Forecasting the VIX in the midst of COVID-19

Supplementary Information

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Abstract

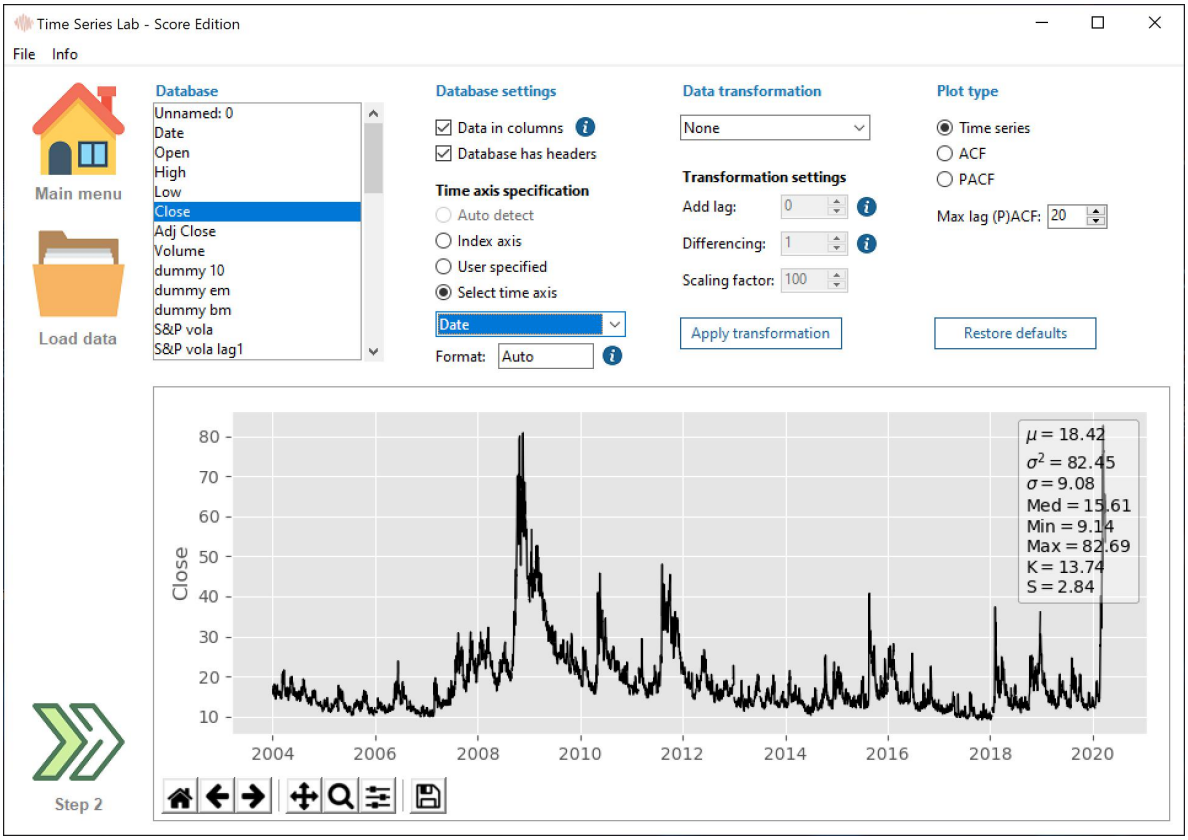
We study the behavior of the Volatility Index (VIX) time series in the period leading up to the COVID-19 outbreak. Time-varying location/scale models are used to extract a range of unobserved components from the VIX time series. The time-varying unobserved components are driven by the score of the predictive density. These so called score-driven models have proven to be powerful in extracting unobserved components like autoregressive processes and seasonal patterns. A range of model specifications is used to forecast the VIX in the COVID-19 period that spans the first quarter of 2020. Explanatory variables are used to improve in-sample model fit and out-of-sample forecast accuracy. All model computations are carried out with the *Time Series Lab* software package.

