The Duration of Unemployment - Replicating Lalive et al. (2006, ReStud)

December 11, 2018

1 The contribution of this study

The principal objective of the study of Lalive et al, (2006) is to consider the influence of the change in insurance policy on the unemployment duration in Austria in late 1990s, which drives by both parameters of benefit replacement rate (RR) and the potential benefit duration (PBD).

In order to identify the causal effect of benefit duration on the willingness of individuals in job searching, a combined longitudinal database from both Austrian social security and Austrian unemployment register is employed which ranges from 1 August 1987 until 31 July 1991 (including 2 years prior to the enactment on the unemployment compensation and the following 2 years. In detail, in this natural experiment of studying the effect of exogeneous policy change on both compensated generosity and benefit duration of joblessness, Lalive et al (2006) divided in 4 groups based on the change of both parameters RR and BPD.

Both effect of PBD and RR on unemployment duration and its exit rate had presented in various researches in both US and European countries. While the evidences for these effects is mixed but all of these studies share the common objection in policy endogeineity and most of them focused on studying the different level of effect on female and male workers.

In this study, two types of sensitivity analyses were conducted on several specific subgroups in terms of age, monthly income and previous wage which focus on the main issue of heterogeneity in treatment and control groups; if the exit rate of these groups are subject to different time trend, estimated treatment effects may suffer from biaseness problem.

In the conclusion part of this study, the authors introduced totally 3 predictions in the influences of the isolated change in RR, PBD and the combined effects on the change of both parameters on the job search effort, unemployment duration and joblessness exit rate.

The first prediction is if the entitlement effects are negligile and/or most unemployment exists take place before benefit expire, increases in RR and extension in PBD should lead to a reduction in job search effort and hence to longer unemployment durations. The second one was that increases of RR should trigger strong behavioural responses early in the unemployment spells, whereas behavioural responses due to an extension of PBD should lead to strong responses around the dates when the benefits expire. The last one is that a simultaneous increase in RR and PBD should lead to an increase in unemployment durations larger than the sum of the increases from 2 isolated changes in these policy parameters.

Fortunately, the empirical results are clearly consistent with these prediction, however, there are 2 points of empirical results in this study which may not be reconciled with the theoretical predictions. The first one is the heterogeneity of PBD effect across the age groups. Contradicting to the prediction where an increase in experiences in older groups (more than age of 40) associates with a higher extension PBD, the empirical results illustrates a strong reaction of this group compared with the prime-age group. One of the reasons to explain this situation is the hirers' preferences for a position. Comparing with a candidate in prime-age groups, the olders one stands in a weaker position in the job market and may suffer from

the strict age-discrimination for the same vacancy. This means that they have low incentive in searching a job due to low probability of employability. Therefore, a more generous unemployment insurance system may reduce the effort of searching job in old worker than one in prime-aged group.

The second problem illustrated through empirical results is the lackage of theoretical evidence in explaining the interaction effects in variation of policy parameters among older and prime-age groups. An explanation given by Lalive et al (2006) is the too small size in the two policy changes which trigger to difficulty in measuring the interaction effects. However, the large interaction effect on the older worker group can be rationalized in much the same way to the large isolated effect of an effective tool PBD.

2 Attempt to replicate Table 4 of the paper

```
In [1]: # Data Preparation
        rm(list=objects())

In [2]: # Loading some necessary packages
        library(foreign)
        library(survival)
        library(dplyr)
        library(tidyr)
        library(KernSmooth)
        library(ggplot2)

In [3]: # Loading the dataset
        udat <- read.dta("fi.dta")

In [4]: # Checking the dimension
         print(dim(udat))

Out [4]: 225821    135


In [5]: # Getting rid of some superfluous variables
        udat <- udat[,1:134]

In [6]: # Checking the quantity of four groups of unemployed workers
        table(udat$type)


PBD and RR        PBD         RR    control
     21174      99404      32470      72773


In [7]: # Computation of average spells when durations are truncated at 104 weeks
         udat$dur104 <- udat$dur
         udat$dur104[(udat$dur104 > 104)] = 104

In [8]: # Creating a table containing "average", "std_dev", "std_error", "count"
        table4 <- udat %>%
        mutate(Type = ifelse(type == 'PBD', 'ePBD group',
```

```
            ifelse(type == 'RR', 'eRR group',
            ifelse(type == 'PBD and RR', 'ePBD-RR group', 'Control group')))) %>%
    group_by(Type, after) %>%
    summarize(average=mean(dur104), standard_deviation=sd(dur104), count=n()) %>%
    mutate(standard_error = standard_deviation / sqrt(count))
```

