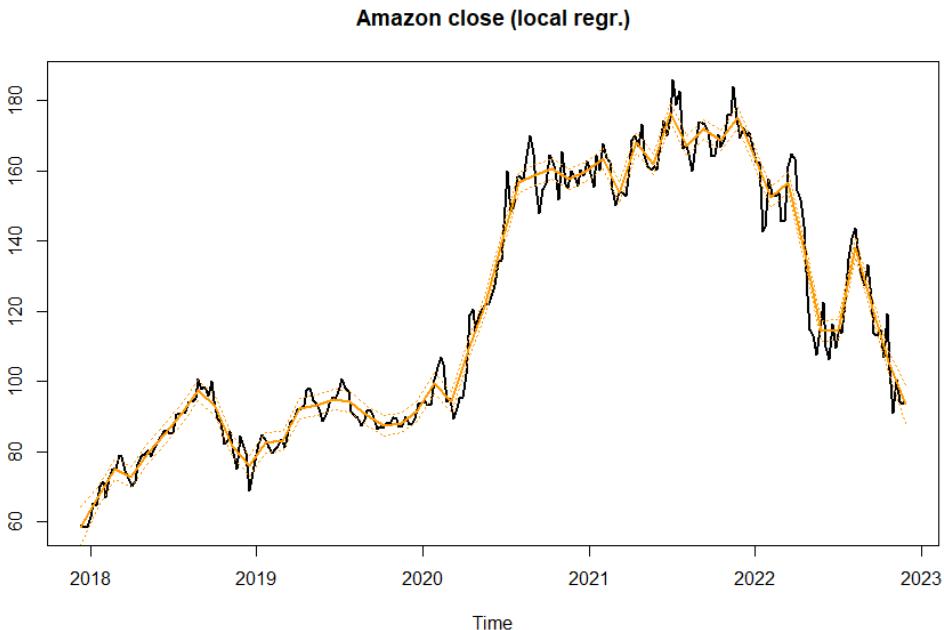


AMZN - Non parametric modelling



	Loess	Loc. Regr.	Spline
RMSE	4.931	4.726	5.487
MAPE	3.2%	2.9%	3.4%

AMZN - Non parametric modelling



Financial Events

- Increase in subscription
- Agreement to stream UEFA Champions League (Q3 2021)
- Partnership with Salesforce (Q2 2021)

Other Events

- COVID-19 (2020)
- Price of the actions is not too much influenced by all the subsequent waves

NOTE

Fiscal year corresponds to the calendar year.

AMZN - TSLM

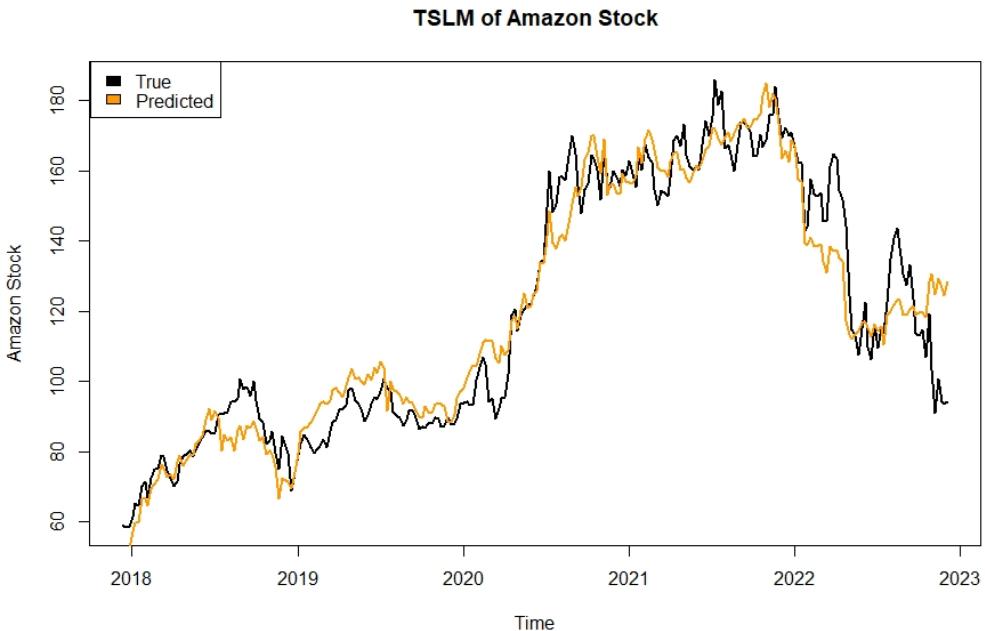
Predictor	p-value
Intercept	< 2e-16 ***
Trend	< 2e-16 ***
Netflix stock	< 2e-16 ***
Zoom stock	< 2e-16 ***
Amazon gt	6.23e-05 ***

Adjusted R-squared: 0.92

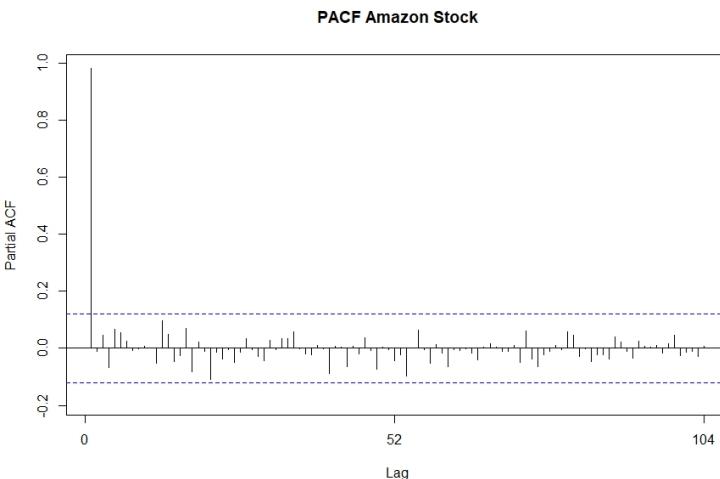
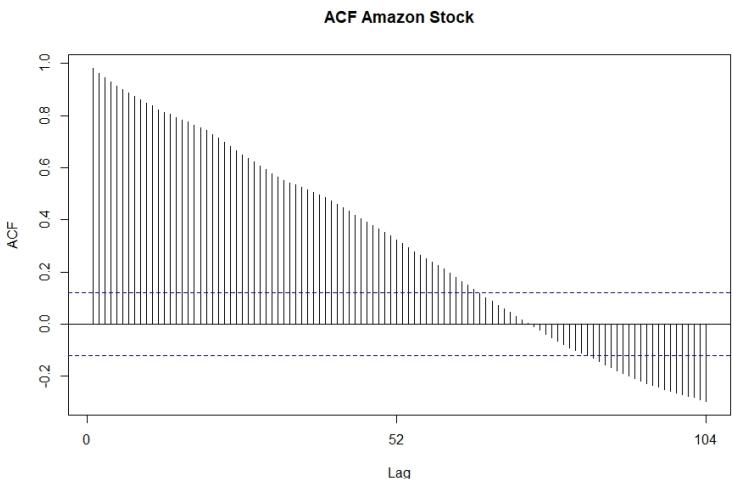
RMSE: 9.73