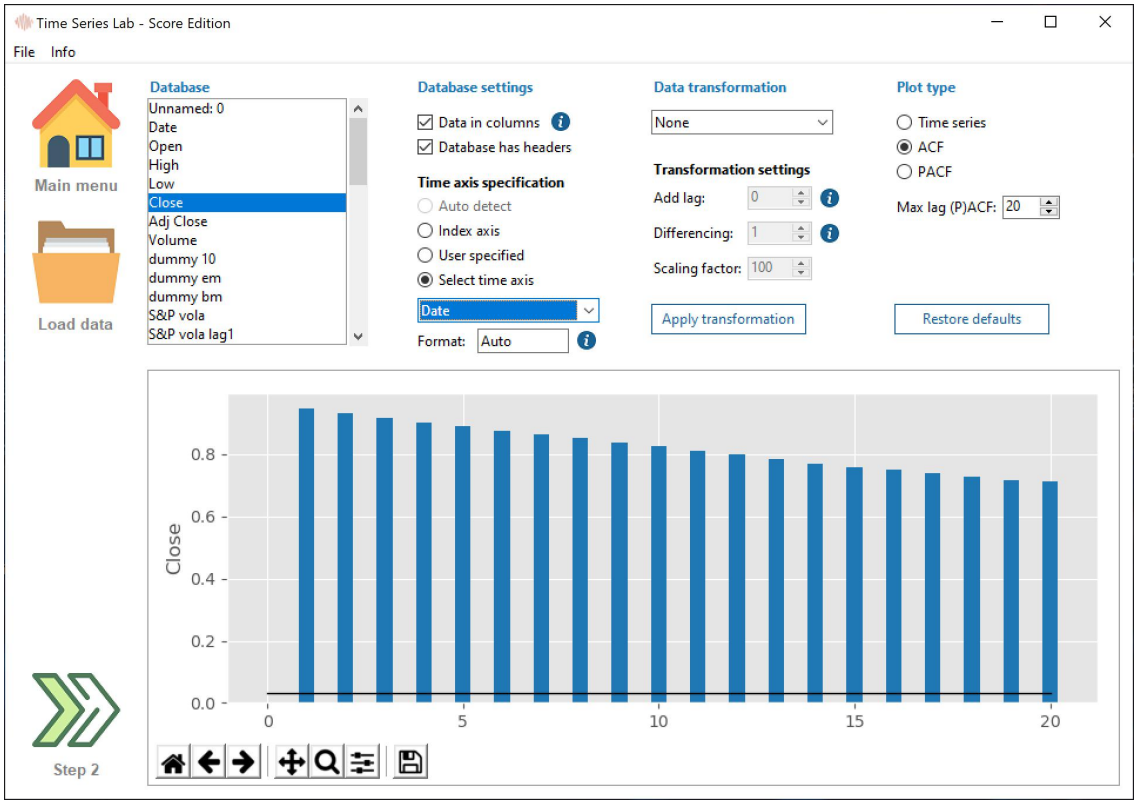
Key words: VIX, COVID-19, Time Series Lab, Unobserved components, Time Series, Forecasting, Score-driven models