In [9]:
```
table4
```

Type	after	average	standard_deviation	count	standard_error
Control group	0	14.46226	14.38562	33815	0.07823008
Control group	1	15.63168	17.16584	38958	0.08696947
ePBD-RR group	0	18.48832	17.71669	11992	0.16178444
ePBD-RR group	1	22.73973	22.32690	9182	0.23300208
ePBD group	0	15.83402	16.64017	48294	0.07572010
ePBD group	1	18.08298	20.61513	51110	0.09118705
eRR group	0	17.10815	15.45186	17160	0.11795657
eRR group	1	19.09596	18.83882	15310	0.15225308

In [10]:
```
# Changing the of average table
avg_table4 <- table4 %>%
    select(Type, after, average) %>%
    spread(after, average) %>%
    mutate(Value = 'average') %>%
    rename(Before_August_1989 = '0', After_August_1989 = '1') %>%
    mutate(Change_After_Before = After_August_1989 - Before_August_1989) %>%
    mutate(Diff_in_diff = Change_After_Before - 1.17) %>%
    mutate_if(is.numeric, round, 2)
avg_table4$Position = c(4, 3, 1, 2)
```

In [11]:
```
# Changing form of std_error table
ste_table4 <- table4 %>%
select(Type, after, standard_error) %>%
spread(after, standard_error) %>%
mutate(Value = 'ste') %>%
rename(Before_August_1989 = '0', After_August_1989 = '1') %>%
mutate(Change_After_Before=sqrt(After_August_1989**2+Before_August_1989**2)) %>%
mutate(Diff_in_diff = sqrt(Change_After_Before**2 + 0.12**2)) %>%
mutate_if(is.numeric, round, 2)
ste_table4$Position = c(4, 3, 1, 2)
```

In [12]:
```
# Changing form of count table
count_table4 <- table4 %>%
    select(Type, after, count) %>%
    spread(after, count) %>%
    mutate(Value = 'count') %>%
    rename(Before_August_1989 = '0', After_August_1989 = '1') %>%
    mutate_if(is.numeric, round, 0)
count_table4$Position = c(4, 3, 1, 2)
```

In [13]:
```
# Concatenating three tables by rows
table4_final <- bind_rows(avg_table4, ste_table4, count_table4)
```

In [14]:
```
# Selecting necessaire variables
table4_final <- table4_final %>%
```

```
    arrange(Position) %>%
    select(Type, Value, Before_August_1989, After_August_1989,
           Change_After_Before, Diff_in_diff)
```

```
In [15]: # Putting values of Diff_in_diff variable in Control group = NA
         table4_final$Diff_in_diff[table4_final$Type == 'Control group'] = NA
```

```
In [16]: # Performing the results
         table4_final
```

Type	Value	Before_1989	After_1989	Change_After_Before	Diff_in_diff
ePBD group	average	15.83	18.08	2.25	1.08
ePBD group	ste	0.08	0.09	0.12	0.17
ePBD group	count	48,294	51,110	NA	NA
eRR group	average	17.11	19.10	1.99	0.82
eRR group	ste	0.12	0.15	0.19	0.23
eRR group	count	17,160	15,310	NA	NA
ePBD-RR group	average	18.49	22.74	4.25	3.08
ePBD-RR group	ste	0.16	0.23	0.28	0.31
ePBD-RR group	count	11,992	9,182	NA	NA
Control group	average	14.46	15.63	1.17	NA
Control group	ste	0.08	0.09	0.12	NA
Control group	count	33,815	38,958	NA	NA