AIC: 1932.94

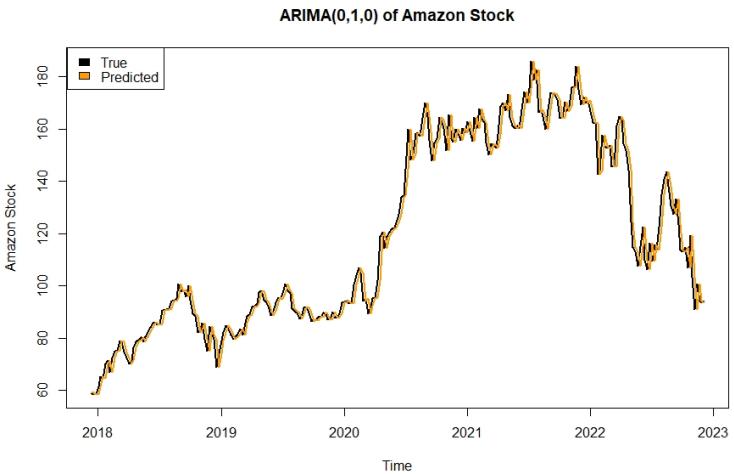
MAPE: 6.47%



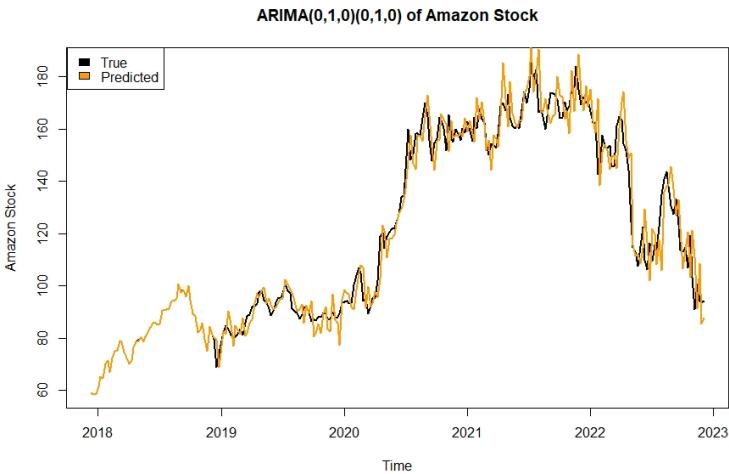
AMZN - Autocorrelations



AMZN - auto.ARIMA



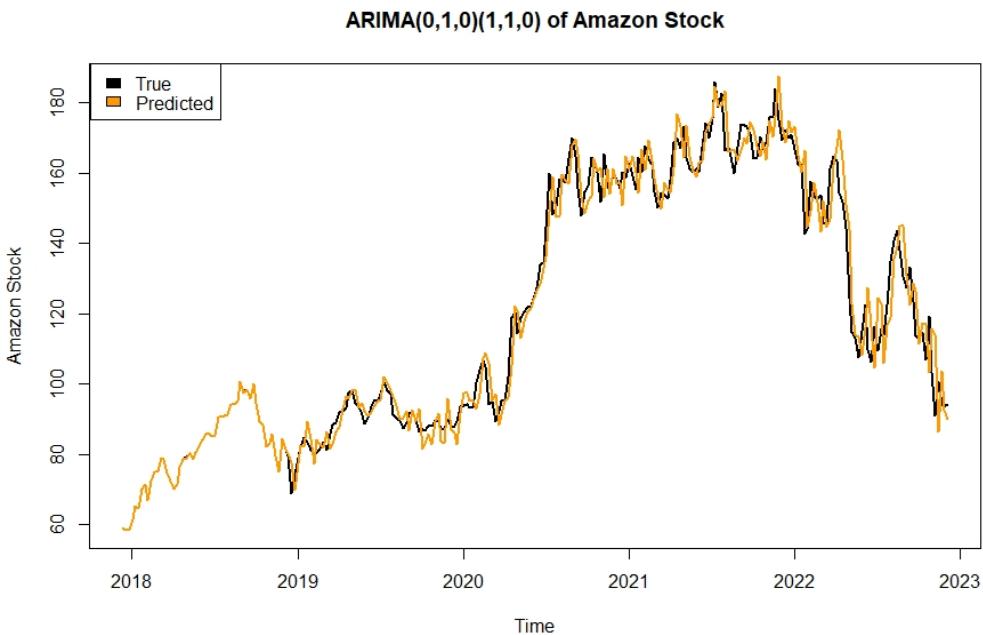
RMSE: 5.59
AIC: 1630.33
MAPE: 3.44%



RMSE: 7.08
AIC: 1447.18
MAPE: 3.77%

AMZN - SARIMA(0,1,0)(1,1,0)

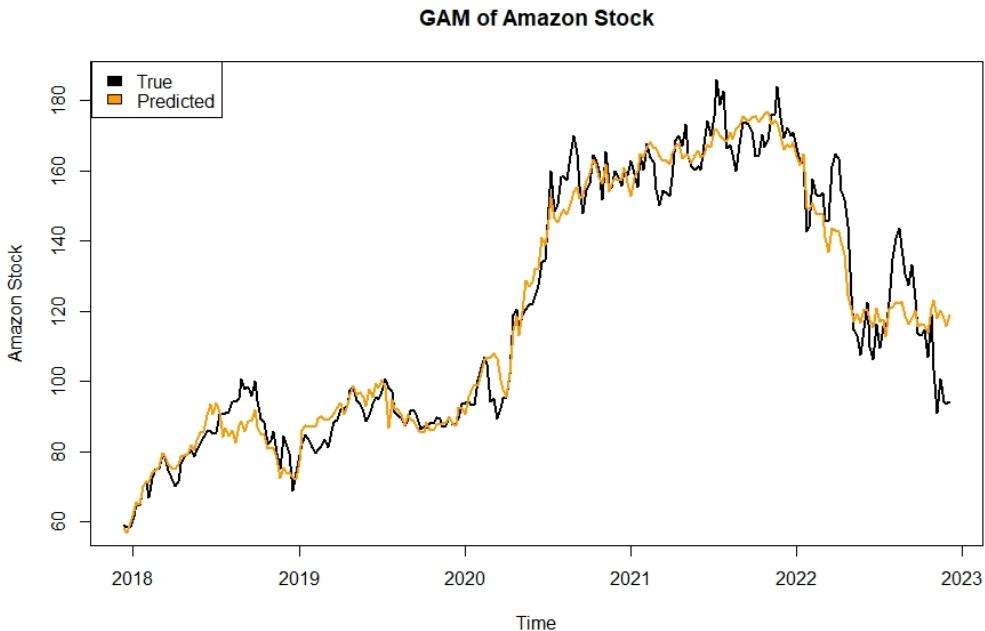
RMSE: 6.06
AIC: 1402.35
MAPE: 3.26%



AMZN - GAM

AMZN ~ s(tt) + s(NFLX) + s(ZM) + s(ZoomGT) + s(AmazonGT) + s(NetflixGT)

RMSE: 7.46
AIC: 1834.68
MAPE: 4.57%



AMZN - Summary

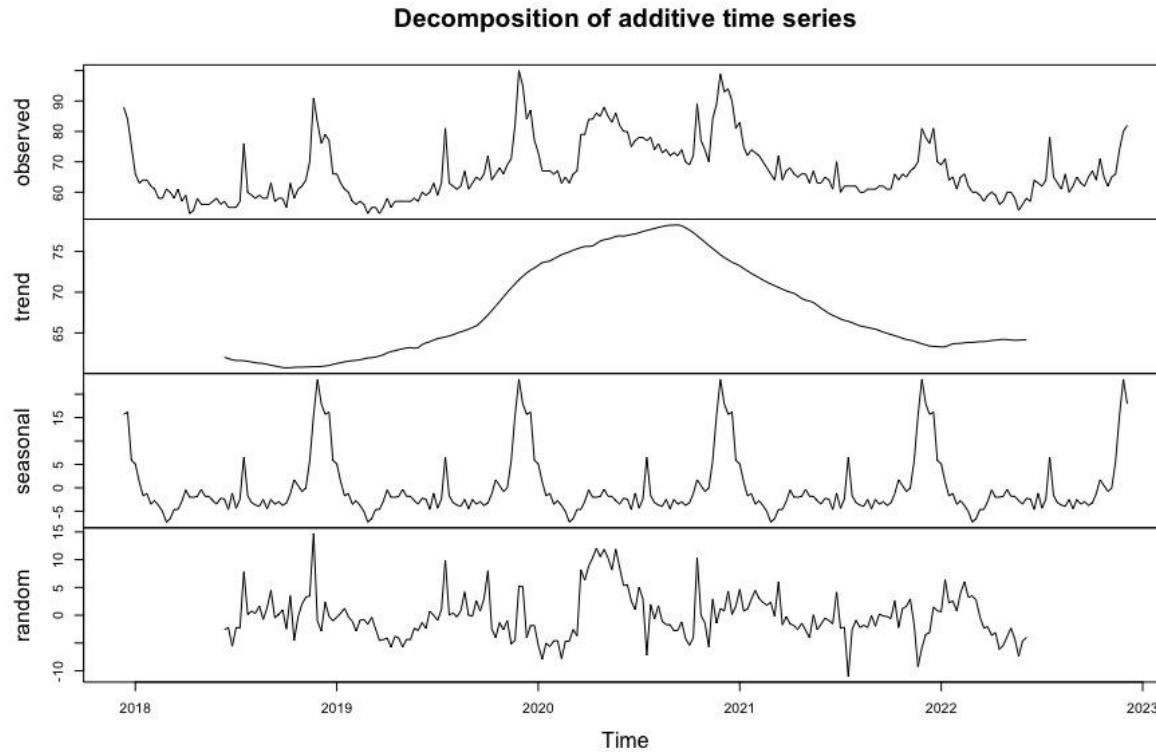
Model	AIC	RMSE	MAPE
TSLM	1932.94	9.73	6.47%
auto.ARIMA(0,1,0)	1630.33	5.59	3.44%
auto.ARIMA(0,1,0)(0,1,0)	1447.18	7.08	3.77%
SARIMA(0,1,0)(1,1,0)	1402.35	6.06	3.26%
GAM	1834.68	7.46	4.57%

AMZN - Forecasting

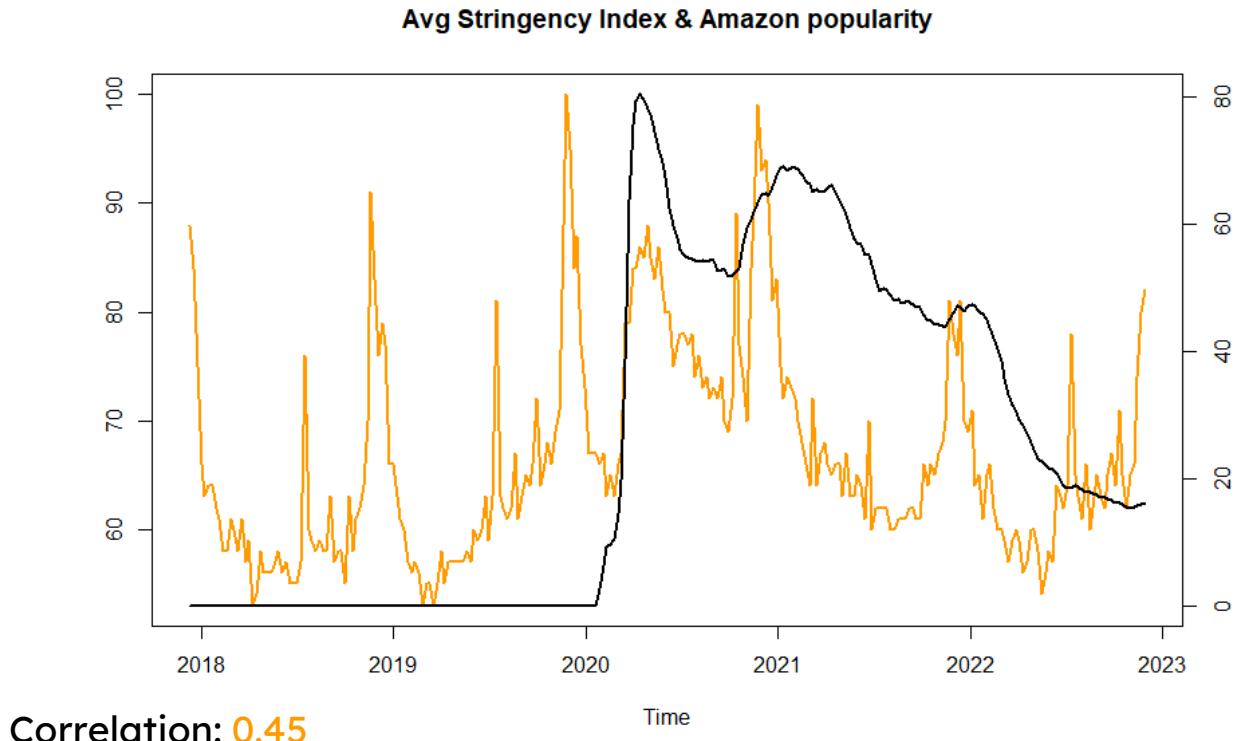
Forecasts from ARIMA(0,1,0)(1,1,0)



