Prílohy

Príloha č. 1 – Ukážka programu nelineárnej regresie a ARIMA modelovania v SAS Enterprise Guide

Nelineárna regresia

```
/* ---------------------------------------------------------------------
   Code generated by Jana Kútiková
   Input Data: Local:WORK.TOSAS_CODE
   Server:  Local
   --------------------------------------------------------------------- */
%_eg_conditional_dropds(WORK.SORTTempTableSorted,
             WORK.TMP0TempTableForPlots);
/* ---------------------------------------------------------------------
   Sort data set Local:WORK.TOSAS_CODE
   --------------------------------------------------------------------- */
PROC SQL;
      CREATE VIEW WORK.SORTTempTableSorted AS
            SELECT T."2020"n, T.Vek
      FROM WORK.TOSAS_CODE as T
;
QUIT;
TITLE;
TITLE1 "Nonlinear Regression";
TITLE2 "Results";
FOOTNOTE;
FOOTNOTE1;
PROC NLIN DATA=WORK.SORTTempTableSorted
      METHOD=MARQUARDT
      MAXITER=100
      CONVERGE=1E-05
      SINGULAR=1E-08
      MAXSUBIT=30
      NOITPRINT
      ;
      MODEL "2020"n = a /(Vek + b)+
      c*exp(Vek-16)/(1+exp(Vek-16))+
      d*exp(d*(Vek-90))/(1+(d/0.7)*exp(d*(Vek-90)))*
      (if Vek <= 50 then 1 else 0) +
      ((e*exp(e*(Vek-90))/(1+(e/0.7)*exp(e*(Vek-90))))+
      (d*exp(d*(-40))/(1+(d/0.7)*exp(d*(-40))))-
      (e*exp(e*(-40))/(1+(e/0.7)*exp(e*(-40)))))*
      (if 50<Vek<=90 then 1 else 0)+
      ((f*exp(f*(Vek-90))/(1+(f/0.7)*exp(f*(Vek-90))))+
      e/(1+e/0.7)-f/(1+f/0.7)+
      (d*exp(d*(-40))/(1+(d/0.7)*exp(d*(-40))))-
      (e*exp(e*(-40))/(1+(e/0.7)*exp(e*(-40)))))*
      (if Vek>90 then 1 else 0)
      ;
      PARMS
            a=0.001
            b=0.001
            c=0.001
```

```
            d=0.001
            e=0.001
            f=0.001
      ;
      OUTPUT OUT=WORK.TMP0TempTableForPlots
            H=_h1
            L95M=_l95m
            L95=_l95
            PARMS=a b
            PREDICTED=_predicted1
            RESIDUAL=_residual1
            SSE=_sse1
            STDI=_stdi1
            STDP=_stdp1
            STDR=_stdr1
            STUDENT=_rstudent1
            U95M=_u95m
            U95=_u95
            WEIGHT=_weight1
      ;
RUN;
TITLE;
TITLE1 "Regression Analysis Plots";
PROC SORT DATA=WORK.TMP0TempTableForPlots
      OUT=WORK.TMP0TempTableForPlots;
      BY  Vek;
RUN;
AXIS1 MAJOR=(NUMBER=5) WIDTH=1;
AXIS2 OFFSET=(10 PCT) WIDTH=1;
AXIS3 MAJOR=(NUMBER=5) OFFSET=(5 PCT) WIDTH=1;
PROC GPLOT DATA=WORK.TMP0TempTableForPlots
      ;
      WHERE "2020"n IS NOT MISSING AND
            Vek IS NOT MISSING;

/* ********* PREDICTED plots ********* */
      TITLE4 "Observed 2020 by Predicted 2020";
      SYMBOL1 C=BLUE V=DOT HEIGHT=2PCT INTERPOL=NONE L=1 W=1;
      LABEL _predicted1 = "Predicted 2020";
      WHERE "2020"n IS NOT MISSING AND _predicted1 IS NOT MISSING;
      PLOT "2020"n * _predicted1 /
            VAXIS=AXIS1 VMINOR=0 HAXIS=AXIS3 HMINOR=0
            DESCRIPTION = "Observed 2020 by Predicted 2020"
      ;
      RUN;
      TITLE4 "Observed 2020 by Vek";
      SYMBOL1 C=BLUE V=DOT HEIGHT=2PCT INTERPOL=NONE L=1 W=1;
      SYMBOL2 C=BLUE V=NONE INTERPOL=JOIN L=1 W=1;
      SYMBOL3 C=BLUE V=NONE INTERPOL=JOIN L=1 W=1;
      SYMBOL4 C=BLUE V=NONE INTERPOL=JOIN L=1 W=1;
      WHERE "2020"n IS NOT MISSING AND Vek IS NOT MISSING;
      PLOT ("2020"n _predicted1 _l95m _u95m) * Vek /
            VAXIS=AXIS1 VMINOR=0 HAXIS=AXIS3 HMINOR=0
            DESCRIPTION = "Observed 2020 by Vek"
            OVERLAY
      ;
      RUN;
SYMBOL;
QUIT;
```

```
/* ---------------------------------------------------------------------
   End of task code.
   --------------------------------------------------------------------- */
RUN; QUIT;
%_eg_conditional_dropds(WORK.SORTTempTableSorted,
            WORK.TMP0TempTableForPlots);
TITLE; FOOTNOTE;
```