3 Seek to reproduce Figure 3 in Lalive et al. (2006)

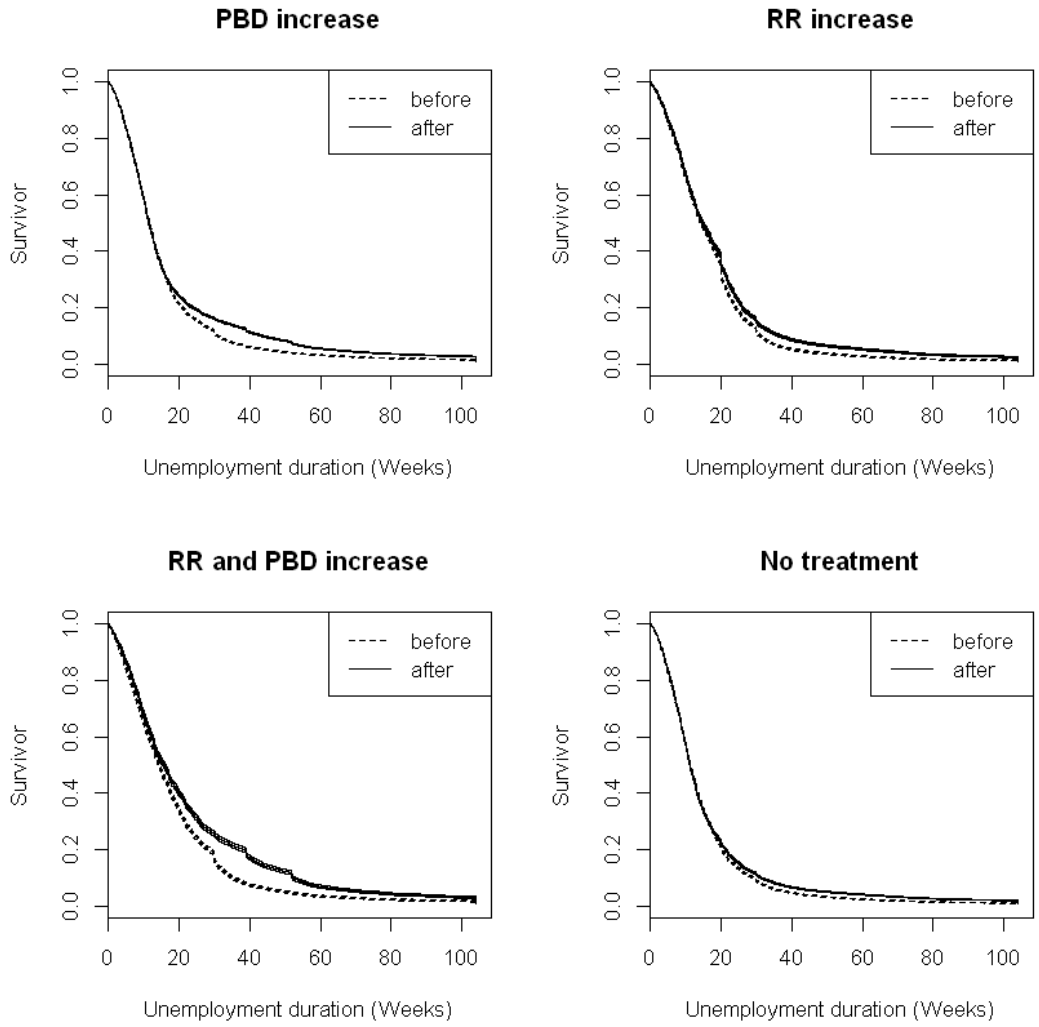
```
In [17]: # Selecting sub-samples
         PBD_before <- udat %>%
             filter(after == 0, type == 'PBD') %>%
             select(dur, dur104, uncc)
         PBD_after <- udat %>%
             filter(after == 1, type == 'PBD') %>%
             select(dur, dur104, uncc)
         RR_before <- udat %>%
             filter(after == 0, type == 'RR') %>%
             select(dur, dur104, uncc)
         RR_after <- udat %>%
             filter(after == 1, type == 'RR') %>%
             select(dur, dur104, uncc)
         PBD_RR_before <- udat %>%
             filter(after == 0, type == 'PBD and RR') %>%
             select(dur, dur104, uncc)
         PBD_RR_after <- udat %>%
             filter(after == 1, type == 'PBD and RR') %>%
             select(dur, dur104, uncc)
         control_before <- udat %>%
             filter(after == 0, type == 'control') %>%
             select(dur, dur104, uncc)
         control_after <- udat %>%
             filter(after == 1, type == 'control') %>%
             select(dur, dur104, uncc)
```