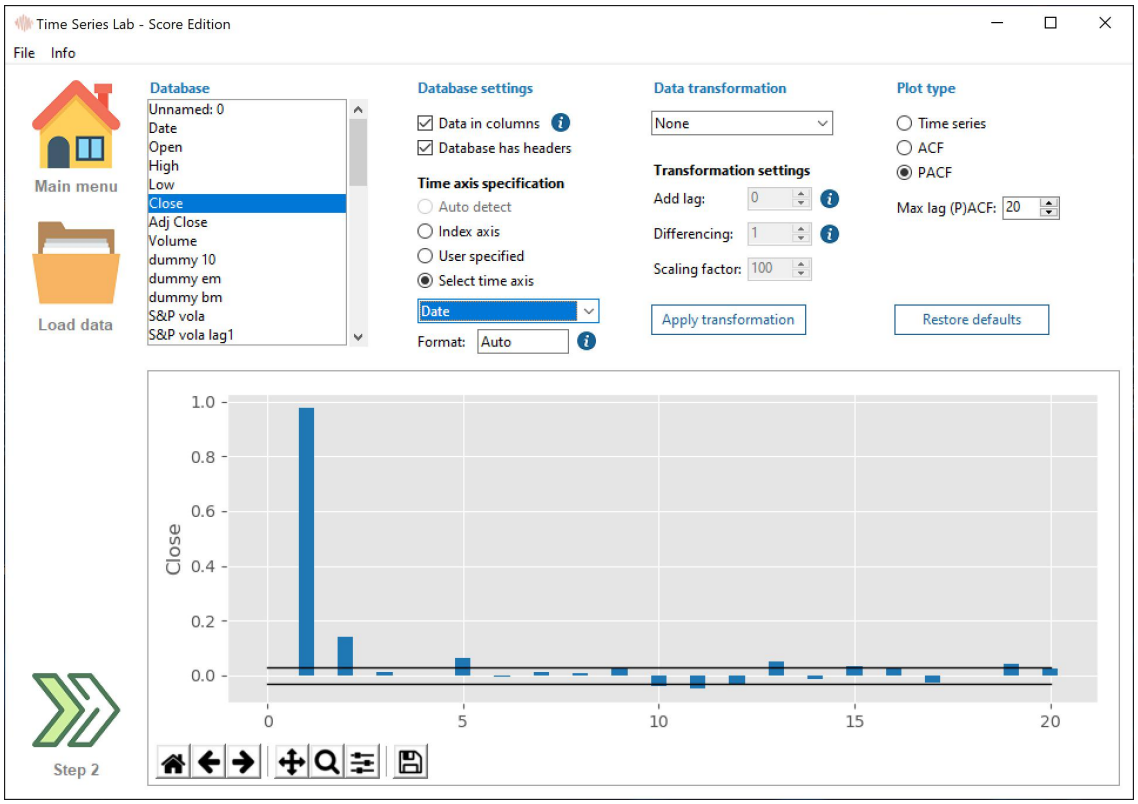
Five step procedure

The *Time Series Lab* modelling and forecasting of time series is a five-step procedure. For basic models, not many choices need to be made while for others some advanced settings need to be adjusted. We present screenshots of *Time Series Lab* that were made during the research that lead to the results in this paper.