ARIMA

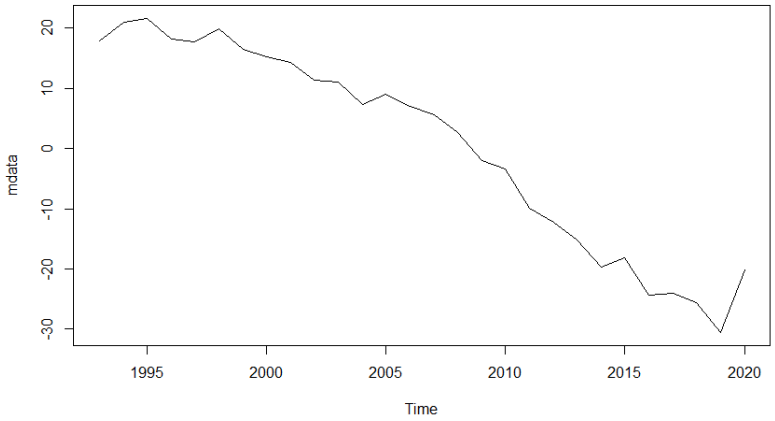
```
/* ---------------------------------------------------------------------
   Code generated by SAS Task
   Input Data: Local:WORK.LC_TOSAS1
   Server:  Local
   --------------------------------------------------------------------- */
ODS GRAPHICS ON;
%_eg_conditional_dropds(WORK.TMP0TempTableInput,
            WORK.TMP2TempTableForecastData);
/* ---------------------------------------------------------------------
   Sort data set WORK.LC_TOSAS1
   --------------------------------------------------------------------- */
PROC SORT
      DATA=WORK.LC_TOSAS1(KEEP=kappa_s Date)
      OUT=WORK.TMP0TempTableInput
      ;
      BY Date;
RUN;
TITLE;
TITLE1 "ARIMA Modeling and Forecasting";
TITLE2 "Results";
FOOTNOTE;
FOOTNOTE1 "Generated by the SAS System (&_SASSERVERNAME, &SYSSCPL) on
%TRIM(%QSYSFUNC(DATE(), NLDATE20.)) at %TRIM(%SYSFUNC(TIME(),
TIMEAMPM12.))";
PROC ARIMA DATA=WORK.TMP0TempTableInput PLOTS=FORECAST(FORECAST);
      IDENTIFY
            VAR=kappa_s(1)
            ;
      ESTIMATE
            P=(1)
            METHOD=ML
            MAXITER=50
            ;

      FORECAST
            ID=Date
            INTERVAL=YEAR
            LEAD=11
            ALPHA=0.05
            OUT=WORK.TMP2TempTableForecastData(LABEL="Forecasts for
WORK.LC_TOSAS1")
            ;
RUN; TITLE; FOOTNOTE;
DATA _NULL_;
      DSID = OPEN("WORK.TMP0TempTableInput");

      NUMOBS = ATTRN(DSID, 'NOBS');
```

```
      IF NUMOBS = -1 THEN
            NUMOBS = ATTRN(DSID, 'NLOBSF');
      PLOTSTART = 1;

      DATEVAR = VARNUM(DSID, "Date");

      SYSRC = FETCHOBS(DSID, PLOTSTART);
      STARTVAL = GETVARN(DSID, DATEVAR);

      SYSRC = FETCHOBS(DSID, NUMOBS);
      REFVAL = GETVARN(DSID, DATEVAR);
      RC = CLOSE(DSID);

      CALL SYMPUT('REFDATE', REFVAL);
      CALL SYMPUT('STARTDATE', STARTVAL);
RUN;
FOOTNOTE;
FOOTNOTE1 "Generated by the SAS System (&_SASSERVERNAME, &SYSSCPL) on
%TRIM(%QSYSFUNC(DATE(), NLDATE20.)) at %TRIM(%SYSFUNC(TIME(),
TIMEAMPM12.))";
/*------------------------------------------------------
    Plot the actual values
------------------------------------------------------ */
TITLE;
TITLE1 "ARIMA Modeling and Forecasting";
TITLE2 "Actual Values";

SYMBOL1 I=JOIN V=NONE C=BLUE;
GOPTIONS PUBLISH;
PROC GPLOT DATA = WORK.TMP0TempTableInput;
      PLOT (kappa_s) * Date = 1 /
;
RUN;
QUIT;
TITLE3;
SYMBOL;
TITLE;
/*------------------------------------------------------
    Plot of Residuals
------------------------------------------------------ */
TITLE;
TITLE1 "ARIMA Modeling and Forecasting";
TITLE2 "Residuals";

GOPTIONS PUBLISH;
PROC GPLOT DATA = WORK.TMP2TempTableForecastData NOCACHE ;
      PLOT (RESIDUAL) * Date = 1 / VREF=0
;
      SYMBOL1 I=NEEDLE V=NONE C=BLUE;
      WHERE Date > &STARTDATE & Date <= &REFDATE;
RUN;
QUIT;
TITLE3;
SYMBOL;
TITLE;
RUN;QUIT;TITLE;
/* ---------------------------------------------------------------------
   End of task code.
   --------------------------------------------------------------------- */
```

```
RUN; QUIT;
%_eg_conditional_dropds(WORK.TMP0TempTableInput,
            WORK.TMP2TempTableForecastData);
TITLE; FOOTNOTE;
ODS GRAPHICS OFF;
```