In [18]:
```
# Indicating censored/non-censored observations
surv_PBD_before <- Surv(PBD_before$dur104, PBD_before$uncc)
surv_PBD_after <- Surv(PBD_after$dur104, PBD_after$uncc)

surv_RR_before <- Surv(RR_before$dur104, RR_before$uncc)
surv_RR_after <- Surv(RR_after$dur104, RR_after$uncc)

surv_PBD_RR_before <- Surv(PBD_RR_before$dur104, PBD_RR_before$uncc)
surv_PBD_RR_after <- Surv(PBD_RR_after$dur104, PBD_RR_after$uncc)

surv_control_before <- Surv(control_before$dur104, control_before$uncc)
surv_control_after <- Surv(control_after$dur104, control_after$uncc)
```

In [19]:
```
# Estimating survivor function using Kaplan-Meier model
surv_PBD_before.fit <- survfit(surv_PBD_before ~ 1)
surv_PBD_after.fit <- survfit(surv_PBD_after ~ 1)

surv_RR_before.fit <- survfit(surv_RR_before ~ 1)
surv_RR_after.fit <- survfit(surv_RR_after ~ 1)

surv_PBD_RR_before.fit <- survfit(surv_PBD_RR_before ~ 1)
surv_PBD_RR_after.fit <- survfit(surv_PBD_RR_after ~ 1)

surv_control_before.fit <- survfit(surv_control_before ~ 1)
surv_control_after.fit <- survfit(surv_control_after ~ 1)
```

In [20]:
```
# Plotting the results
par(mfrow = c(2, 2))
plot(surv_PBD_before.fit, lty = "dashed", main="PBD increase",
     xlab="Unemployment duration (Weeks)", ylab="Survivor")
par(new=TRUE)
plot(surv_PBD_after.fit, lty = "solid", lwd = 1,
     xlab="Unemployment duration (Weeks)", ylab="Survivor")
par(new=T)
legend("topright", legend=c("before","after"),lty=2:1)

plot(surv_RR_before.fit, lty = "dashed", main="RR increase",
     xlab="Unemployment duration (Weeks)", ylab="Survivor")
par(new=TRUE)
plot(surv_RR_after.fit, lty = "solid", lwd = 1,
     xlab="Unemployment duration (Weeks)", ylab="Survivor")
par(new=T)
legend("topright", legend=c("before","after"),lty=2:1)

plot(surv_PBD_RR_before.fit, lty = "dashed", main="RR and PBD increase",
     xlab="Unemployment duration (Weeks)", ylab="Survivor")
par(new=TRUE)
plot(surv_PBD_RR_after.fit, lty = "solid", lwd = 0.5,
     xlab="Unemployment duration (Weeks)", ylab="Survivor")
par(new=T)
legend("topright", legend=c("before","after"),lty=2:1)
```

```
plot(surv_control_before.fit, lty = "dashed", main="No treatment",
     xlab="Unemployment duration (Weeks)", ylab="Survivor")
par(new=TRUE)
plot(surv_control_after.fit, lty = "solid", lwd = 1,
     xlab="Unemployment duration (Weeks)", ylab="Survivor")
par(new=T)
legend("topright", legend=c("before","after"),lty=2:1)
```