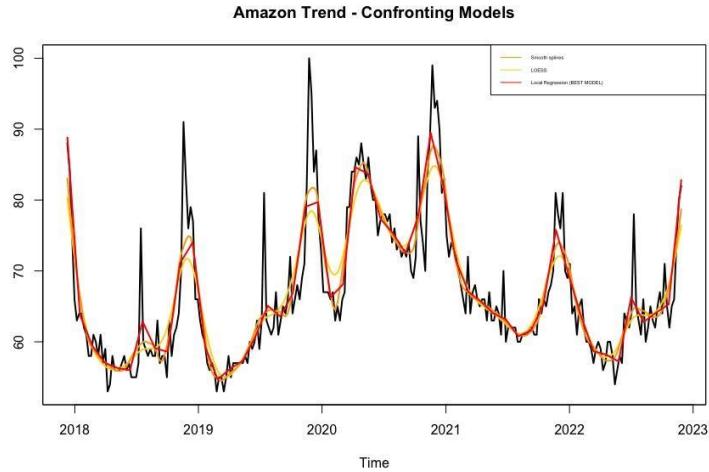
Amazon GT - Decomposition



Amazon GT - Relation with the pandemic

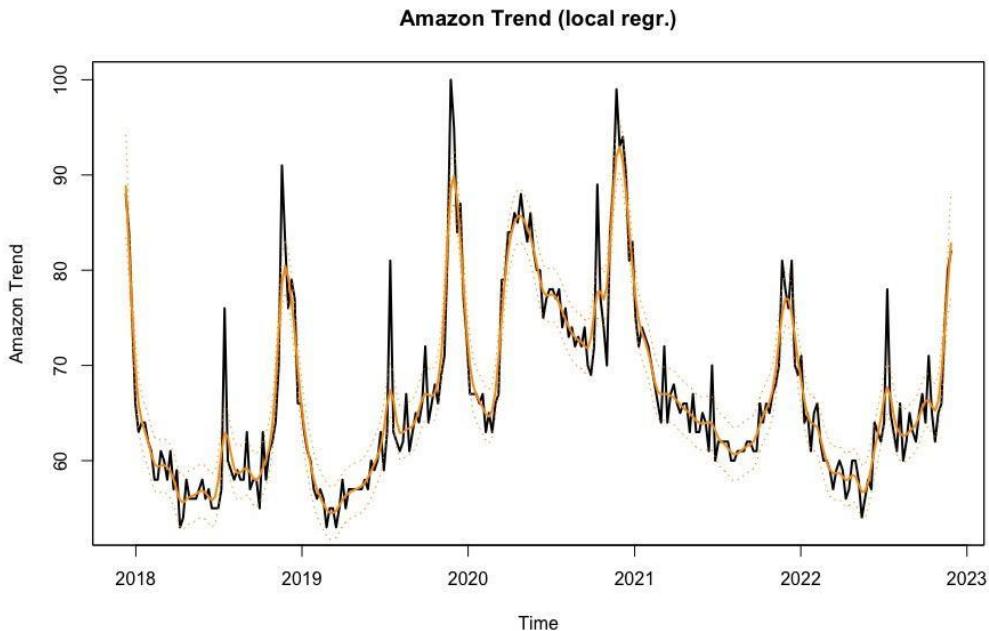


Amazon GT - Non parametric modelling



	Loess	Loc. Regr.	Spline
RMSE	6.526	2.772	4.535
MAPE	5%	2.6%	4.3%

Amazon GT - Non parametric modelling



Seasonal Events

- Christmas
- Black Friday
- Amazon Prime Day

Significant Events

- COVID-19 (2020)

Summary

Very susceptible to seasonality and marketing

Amazon GT - TSLM

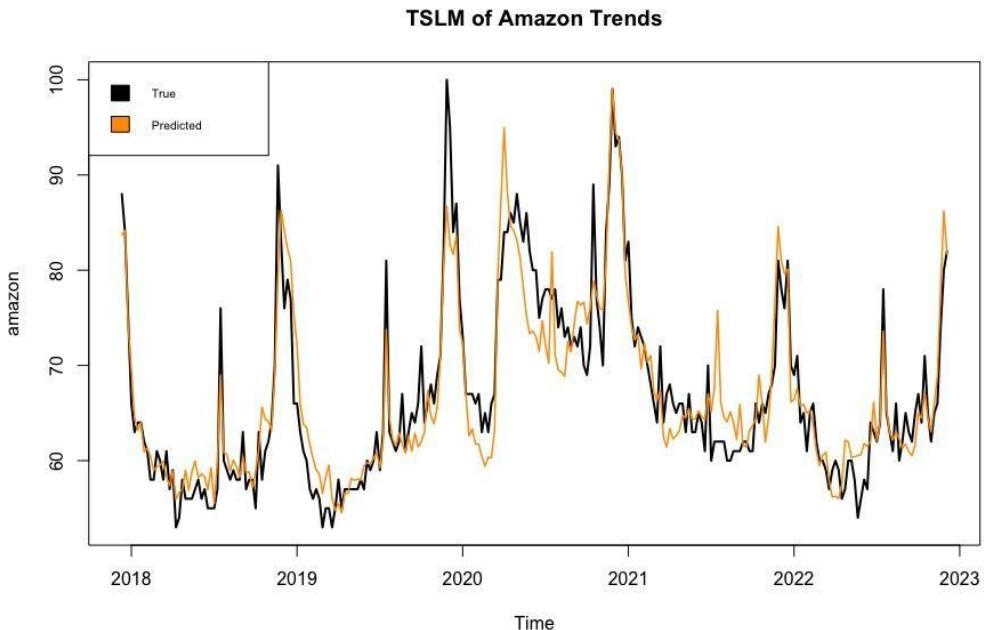
Predictor	p-value
Intercept	< 2e-16 ***
Trend	0.00159 **
Netflix stock	0.00240 **
Zoom stock	7.26e-07 ***
Netflix gt	3.18e-05 ***

Adjusted R-squared: **0.92**

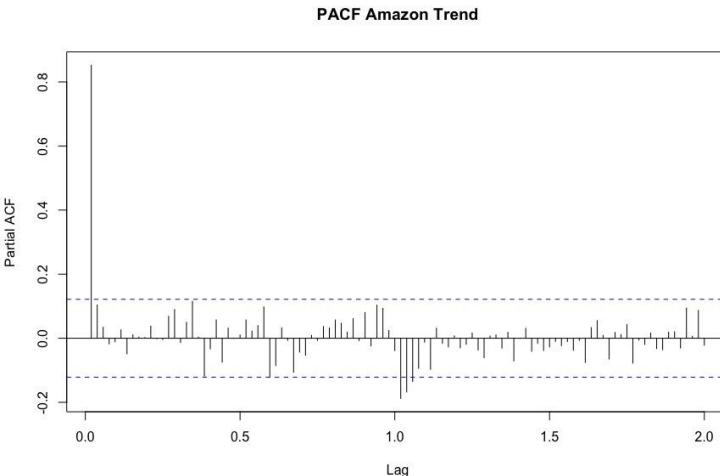
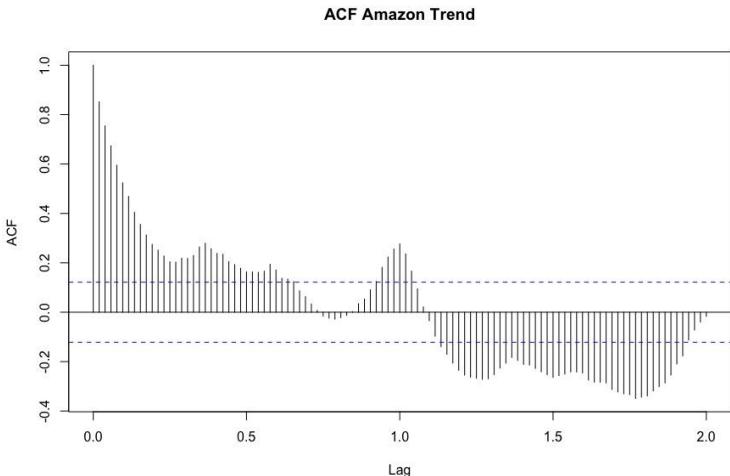
RMSE: **3.81**