Príloha č. 2 – Ukážka ARIMA modelovania za pomoci funkcie *auto.arima()* v RStudio

```
'ARIMA model parametra kappa závislého od času LC modelu pre mužov:'

library(forecast)

library(tidyverse)

library(tseries)

data3 <- read.csv(file.choose())

mdata <- ts(data3$kappa_m,frequency = 1, start =c(1993,1) )

plot(mdata)
```



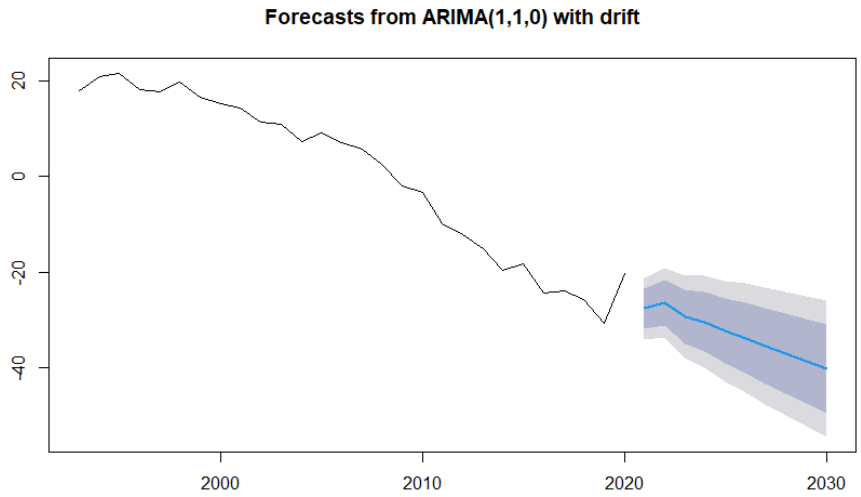

```
fit_ARIMA_m <- auto.arima(mdata)

fit_ARIMA_m
```

```
Series: mdata
ARIMA(1,1,0) with drift

Coefficients:
          ar1    drift
      -0.4848  -1.6130
s.e.   0.2527   0.4175

sigma^2 estimated as 10.61:  log likelihood=-69.29
AIC=144.57   AICc=145.62   BIC=148.46
```

```
forcastM <- forecast (fit_ARIMA_m, h = 10)

forcastM
```

```
     Point Forecast     Lo 80     Hi 80     Lo 95     Hi 95
2021      -27.63610 -31.80989 -23.46230 -34.01936 -21.25283
2022      -26.43346 -31.12858 -21.73833 -33.61403 -19.25289
2023      -29.41155 -35.05506 -23.76803 -38.04256 -20.78054
2024      -30.36274 -36.59988 -24.12560 -39.90162 -20.82386
2025      -32.29661 -39.16920 -25.42403 -42.80733 -21.78590
2026      -33.75407 -41.16555 -26.34258 -45.08896 -22.41917
2027      -35.44250 -43.37544 -27.50955 -47.57488 -23.31011
2028      -37.01894 -45.43232 -28.60556 -49.88610 -24.15178
2029      -38.64968 -47.52155 -29.77781 -52.21803 -25.08133
2030      -40.25410 -49.56002 -30.94817 -54.48628 -26.02191
```