4 Seek to reproduce Figure 4 in Lalive et al. (2006)

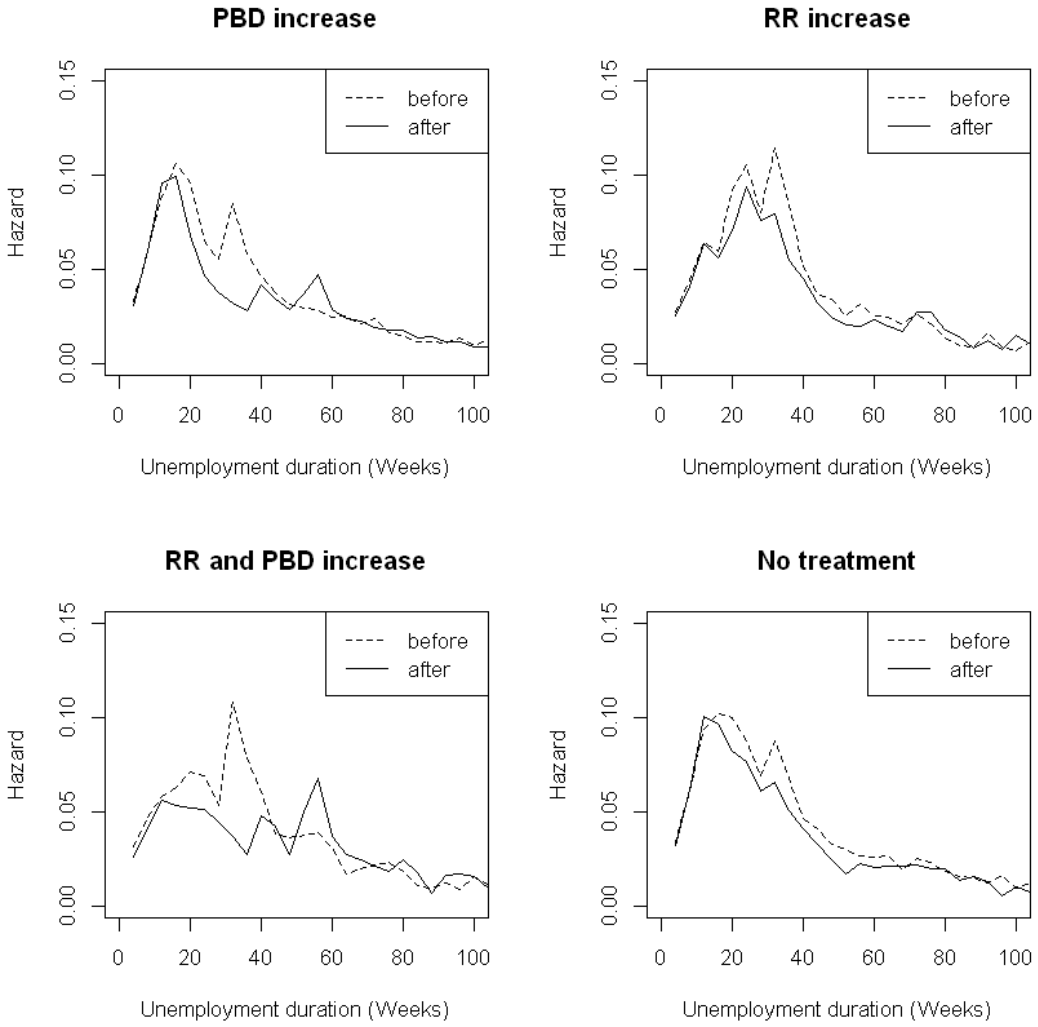
In [21]:
```
# Estimating the hazard using PH model
breaks <- seq(from=4,to=104, by=4)
# PBD before
gux1 <- survSplit(Surv(dur,uncc) ~., data=PBD_before, cut = breaks,
        end = "time", event="death", start="start", episode="interval")
gux1 <- mutate(gux1,exposure = time - start,
        interval=factor(interval+1, labels = 1))
```

```
di_PBD0 <- death~interval
model1 <- glm(di_PBD0 , offset = log(exposure),data=gux1,family = "poisson")
levels1 <- c(coefficients(model1)[1], coefficients(model1)[2:26] +
           coefficients(model1)[1])

# PBD after
gux2 <- survSplit(Surv(dur,uncc) ~., data=PBD_after, cut = breaks,
        end = "time", event="death", start="start", episode="interval")
gux2 <- mutate(gux2,exposure = time - start,
        interval=factor(interval+1, labels = 1))
model2 <- glm(di_PBD0 , offset = log(exposure),data=gux2,family = "poisson")
levels2 <- c(coefficients(model2)[1], coefficients(model2)[2:26] +
           coefficients(model2)[1])

# RR before
gux3 <- survSplit(Surv(dur,uncc) ~., data=RR_before, cut = breaks,
        end = "time", event="death", start="start", episode="interval")
gux3 <- mutate(gux3,exposure = time - start,
        interval=factor(interval+1, labels = 1))
di_RR0 <- death~interval
model3 <- glm(di_RR0 , offset = log(exposure),data=gux3,family = "poisson")
levels3 <- c(coefficients(model3)[1], coefficients(model3)[2:26] +
           coefficients(model3)[1])

# RR after
gux4 <- survSplit(Surv(dur,uncc) ~., data=RR_after, cut = breaks,
        end = "time", event="death", start="start", episode="interval")
gux4 <- mutate(gux4,exposure = time - start,
        interval=factor(interval+1, labels = 1))
model4 <- glm(di_RR0 , offset = log(exposure),data=gux4,family = "poisson")
levels4 <- c(coefficients(model4)[1], coefficients(model4)[2:26] +
           coefficients(model4)[1])

# RR and PBD before
gux5 <- survSplit(Surv(dur,uncc) ~., data=PBD_RR_before, cut = breaks,
        end = "time", event="death", start="start", episode="interval")
gux5 <- mutate(gux5,exposure = time - start,
        interval=factor(interval+1, labels = 1))
di_PBD_RR0 <- death~interval
model5 <- glm(di_PBD_RR0 , offset = log(exposure),data=gux5,family = "poisson")
levels5 <- c(coefficients(model5)[1], coefficients(model5)[2:26] +
           coefficients(model5)[1])

# RR and PBD after
gux6 <- survSplit(Surv(dur,uncc) ~., data=PBD_RR_after, cut = breaks,
        end = "time", event="death", start="start", episode="interval")
gux6 <- mutate(gux6,exposure = time - start,
        interval=factor(interval+1, labels = 1))
model6 <- glm(di_PBD_RR0 , offset = log(exposure),data=gux6,family = "poisson")
levels6 <- c(coefficients(model6)[1], coefficients(model6)[2:26] +
           coefficients(model6)[1])
```

```
# Control before
gux7 <- survSplit(Surv(dur,uncc) ~., data=control_before, cut = breaks,
        end = "time", event="death", start="start", episode="interval")
gux7 <- mutate(gux7,exposure = time - start,
        interval=factor(interval+1, labels = 1))
di_control0 <- death~interval
model7 <- glm(di_control0 , offset = log(exposure),data=gux7,family = "poisson")
levels7 <- c(coefficients(model7)[1], coefficients(model7)[2:26] +
           coefficients(model7)[1])

# Control after
gux8 <- survSplit(Surv(dur,uncc) ~., data=control_after, cut = breaks,
        end = "time", event="death", start="start", episode="interval")
gux8 <- mutate(gux8,exposure = time - start,
        interval=factor(interval+1, labels = 1))
model8 <- glm(di_control0 , offset = log(exposure),data=gux8,family = "poisson")
levels8 <- c(coefficients(model8)[1], coefficients(model8)[2:26] +
           coefficients(model8)[1])
```