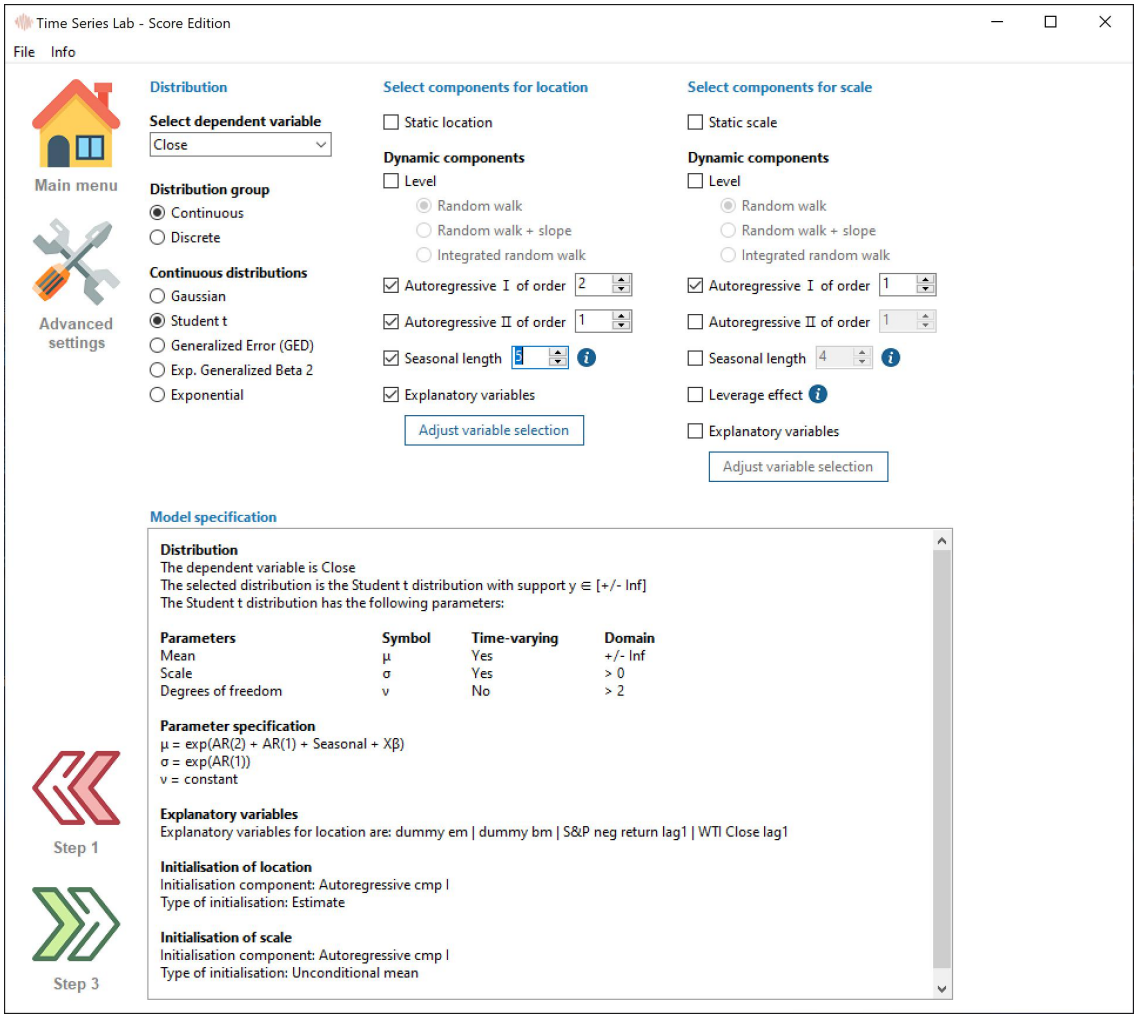
Step 1: Load data

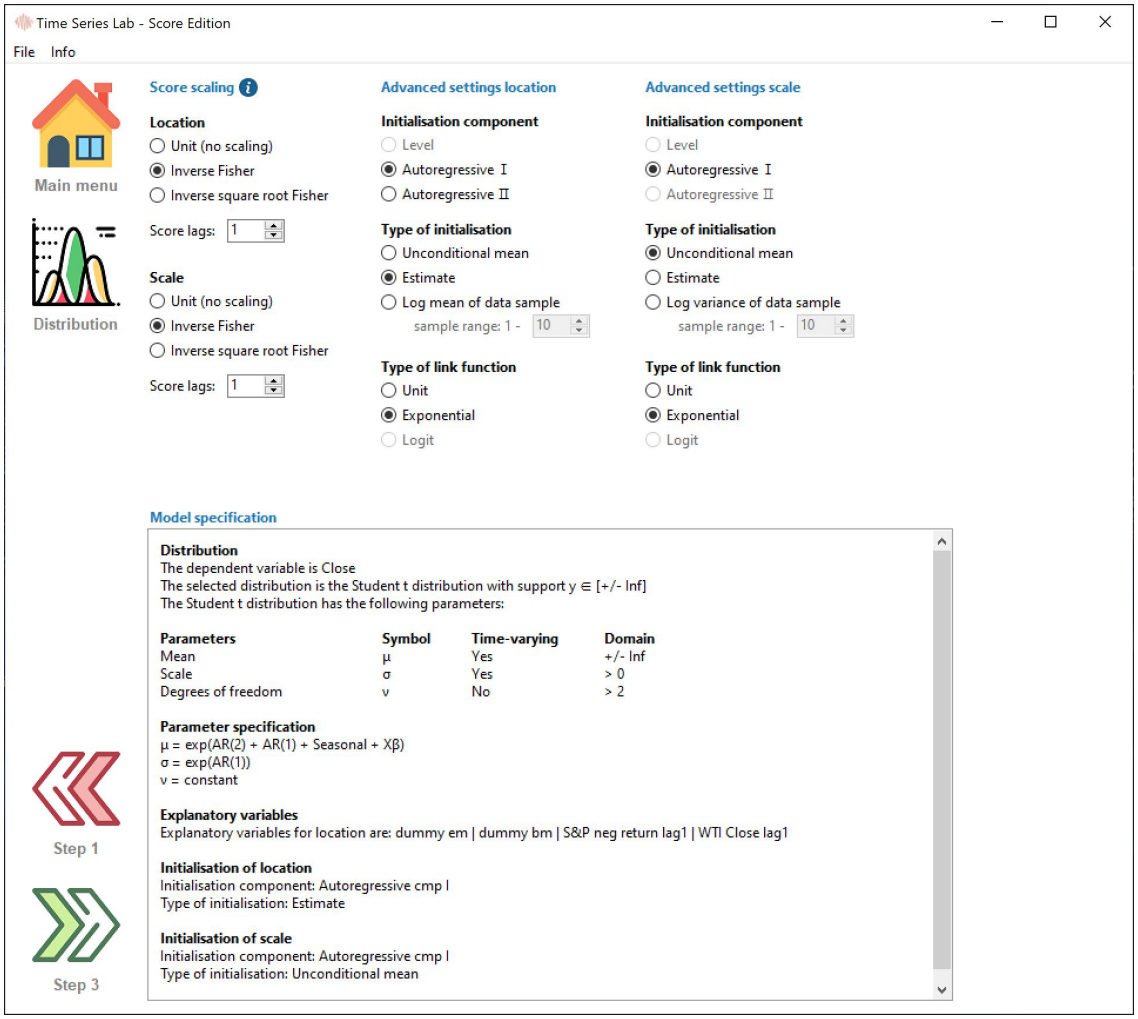



Time Series Lab - Score Edition
File Info
Main menu
Load data
Step 2
Database
Unnamed: 0
Date
Open
High
Low
Close
Adj Close
Volume
dummy 10
dummy em
dummy bm
S&P vola
S&P vola lag1
Database settings
Data in columns
Database has headers
Time axis specification
Auto detect
Index axis
User specified
Select time axis
Date
Format: Auto
Data transformation
None
Transformation settings
Add lag: 0
Differencing: 1
Scaling factor: 100
Apply transformation
Plot type
Time series
ACF
PACF
Max lag (P)ACF: 20
Restore defaults
Close
0.0
0.2
0.4
0.6
0.8
0
5
10
15
20

