JSUparameters Application

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Acknowledgement The following has been extracted from C.J. Clarke's M.Sc. thesis, entitled "How can we use QQ plots for estimation?".

Example Application In this application, we make use of the Irish Stock Exchange Quotient (ISEQ) dataset, which consists of data recorded every Monday, from July 14th 1997 to May 31st 2021. This dataset was downloaded from Yahoo! Finance on June 2nd, 2021.

```
# go to https://finance.yahoo.com/quote/%5EISEQ/history?period1=868838400&period2=1622419
# 200&interval=1wk&filter=history&frequency=1wk&includeAdjustedClose=true
# download the csv file
# NOTE: the file is continuously updated, so it may not match the version used here
# load in the csv file (check your own file path)
iseq = read.csv("^ISEQ.csv")

head(iseq, 4)
```

```
##         Date        Open        High         Low       Close   Adj.Close Volume
## 1 1997-07-14 3514.439941 3622.800049 3514.020020 3610.570068 3610.570068      0
## 2 1997-07-21 3610.570068 3649.909912 3544.959961 3640.709961 3640.709961      0
## 3 1997-07-28 3640.709961 3688.330078 3611.399902 3676.540039 3676.540039      0
## 4 1997-08-04 3676.540039 3739.010010 3654.840088 3725.989990 3725.989990      0
```

The above output shows an extract of the dataset, which contains the following information: the weekly start date; the opening price (price of the first trade on the first day of the week); the high price (highest price of the stock during the week); the low price (lowest price of the stock during the week); and the close price (price of the last trade on the last day of the week).

Note: Further references to this dataset refer implicitly to the close price data, as the close price can be considered the most accurate measure of the value of a stock until trading resumes.

Figure 1 displays a time series plot of the ISEQ data. A large increase is seen in the closing price between 2002 and 2007, rising from approximately €4,000 to approximately €10,000; this is followed by a large decrease to approximately €2,000 between 2007 and 2009. After 2011, there seems to be a general rising trend, with some falls appearing throughout.

In general, it is not the raw closing price data that will be modelled; but rather the log returns. Let P_t denote the closing index level in week t, for $1 \leq t \leq 1247$. The log return, x_t, in week t, is the change in the log index from week $t-1$ to week t:

$$x_t = ln(P_t) - ln(P_{t-1}) = ln\left(\frac{P_t}{P_{t-1}}\right).$$

```
# create log returns data
end = length(iseq$Close)
close = as.numeric(iseq$Close)
```

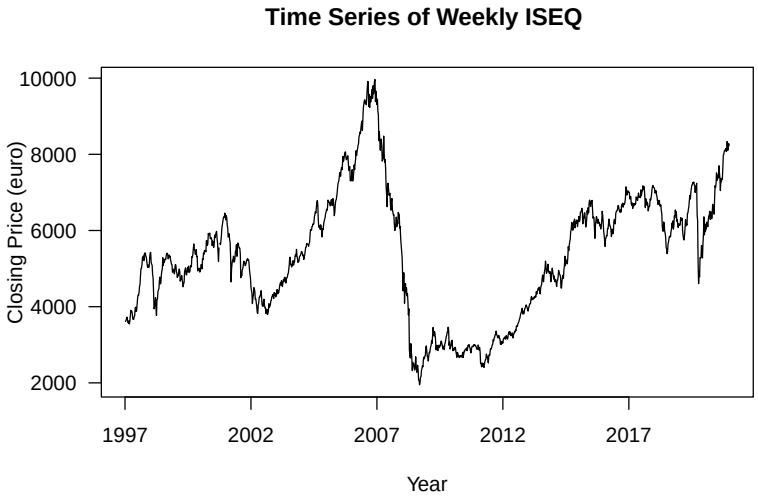

Figure 1: ISEQ time series plot.

```
miss = which(is.na(close)) # 195
close[miss] = mean(close[miss - 1], close[miss + 1]) # mean interpolation

returns = log(close[1:(end - 1)] / close[2:end])
```