plot(forcastM)



Príloha č. 3 – Parametre Lee-Carterovho modelu v závislosti od pohlavia

Tabuľka č. 22 - Odhad parameta $\kappa_t^{(2)}$ LC modelu pre mužov

Rok	$\kappa_t^{(2)}$	Rok	$\kappa_t^{(2)}$
1993	17,900	2007	5,650
1994	20,965	2008	2,603
1995	21,663	2009	-1,934
1996	18,189	2010	-3,413
1997	17,658	2011	-9,946
1998	19,890	2012	-12,234
1999	16,505	2013	-15,125
2000	15,222	2014	-19,682
2001	14,313	2015	-18,169
2002	11,388	2016	-24,350
2003	11,065	2017	-24,008
2004	7,357	2018	-25,665
2005	9,045	2019	-30,581
2006	7,037	2020	-20,215

Zdroj: vlastné spracovanie

Tabuľka č. 23 - Odhad parametrov $\beta_x^{(1)}$ a $\beta_x^{(2)}$ LC modelu pre mužov

Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$	Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$	Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$	Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$	Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$
0	-4,909	0,014	20	-7,018	0,008	40	-5,865	0,015	60	-3,895	0,010	80	-2,291	0,007
1	-7,414	0,011	21	-7,009	0,011	41	-5,757	0,015	61	-3,810	0,008	81	-2,199	0,005
2	-7,927	0,011	22	-7,028	0,010	42	-5,665	0,015	62	-3,717	0,009	82	-2,096	0,006
3	-8,383	0,024	23	-7,012	0,011	43	-5,524	0,016	63	-3,640	0,008	83	-2,009	0,006
4	-8,250	0,015	24	-6,962	0,012	44	-5,430	0,015	64	-3,573	0,009	84	-1,929	0,005
5	-8,431	0,018	25	-6,942	0,012	45	-5,326	0,013	65	-3,507	0,009	85	-1,854	0,004
6	-8,760	0,029	26	-6,932	0,010	46	-5,225	0,014	66	-3,426	0,009	86	-1,739	0,004
7	-8,667	0,021	27	-6,877	0,011	47	-5,118	0,014	67	-3,361	0,009	87	-1,670	0,004
8	-8,616	0,018	28	-6,907	0,011	48	-4,996	0,014	68	-3,277	0,010	88	-1,601	0,002
9	-8,537	0,014	29	-6,799	0,011	49	-4,900	0,014	69	-3,193	0,009	89	-1,514	0,001
10	-8,735	0,014	30	-6,761	0,012	50	-4,780	0,013	70	-3,116	0,010	90	-1,467	0,000
11	-8,562	0,011	31	-6,680	0,008	51	-4,694	0,012	71	-3,028	0,009	91	-1,387	0,000
12	-8,680	0,014	32	-6,665	0,013	52	-4,595	0,011	72	-2,950	0,010	92	-1,321	0,001
13	-8,529	0,021	33	-6,521	0,011	53	-4,507	0,011	73	-2,889	0,009	93	-1,335	-0,001
14	-8,130	0,006	34	-6,470	0,011	54	-4,401	0,011	74	-2,795	0,009	94	-1,291	-0,001
15	-8,047	0,013	35	-6,408	0,012	55	-4,341	0,011	75	-2,717	0,008	95	-1,303	0,000
16	-7,693	0,008	36	-6,296	0,010	56	-4,248	0,010	76	-2,639	0,008	96	-1,376	-0,001
17	-7,558	0,012	37	-6,173	0,010	57	-4,169	0,010	77	-2,567	0,007	97	-1,545	-0,004
18	-7,297	0,009	38	-6,073	0,014	58	-4,091	0,010	78	-2,474	0,006	98	-1,619	0,005
19	-7,156	0,009	39	-5,972	0,015	59	-3,990	0,010	79	-2,378	0,007	99	-2,321	-0,008