In [22]:
```
# Plotting the results -> to reporduce Figure 4 in the paper
par(mfrow = c(2, 2))
plot(exp(levels1)~breaks, type = "l", lty = "dashed", xlim=c(0,100),
     ylim=c(0,0.15),xlab = "Unemployment duration (Weeks)",ylab = "Hazard")
par(new=T)
plot(exp(levels2)~breaks ,type = "l",lty = "solid", xlim=c(0,100),
     ylim=c(0,0.15),xlab = "Unemployment duration (Weeks)",ylab = "Hazard")
par(new=T)
title("PBD increase")
legend("topright", legend=c("before","after"),lty=2:1)

plot(exp(levels3)~breaks ,type = "l",lty = "dashed", xlim=c(0,100),
     ylim=c(0,0.15),xlab = "Unemployment duration (Weeks)",ylab = "Hazard")
par(new=T)
plot(exp(levels4)~breaks ,type = "l",lty = "solid", xlim=c(0,100),
     ylim=c(0,0.15),xlab = "Unemployment duration (Weeks)",ylab = "Hazard")
par(new=T)
title("RR increase")
legend("topright", legend=c("before","after"),lty=2:1)

plot(exp(levels5)~breaks ,type = "l",lty = "dashed", xlim=c(0,100),
     ylim=c(0,0.15),xlab = "Unemployment duration (Weeks)",ylab = "Hazard")
par(new=T)
plot(exp(levels6)~breaks ,type = "l",lty = "solid", xlim=c(0,100),
     ylim=c(0,0.15),xlab = "Unemployment duration (Weeks)",ylab = "Hazard")
par(new=T)
title("RR and PBD increase")
legend("topright", legend=c("before","after"),lty=2:1)

plot(exp(levels7)~breaks ,type = "l",lty = "dashed", xlim=c(0,100),
     ylim=c(0,0.15),xlab = "Unemployment duration (Weeks)",ylab = "Hazard")
par(new=T)
```

```
plot(exp(levels8)~breaks ,type = "l",lty = "solid", xlim=c(0,100),
     ylim=c(0,0.15),xlab = "Unemployment duration (Weeks)",ylab = "Hazard")
par(new=T)
title("No treatment")
legend("topright", legend=c("before","after"),lty=2:1)
```