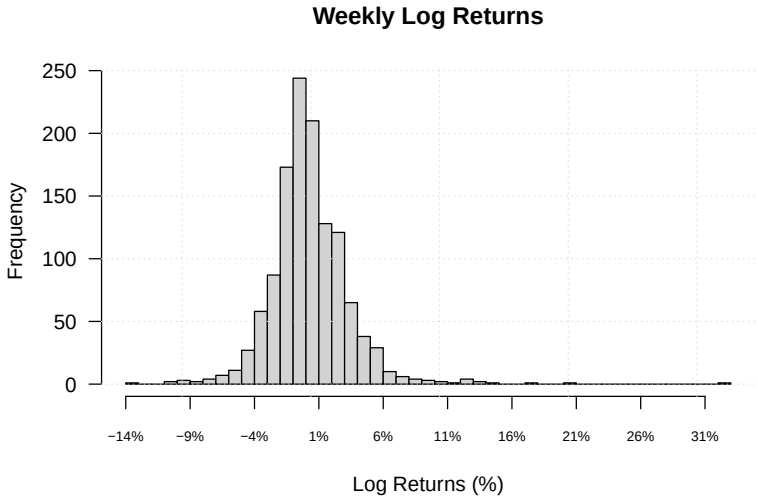

Figure 2: Histogram of the ISEQ weekly log returns.

Figure 2 displays a histogram of the weekly log returns. These data appear approximately bell-shaped, yet there is some asymmetry present, particularly regarding the few large positive returns. This is clear motivation for the decision to investigate the Johnson S_U distribution, as the tails of this histogram are not well-captured by a normal distribution; more flexibility is required.

Our aim is to find the best-fitting Johnson S_U distribution for this dataset, using `JSUparameters`. To do this, we run the following code:

```
# run one of the below lines if you have not yet installed the package
# install.packages("JSUparameters")
# devtools::install_github("cjclarke98/JSUparameters")
```

Table 1: Results from using the algorithm on the one week returns dataset.

Distribution	Johnson S_U
SSQ	0.008841
δ	1.1497839
ξ	-0.0100093
λ	0.0221479
γ	-0.3283412
Flags	None

```
library(JSUparameters)
# find the best-fitting JSU distribution to this (log-returns) data
res = JSUparameters(returns)
```

```
## Johnson SU distribution
## SSQ =  0.008840967
##
## Parameter Estimates:
## delta = 1.149784
## xi = -0.01000928
## gamma = -0.3283412
## lambda = 0.02214788
```

Table 1 displays the results obtained when we use the above algorithm on this dataset.

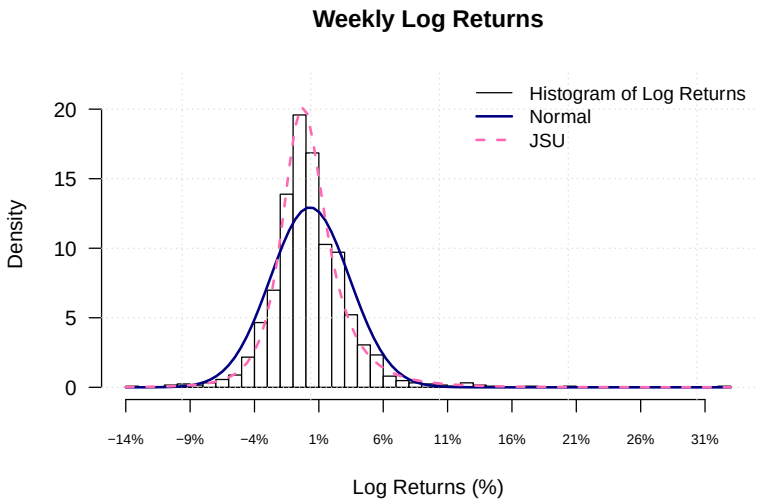

Figure 3: Histograms of the weekly log returns for holding periods of length one week.

Figure 3 displays the following items: the histogram of the weekly log returns data (scaled to produce a total area of 1); the probability density function of a normal distribution with the same mean and standard deviation as the data; and the probability density function of a best-fitting Johnson S_U distribution found using the above algorithm. It is clear that the best-fitting Johnson S_U distribution, found by our algorithm, is a far better fit to the data than the corresponding best-fitting normal distribution.