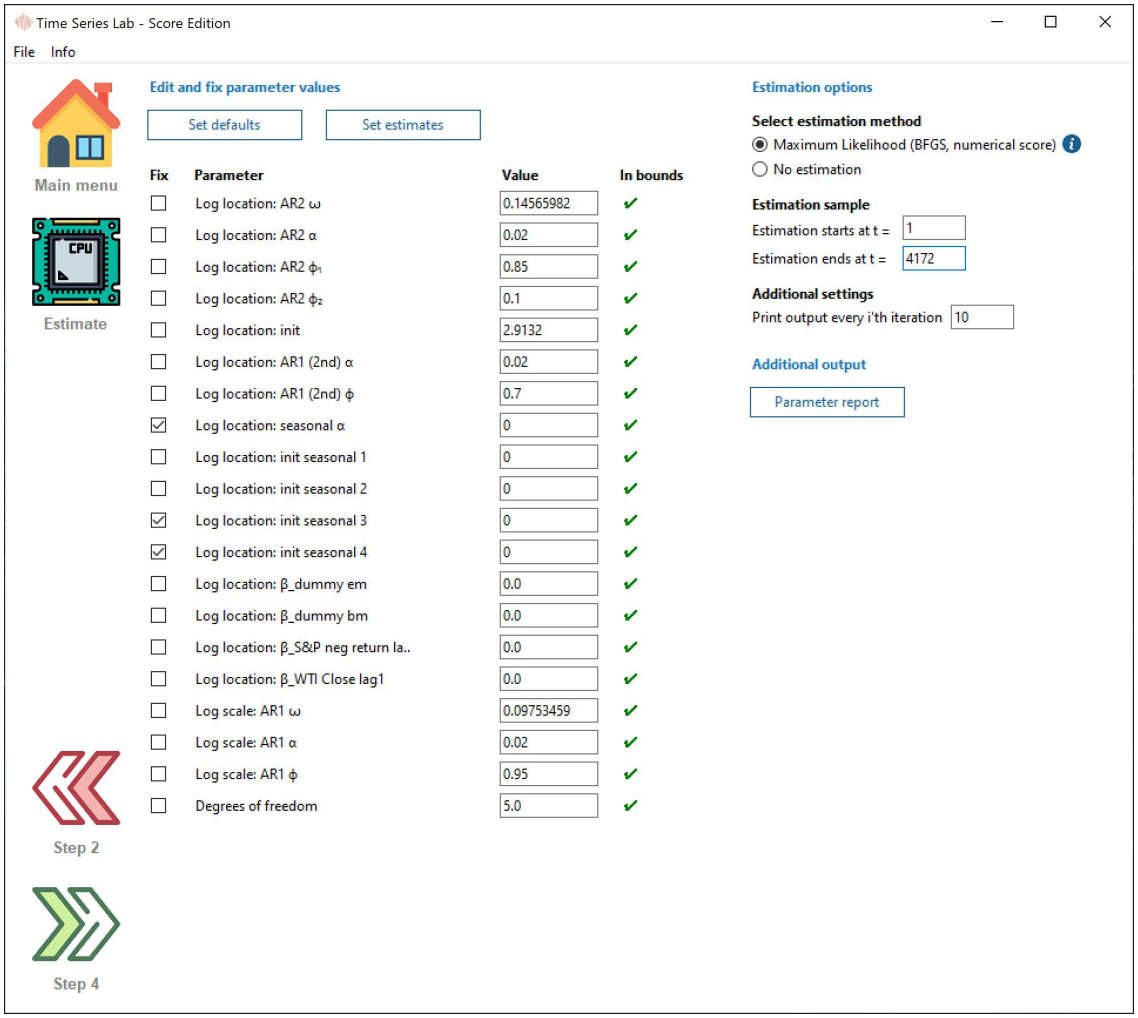

Time Series Lab - Score Edition
File Info
Main menu
Load data
Step 2
Database
Unnamed: 0
Date
Open
High
Low
Close
Adj Close
Volume
dummy 10
dummy em
dummy bm
S&P vola
S&P vola lag1
Database settings
Data in columns
Database has headers
Time axis specification
Auto detect
Index axis
User specified
Select time axis
Date
Format: Auto
Data transformation
None
Transformation settings
Add lag: 0
Differencing: 1
Scaling factor: 100
Apply transformation
Plot type
Time series
ACF
PACF
Max lag (P)ACF: 20
Restore defaults
Close
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20

