

## Appendix I

The program (in R) and numerical results generated for Poland for the period December 31, 2019 – September 10, 2020. The results were used in this work. All estimated coefficients and parameters for the three functions considered are statistically significant. The data used on the cumulative counts are freely available (see [9]). The data are published on line at the link:

<https://github.com/owid/covid-19-data/blob/master/public/data/README.md> and are available in the form of CSV | XLSX | JSON files.

```
# Program FitNLGC in R (September 2020).
# The program fits Non-Linear Growth Curves.
library(minpack.lm) # install if not-present.
datX <- read.table("owid-covid-dataA.csv",header=TRUE,sep=",")
attach(datX)
# Country Poland (iso_code = "POL"); # Country Italy (iso_code = "ITA")
# Country Canada (iso_code = "CAN"); # Country USA (iso_code = "USA")
CUMD = datX[iso_code == "POL",3] # retrieve cumulative data
DAYD = c(1:length(CUMD)) # take a length of data (=number of days)
DATF = data.frame (cbind (DAYD,CUMD)) # this construction is needed in the model
#####
# Start values:
K=10000; M=20000; L=3000; A=.3; B=3; C=.5; D= 2; E=10; F=20
# The fitted model:
fitG = nlsLM (CUMD ~ M* exp(-A*exp(-B*DAYD)) +
K*exp(-C*exp(-D*DAYD)) + L* pnorm (DAYD, E, F),
start = list (A=A,B=B,C=C,D=D,E=E,F=F,K=K,L=L, M=M), data=DATF)
#####
plot(DAYD,CUMD, pch=18, cex=.75, col="black")
lines (DAYD,fitted(fitG), lwd=4,lty=1,col="red" )
# summary(fitG)
#####The end #####
# Output from the summary(fitG)
Formula: CUMD ~ M * exp(-A * exp(-B * DAYD)) + K * exp(-C * exp(-D * DAYD)) + L * pnorm(DAYD, E, F)
Parameters:
  Estimate Std. Error t value Pr(>|t|)
A 9.294e+00 3.554e-01 26.148 < 2e-16 ***
B 5.676e-02 1.836e-03 30.905 < 2e-16 ***
C 4.339e+01 5.575e+00 7.784 5.33e-13 ***
D 4.068e-02 1.322e-03 30.762 < 2e-16 ***
E 1.673e+02 1.882e-01 888.955 < 2e-16 ***
```

F 2.012e+01 3.289e-01 61.181 < 2e-16 \*\*\*  
K 2.331e+04 9.731e+02 23.957 < 2e-16 \*\*\*  
L 3.617e+04 6.528e+02 55.402 < 2e-16 \*\*\*  
M 1.810e+04 6.028e+02 30.032 < 2e-16 \*\*\*

=====  
Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
Residual standard error: 148.1 on 180 degrees of freedom  
Number of iterations to convergence: 47  
Achieved convergence tolerance: 1.49e-08

##### The end #####