AIC: **1552.26**

MAPE: **4%**

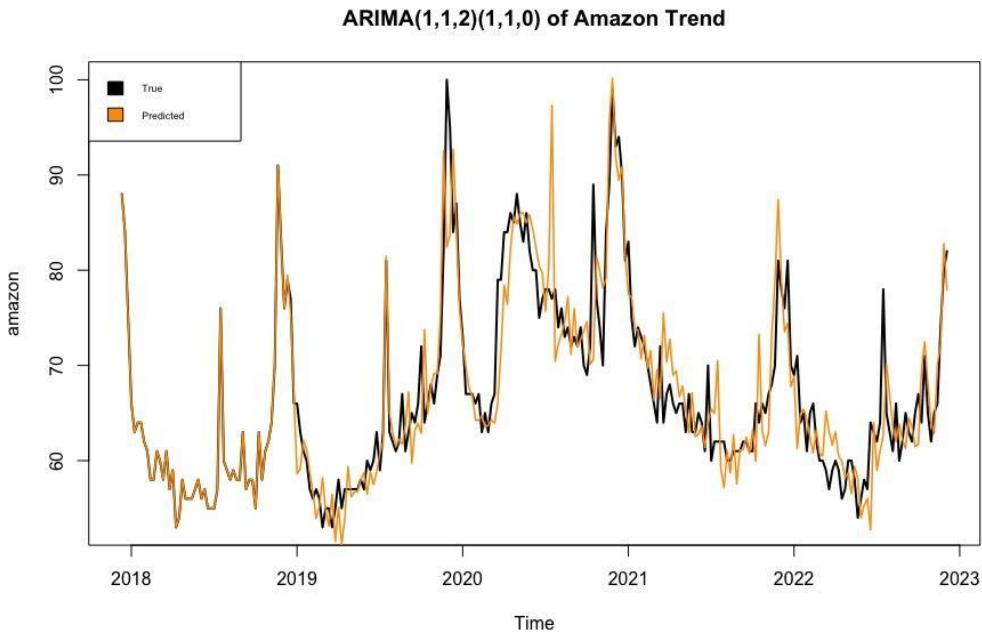


Amazon GT - Autocorrelations



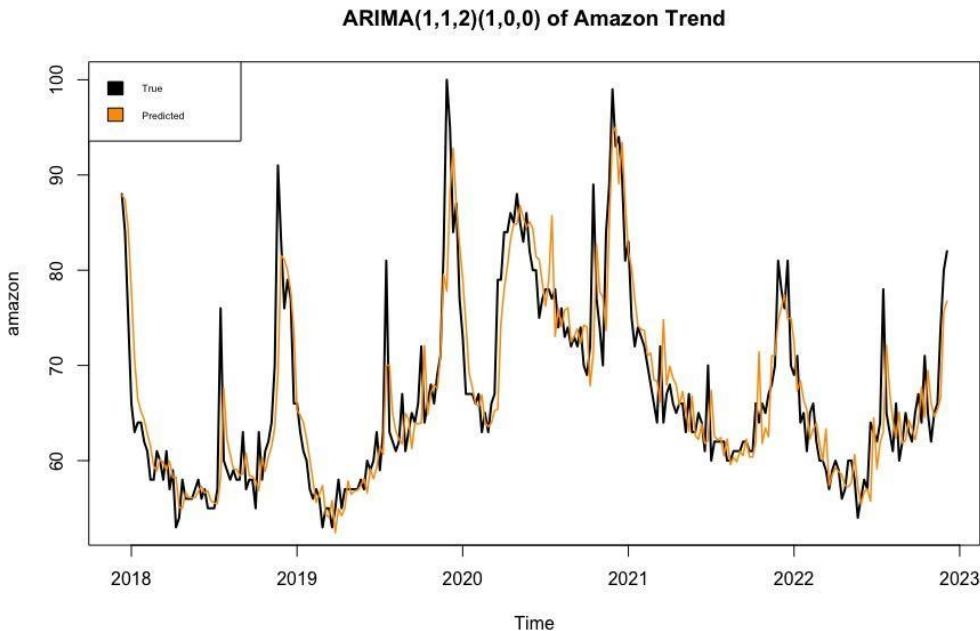
Amazon GT - auto.ARIMA

RMSE: 4.193
AIC: 1250.196
MAPE: 3.87%



Amazon GT - SARIMA(1,1,2)(1,0,0)

RMSE: 4.566
AIC: 1542.548
MAPE: 4.52%

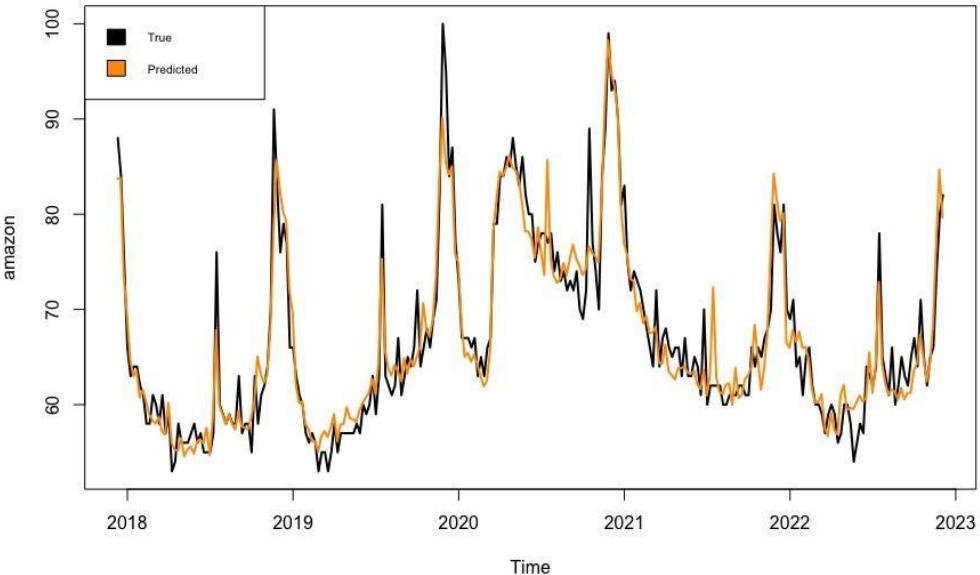


Amazon GT - GAM

AMZN ~ $\text{lo}(\text{tt}) + \text{lo}(\text{AmazonStock}) + \text{lo}(\text{ZoomStock}) + \text{lo}(\text{AmazonTrend}) + \text{lo}(\text{NetflixStock}) + \text{lo}(\text{NetflixTrend}) + \text{lo}(\text{ZoomTrend})$

GAM of Amazon Trend

RMSE: 2.94
AIC: 1450.783
MAPE: 3.2%

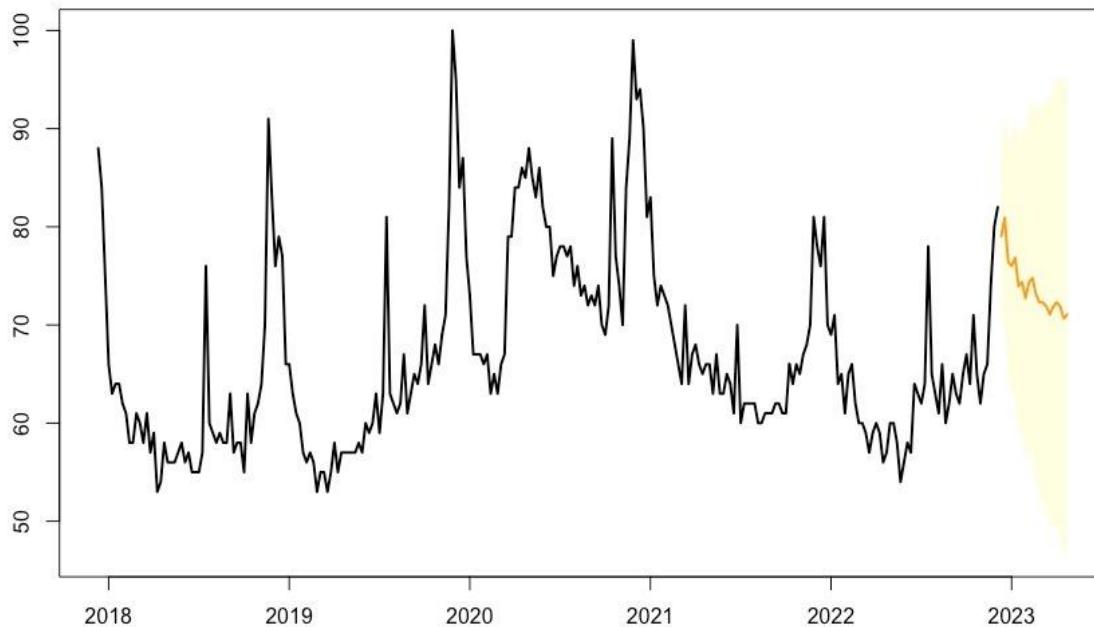


Amazon GT - Summary

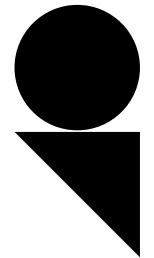
Model	AIC	RMSE	MAPE
TSLM	1552.26	3.81	4%
auto.ARIMA(1,1,2)(1,1,0)	1250.196	4.193	3.87%
ARIMA(1,1,2)(1,0,0)	1542.548	4.566	4.52%
GAM	1450.783	2.94	3.2%

Amazon GT - Forecasting

Forecasts from ARIMA(1,1,2)(1,1,0)