Step 2: Model setup

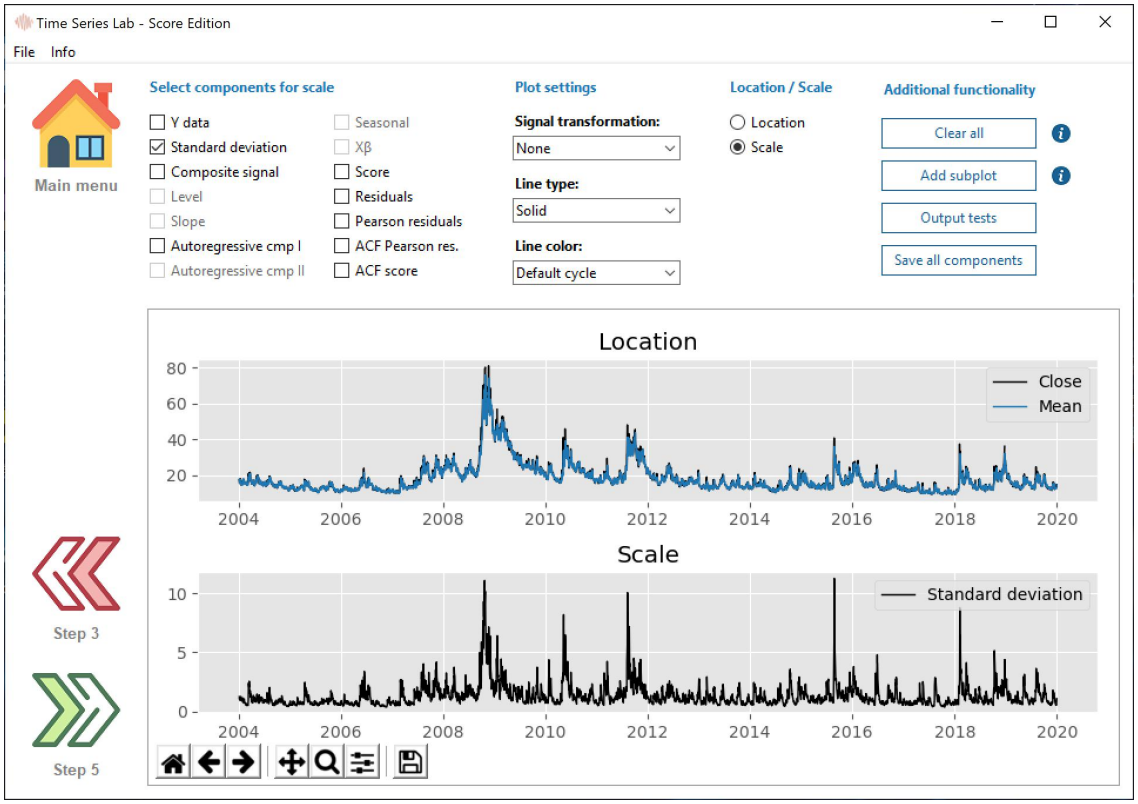



Time Series Lab - Score Edition
File Info
Main menu
Distribution
Step 1
Step 3
Score scaling
Location
Unit (no scaling)
Inverse Fisher
Inverse square root Fisher
Score lags: 1
Scale
Unit (no scaling)
Inverse Fisher
Inverse square root Fisher
Score lags: 1
Advanced settings location
Initialisation component
Level
Autoregressive I
Autoregressive II
Type of initialisation
Unconditional mean
Estimate
Log mean of data sample
sample range: 1 - 10
Type of link function
Unit
Exponential
Logit
Advanced settings scale
Initialisation component
Level
Autoregressive I
Autoregressive II
Type of initialisation
Unconditional mean
Estimate
Log variance of data sample
sample range: 1 - 10
Type of link function
Unit
Exponential
Logit
Model specification
Distribution
The dependent variable is Close
The selected distribution is the Student t distribution with support y ∈ [+/- Inf]
The Student t distribution has the following parameters:
Parameters Symbol Time-varying Domain
Mean μ Yes +/- Inf
Scale σ Yes > 0
Degrees of freedom ν No > 2
Parameter specification
μ = exp(AR(2) + AR(1) + Seasonal + Xβ)
σ = exp(AR(1))
ν = constant
Explanatory variables
Explanatory variables for location are: dummy em | dummy bm | S&P neg return lag1 | WTI Close lag1
Initialisation of location
Initialisation component: Autoregressive cmp I
Type of initialisation: Estimate
Initialisation of scale
Initialisation component: Autoregressive cmp I
Type of initialisation: Unconditional mean