Zdroj: vlastné spracovanie

Tabuľka č. 24 - Odhad parameta $\kappa_t^{(2)}$ LC modelu pre ženy

Rok	$\kappa_t^{(2)}$	Rok	$\kappa_t^{(2)}$
1993	13,374	2007	4,446
1994	18,925	2008	0,021
1995	20,866	2009	-1,204
1996	15,553	2010	-2,315
1997	16,288	2011	-7,601
1998	15,371	2012	-8,247
1999	12,666	2013	-12,711
2000	11,937	2014	-17,655
2001	11,976	2015	-13,600
2002	9,214	2016	-19,983
2003	9,018	2017	-18,836
2004	6,588	2018	-21,106
2005	7,652	2019	-27,369
2006	4,967	2020	-17,255

Zdroj: vlastné spracovanie

Tabuľka č. 25 - Odhad parametrov $\beta_x^{(1)}$ a $\beta_x^{(2)}$ LC modelu pre ženy

Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$	Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$	Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$	Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$	Vek	$\beta_x^{(1)}$	$\beta_x^{(2)}$
0	-5,121	0,018	20	-8,269	0,003	40	-6,856	0,014	60	-4,862	0,010	80	-2,673	0,010
1	-7,604	0,012	21	-8,251	0,017	41	-6,740	0,011	61	-4,757	0,009	81	-2,544	0,010
2	-8,150	0,027	22	-8,245	0,008	42	-6,603	0,012	62	-4,682	0,011	82	-2,429	0,008
3	-8,354	0,021	23	-8,379	0,012	43	-6,545	0,010	63	-4,577	0,011	83	-2,290	0,008
4	-8,716	0,020	24	-8,249	-0,007	44	-6,369	0,012	64	-4,489	0,010	84	-2,192	0,007
5	-8,586	0,015	25	-8,174	0,006	45	-6,275	0,013	65	-4,380	0,013	85	-2,076	0,006
6	-9,023	0,018	26	-8,197	0,018	46	-6,185	0,010	66	-4,283	0,013	86	-1,959	0,005
7	-8,946	0,021	27	-7,987	0,004	47	-6,056	0,010	67	-4,168	0,013	87	-1,857	0,005
8	-8,696	0,004	28	-8,084	0,002	48	-5,997	0,010	68	-4,087	0,012	88	-1,764	0,005
9	-9,133	0,013	29	-8,016	0,008	49	-5,896	0,010	69	-3,987	0,014	89	-1,658	0,004
10	-9,055	0,022	30	-7,874	0,009	50	-5,775	0,008	70	-3,879	0,013	90	-1,564	0,002
11	-8,809	0,008	31	-7,809	0,014	51	-5,667	0,007	71	-3,770	0,013	91	-1,465	0,002
12	-9,055	0,023	32	-7,746	0,004	52	-5,569	0,011	72	-3,643	0,014	92	-1,420	0,001
13	-8,867	0,008	33	-7,619	0,013	53	-5,539	0,009	73	-3,527	0,015	93	-1,337	-0,001
14	-8,914	0,009	34	-7,523	0,011	54	-5,405	0,009	74	-3,411	0,014	94	-1,288	0,000
15	-8,563	0,010	35	-7,309	0,013	55	-5,327	0,011	75	-3,289	0,014	95	-1,277	0,002
16	-8,313	0,010	36	-7,298	0,010	56	-5,226	0,012	76	-3,174	0,013	96	-1,245	-0,002
17	-8,207	0,009	37	-7,161	0,010	57	-5,137	0,011	77	-3,053	0,012	97	-1,311	-0,003
18	-8,234	0,012	38	-7,079	0,015	58	-5,037	0,009	78	-2,925	0,012	98	-1,304	0,001
19	-8,184	0,004	39	-6,902	0,013	59	-4,944	0,010	79	-2,803	0,011	99	-1,802	-0,013

Zdroj: vlastné spracovanie