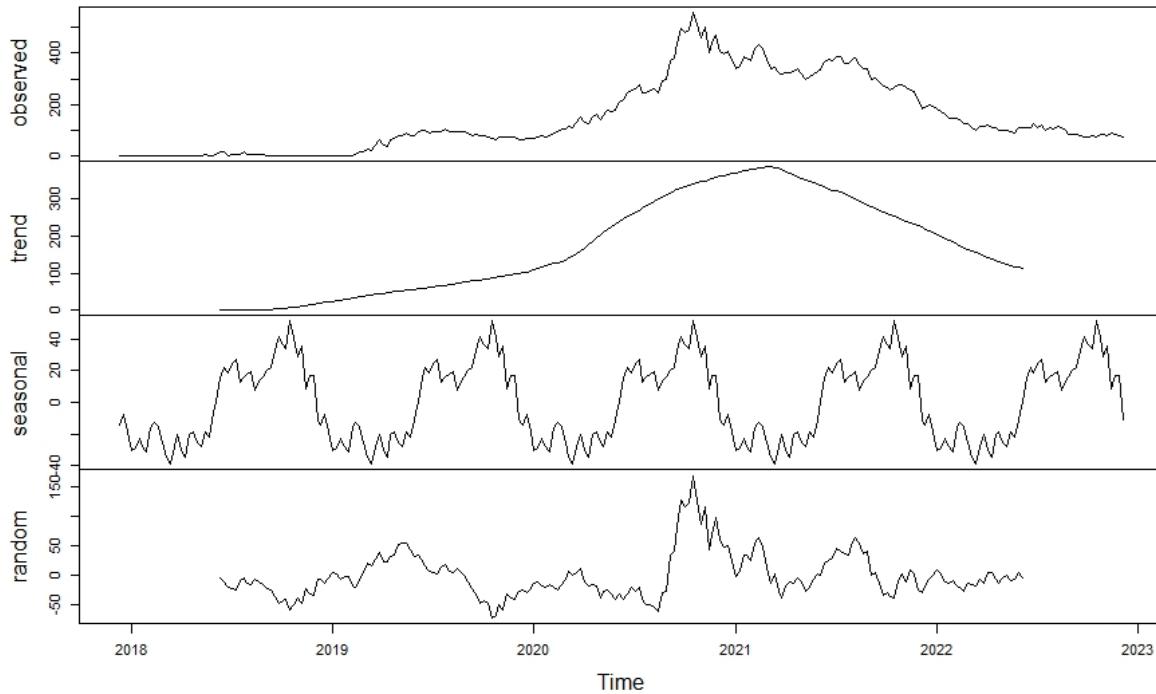


zoom

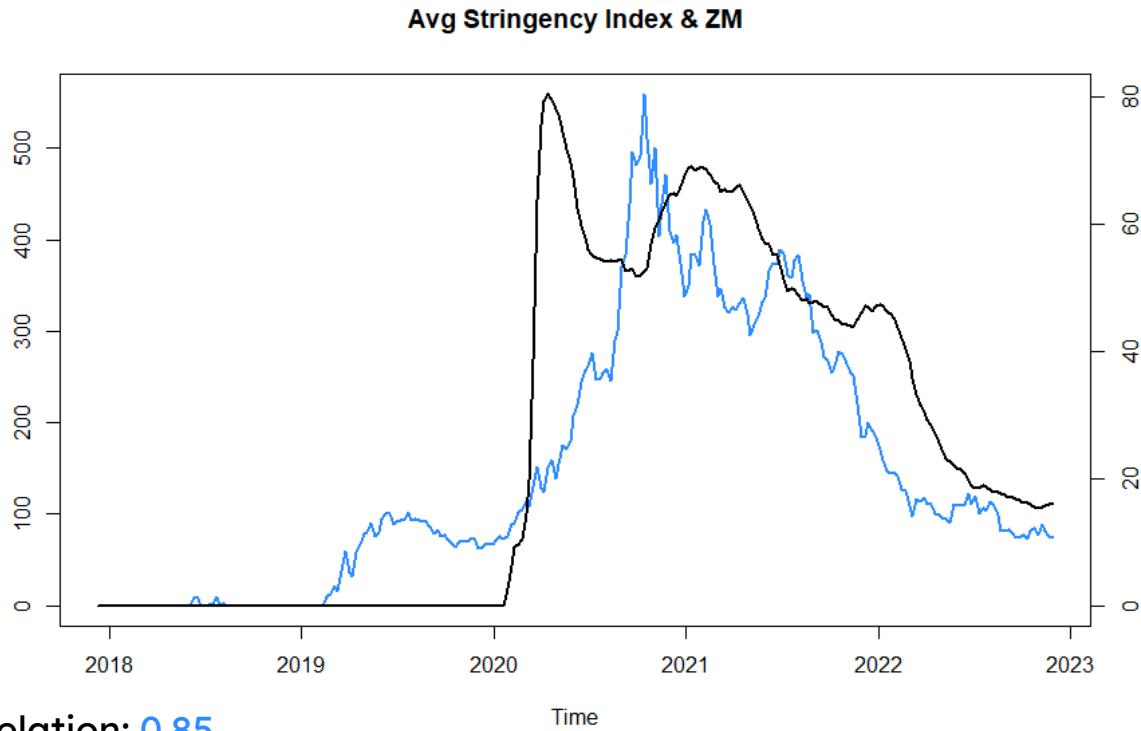


ZM - Decomposition

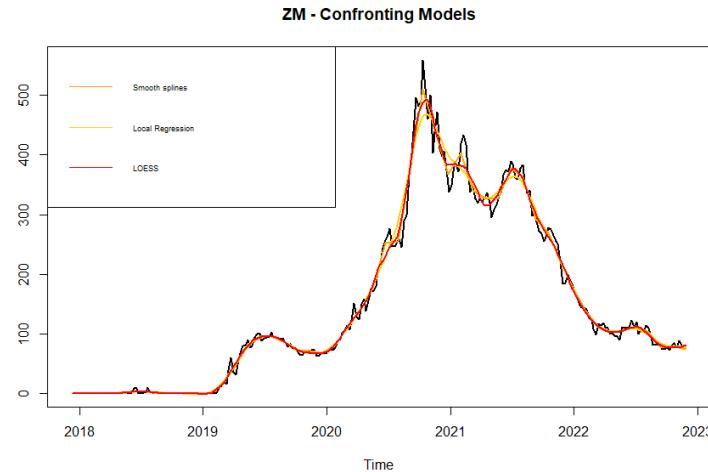
Decomposition of additive time series



ZM - Relation with the pandemic



ZM - Non parametric modelling



	Loess	Loc. Regr.	Spline
RMSE	13.710	11.944	16.758
MAPE	9.5%	10.2%	10.6%

ZM - Non parametric modelling



Financial Events

- Partnership with Verizon (Q2 2020)

Other Events

- 2° and 3° COVID waves
- In Q1 2021, COVID first mentioned in report to shareholders

Summary

Susceptible to COVID restrictions, high growth for 2 years.

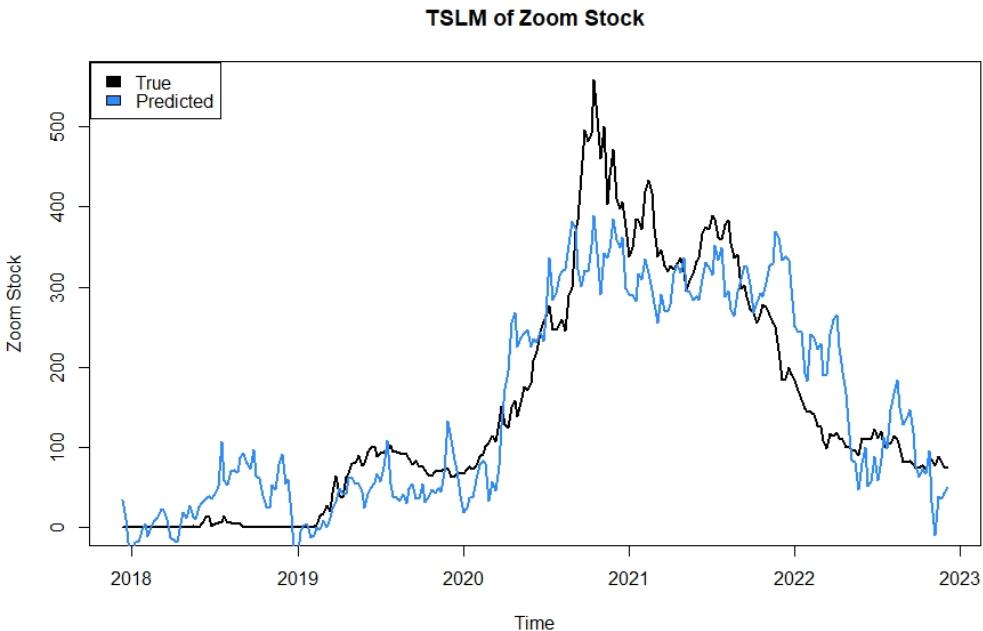
ZM - TSLM

Predictor	p-value
Intercept	8.87e-12 ***
Trend	7.50e-06 ***
Amazon stock	< 2e-16 ***
Zoom Trends	3.53e-05 ***
Netflix Trends	0.0034 **
Amazon Trends	2.85e-07 ***

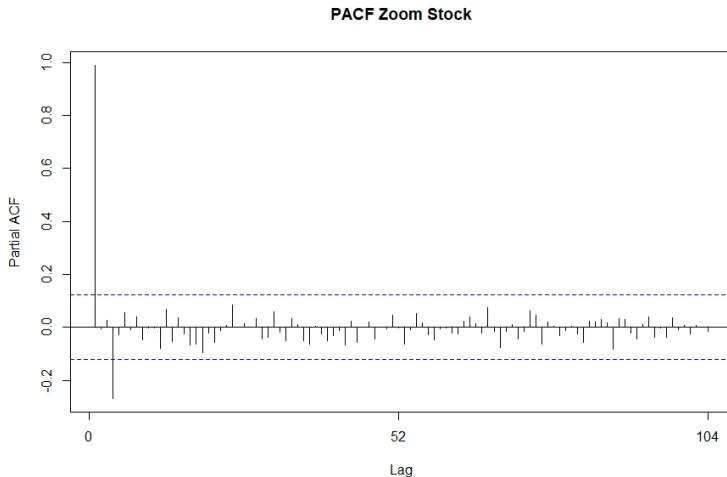
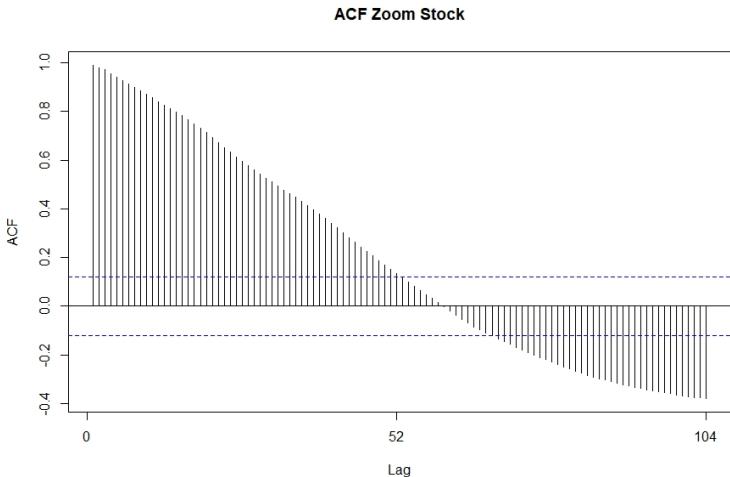
Adjusted R-squared: 0.80