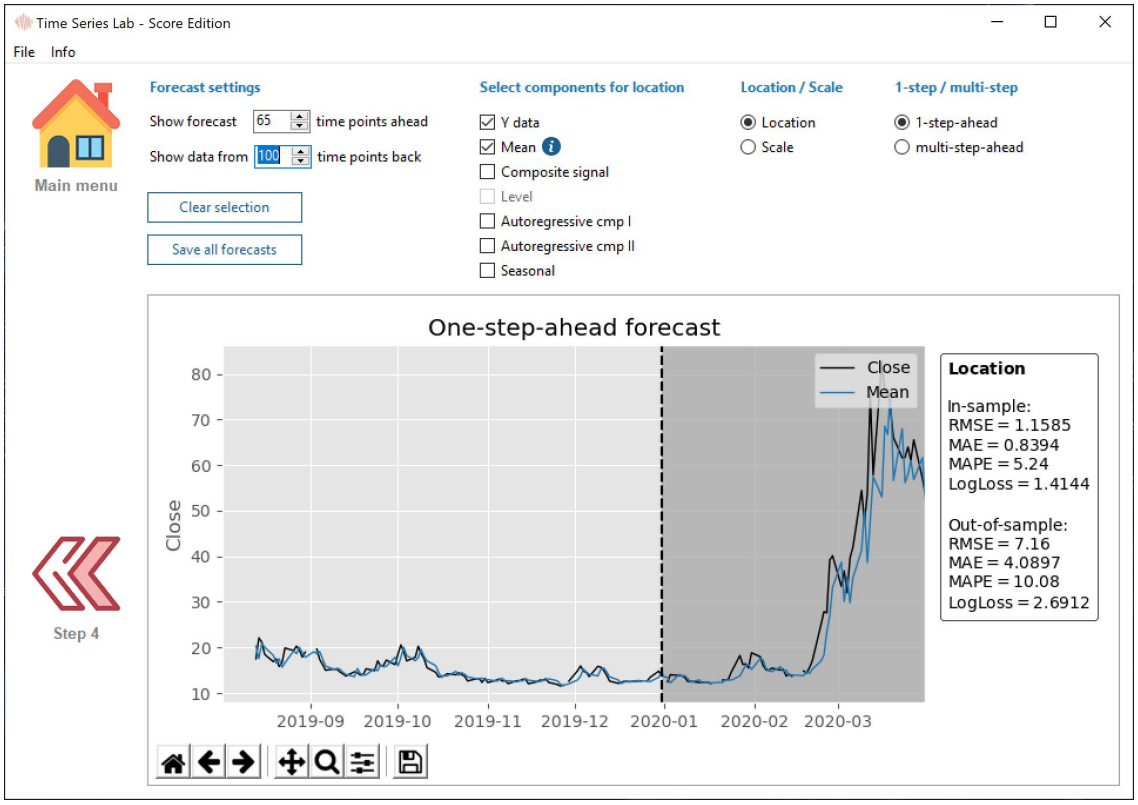
Step 3: Estimation



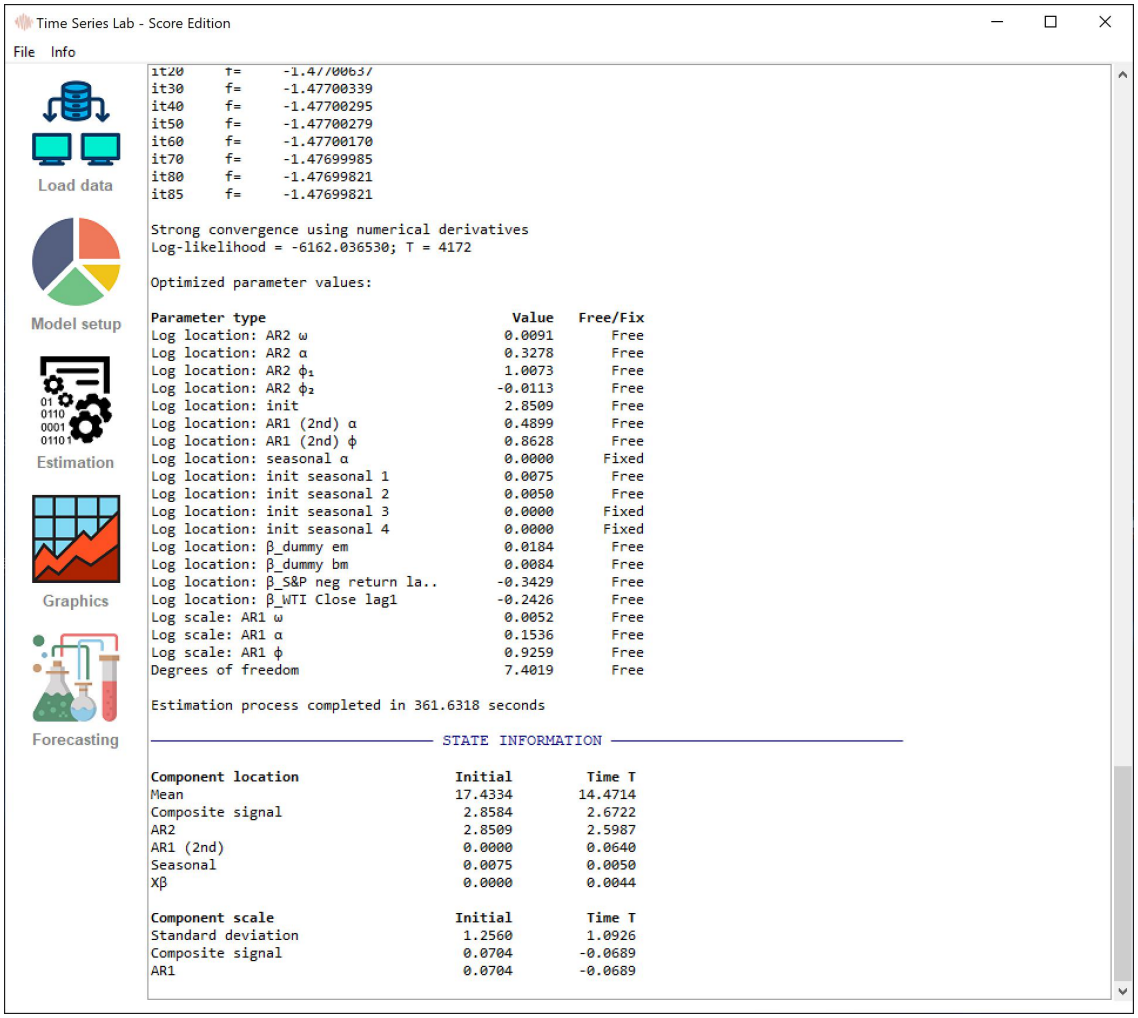
Step 4: Graphics



Step 5: Forecasting



Output


Time Series Lab - Score Edition
File Info
Load data
Model setup
Estimation
Graphics
Forecasting
it20 f= -1.47700637
it30 f= -1.47700339
it40 f= -1.47700295
it50 f= -1.47700279
it60 f= -1.47700170
it70 f= -1.47699985
it80 f= -1.47699821
it85 f= -1.47699821
Strong convergence using numerical derivatives
Log-likelihood = -6162.036530; T = 4172
Optimized parameter values:
Parameter type Value Free/Fix
Log location: AR2 ω 0.0091 Free
Log location: AR2 α 0.3278 Free
Log location: AR2 ϕ₁ 1.0073 Free
Log location: AR2 ϕ₂ -0.0113 Free
Log location: init 2.8509 Free
Log location: AR1 (2nd) α 0.4899 Free
Log location: AR1 (2nd) ϕ 0.8628 Free
Log location: seasonal α 0.0000 Fixed
Log location: init seasonal 1 0.0075 Free
Log location: init seasonal 2 0.0050 Free
Log location: init seasonal 3 0.0000 Fixed
Log location: init seasonal 4 0.0000 Fixed
Log location: β_dummy em 0.0184 Free
Log location: β_dummy bm 0.0084 Free
Log location: β_S&P neg return la.. -0.3429 Free
Log location: β_WTI Close lag1 -0.2426 Free
Log scale: AR1 ω 0.0052 Free
Log scale: AR1 α 0.1536 Free
Log scale: AR1 ϕ 0.9259 Free
Degrees of freedom 7.4019 Free
Estimation process completed in 361.6318 seconds
STATE INFORMATION
Component location Initial Time T
Mean 17.4334 14.4714
Composite signal 2.8584 2.6722
AR2 2.8509 2.5987
AR1 (2nd) 0.0000 0.0640
Seasonal 0.0075 0.0050
Xβ 0.0000 0.0044
Component scale Initial Time T
Standard deviation 1.2560 1.0926
Composite signal 0.0704 -0.0689
AR1 0.0704 -0.0689