RMSE: 62.24

AIC: 2899.99

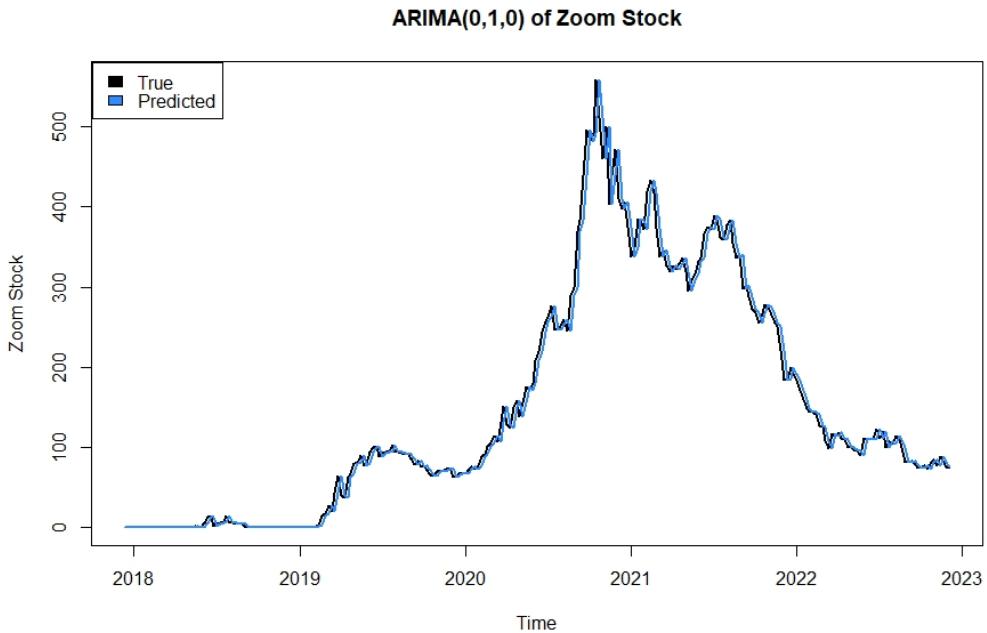


ZM - Autocorrelations



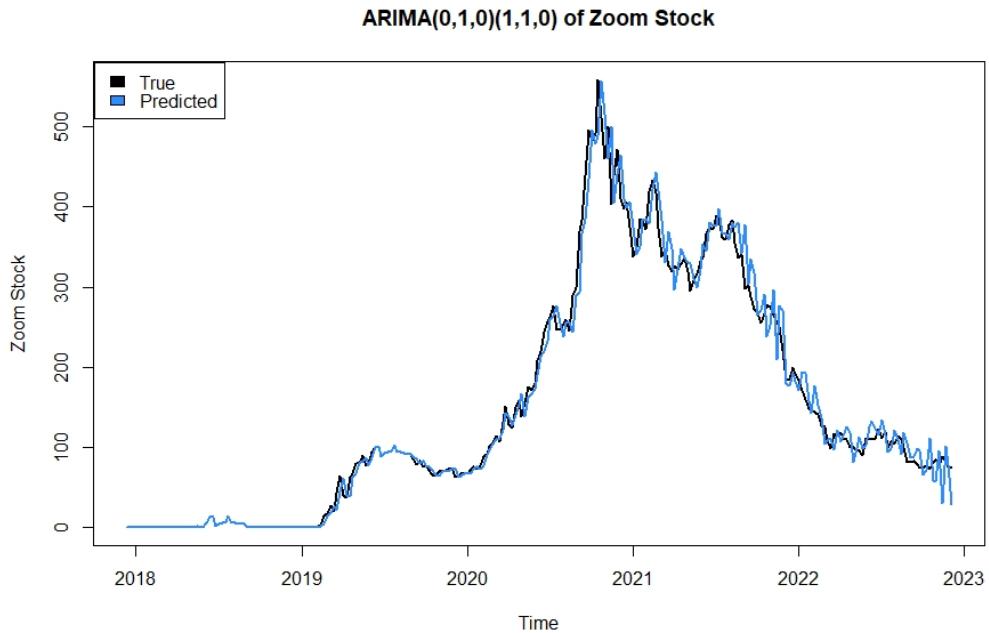
ZM - auto.ARIMA

RMSE: 17.12
AIC: 2209.38



ZM - SARIMA(0,1,0)(1,1,0)

RMSE: 20.40
AIC: 1897.77



ZM - GAM

$ZM \sim s(tt) + s(NFLX) + s(AMZN) + s(\text{ZoomGT}) + s(\text{AmazonGT}) + s(\text{NetflixGT})$

RMSE: 36.56
AIC: 2661.35

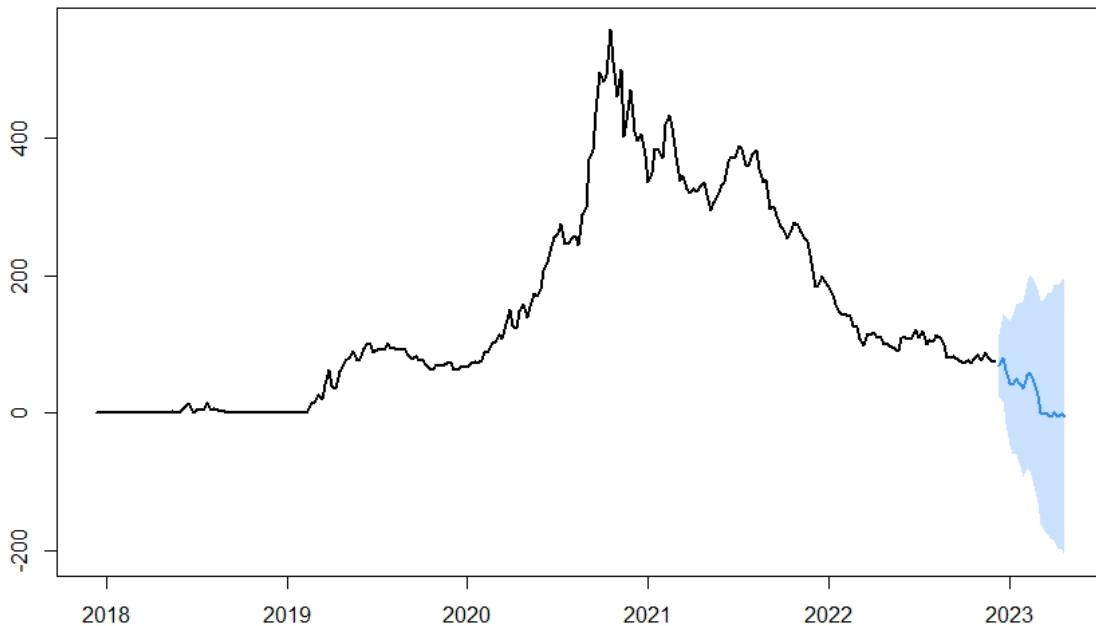


ZM - Summary

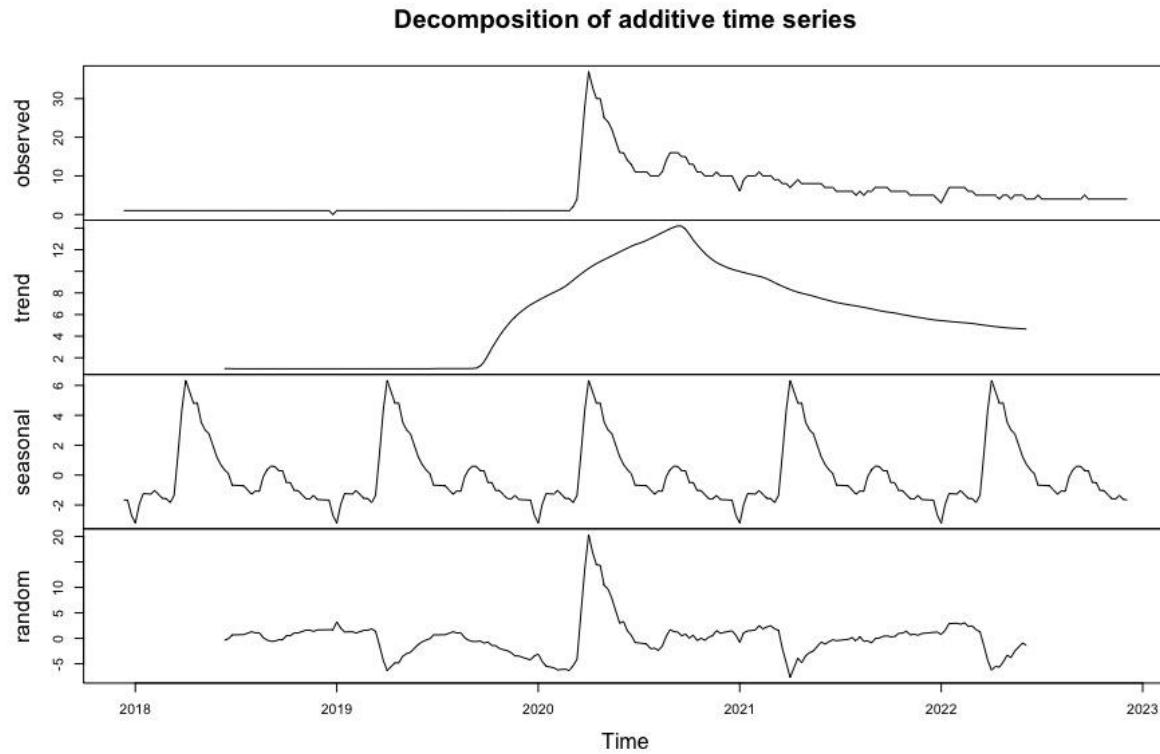
Model	AIC	RMSE
TSLM	2899.99	62.24
auto.ARIMA(0,1,0)	2209.38	17.12
SARIMA(0,1,0)(1,1,0)	1897.77	20.40
GAM	2661.35	36.56

ZM - Forecasting

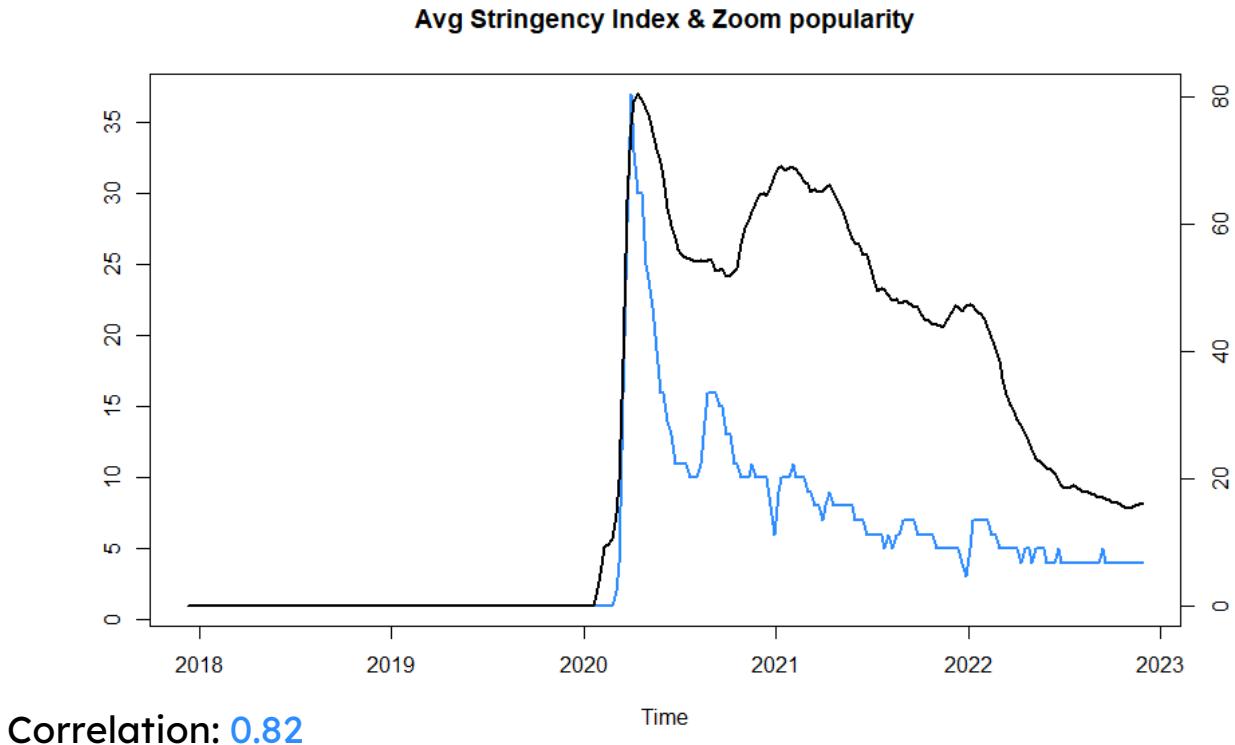
Forecasts from ARIMA(0,1,0)(1,1,0)



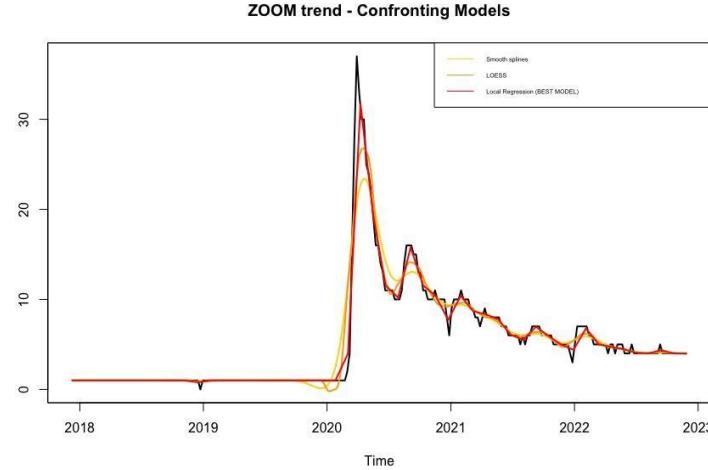
ZoomGT - Decomposition



ZoomGT - Relation with the pandemic

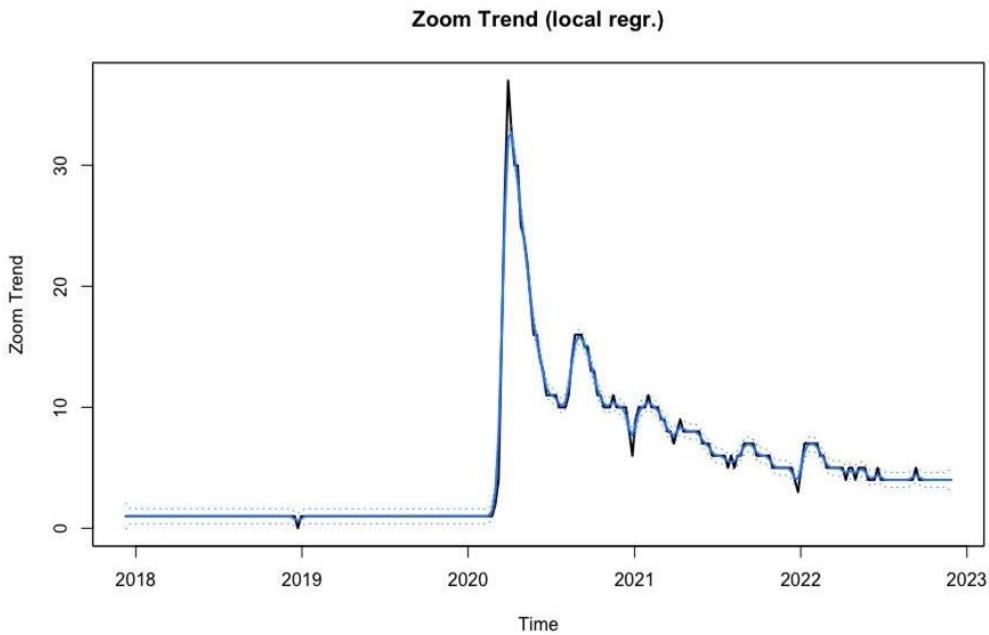


ZoomGT - Non parametric modelling



	Loess	Loc. Regr.	Spline
RMSE	1.559	0.494	2.002
MAPE	9.5%	10.2%	10.6%

ZoomGT - Non parametric modelling



NOTE: Zoom is mainly used on App, not on browser. That's why the Zoom Trend Time Series mainly refers to Zoom Download.

Recurrent Events:

- Christmas

Significant Events:

- COVID-19 (2020)

Summary:

Zoom has a boom during the first week of lockdown (March 2020) in all the world. Zoom Trend is susceptible to Zoom Downloads

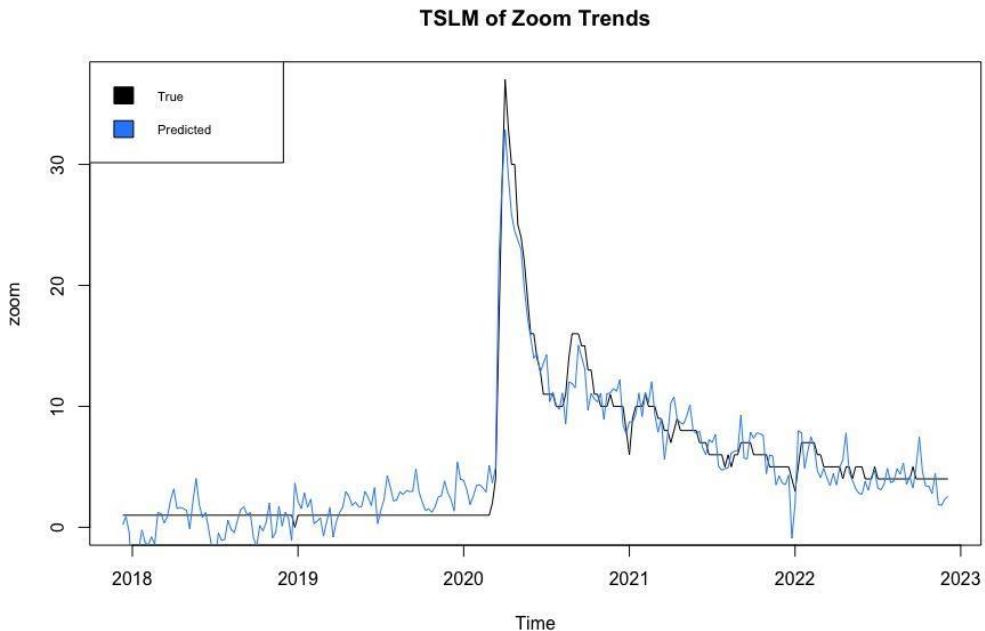
ZoomGT - TSLM

Predictor	p-value
Intercept	< 2e-16 ***
Trend	0.000131 ***
Seasonality	< 2e-16 ***
Netflix Trend	< 2e-16 ***
Zoom Stock	5.47e-14 ***
Amazon Trend	0.002086 **

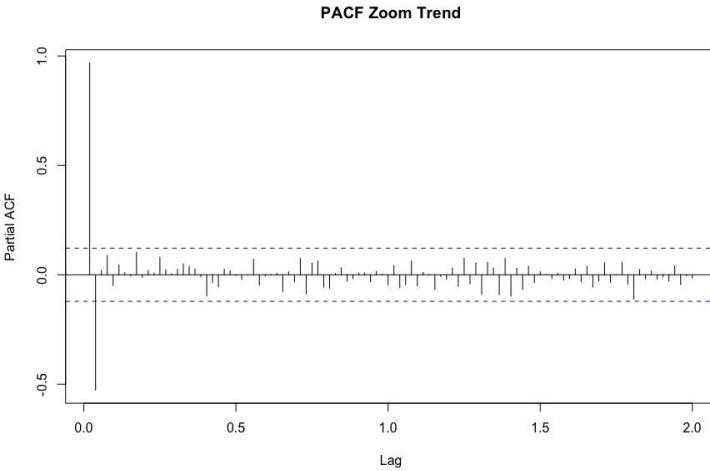
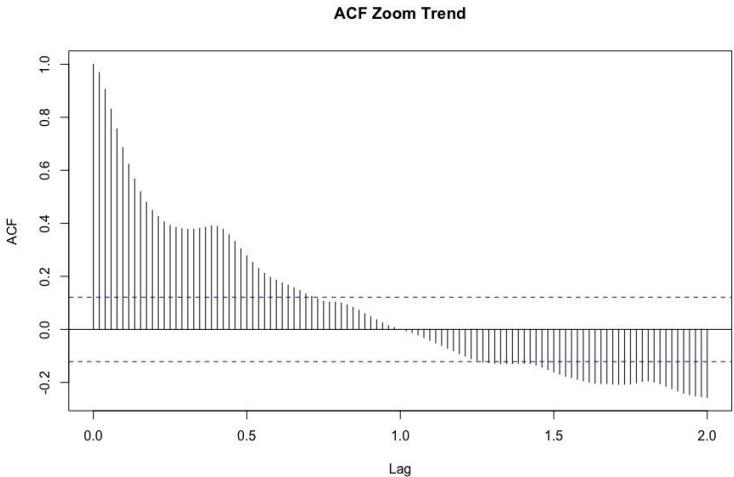
Adjusted R-squared: **0.88**

RMSE: **1.78**

AIC: **1152.33**

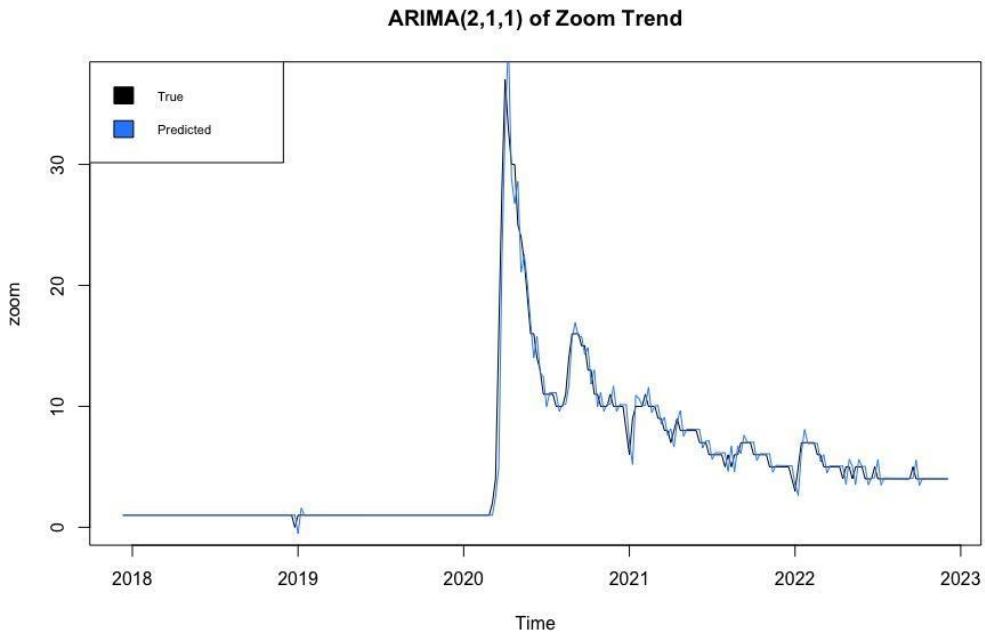


ZoomGT - Autocorrelations



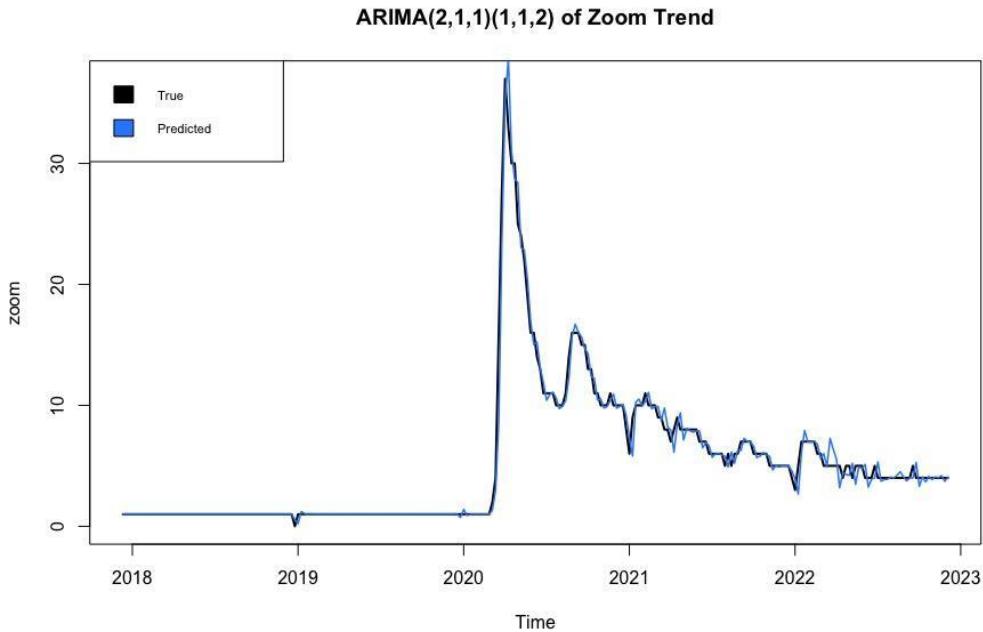
ZoomGT - auto.ARIMA

RMSE: 1.2
AIC: 839.602



ZoomGT - SARIMA(2,1,1)(1,1,2)

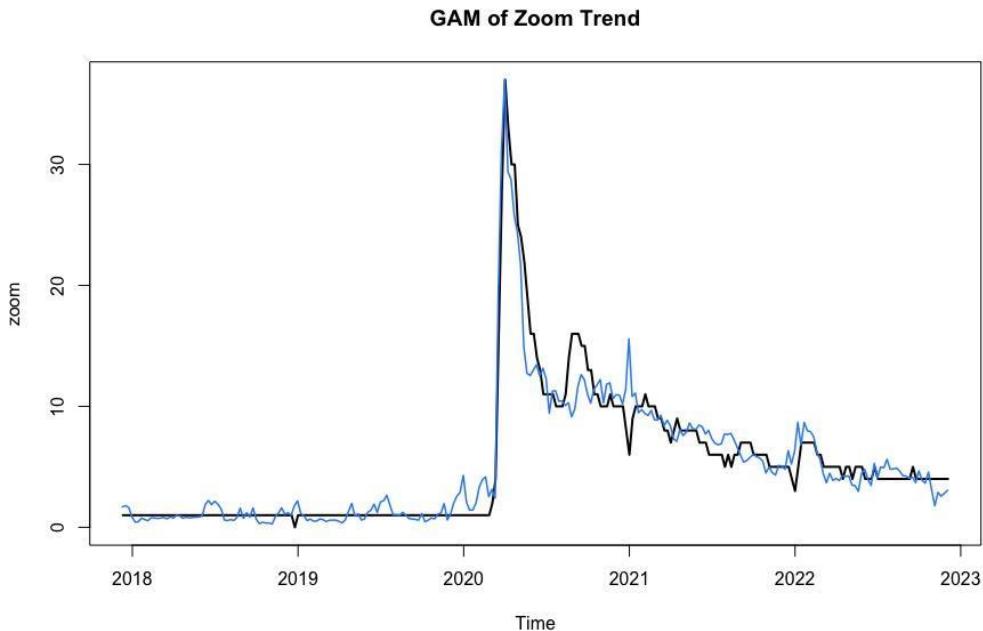
RMSE: 0.9
AIC: 764.67



ZoomGT - GAM

ZM ~ $\text{lo}(\text{tt}) + \text{lo}(\text{NetflixStock}) + \text{lo}(\text{NetflixTrend}) + \text{lo}(\text{AmazonStock}) + \text{lo}(\text{AmazonTrend})$

RMSE: 1.58
AIC: 1026.188

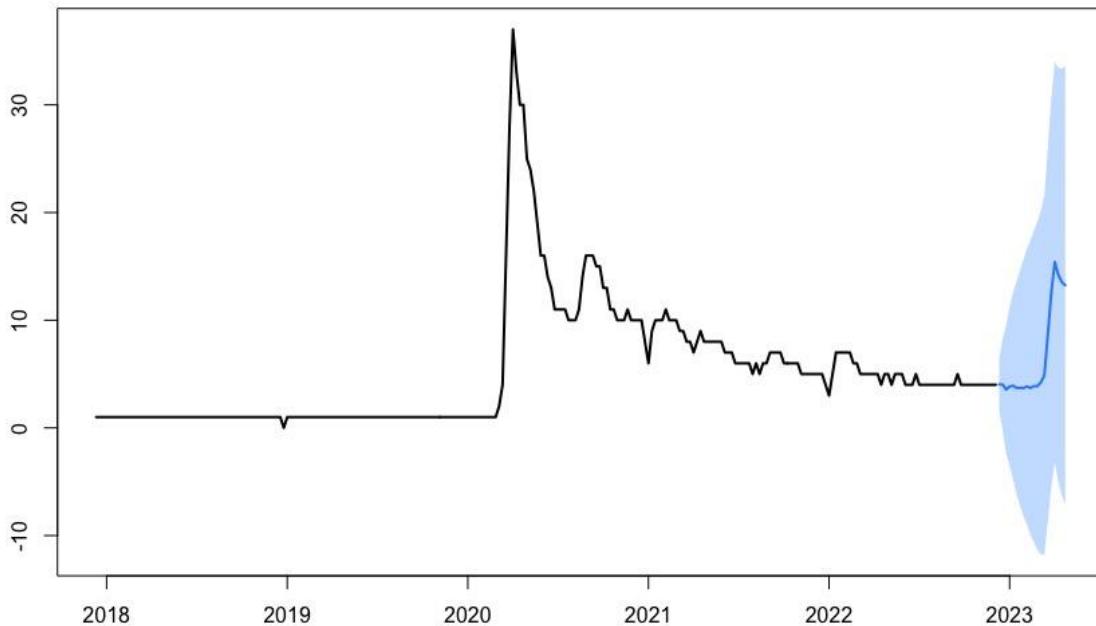


ZoomGT - Summary

Model	AIC	RMSE
TSLM	1152.33	1.78
auto.ARIMA(2,1,1)	839.6019	1.2
SARIMA(2,1,1)(1,1,2)	764.67	0.9
GAM	1026.188	1.58

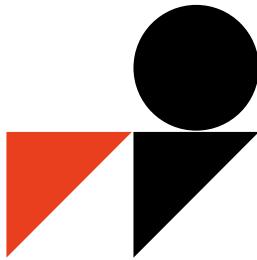
ZoomGT - Forecasting

Forecasts from ARIMA(2,1,1)(1,1,2)

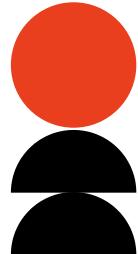




Conclusions



- Q1: the pandemic has indeed changed the online behavior of individuals – Amazon and Netflix show an overall increase of Google popularity, Zoom a shocking peak.
- Q2: there is only a weak correlation between *stocks* and *google trends*. More, the restriction index is more correlated with the former rather than the latter (for Zoom both high correlations).



Conclusions