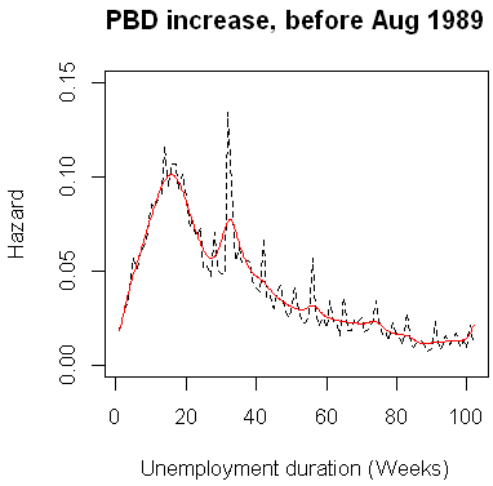
In [23]:
```
# Creating list of survivor function and duration estimated by KM model
hist_surv = list(summary(surv_PBD_before.fit)$surv,
                 summary(surv_PBD_after.fit)$surv,
                 summary(surv_RR_before.fit)$surv,
                 summary(surv_RR_after.fit)$surv,
                 summary(surv_PBD_RR_before.fit)$surv,
                 summary(surv_PBD_RR_after.fit)$surv,
                 summary(surv_control_before.fit)$surv,
                 summary(surv_control_after.fit)$surv)
hist_dur = list(summary(surv_PBD_before.fit)$time,
                 summary(surv_PBD_after.fit)$time,
                 summary(surv_RR_before.fit)$time,
```

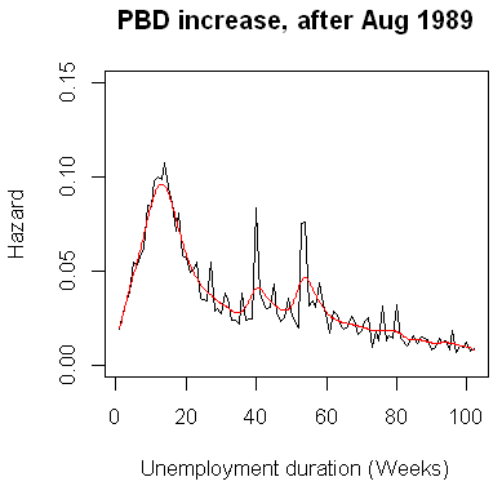
```
                    summary(surv_RR_after.fit)$time,
                    summary(surv_PBD_RR_before.fit)$time,
                    summary(surv_PBD_RR_after.fit)$time,
                    summary(surv_control_before.fit)$time,
                    summary(surv_control_after.fit)$time)
```

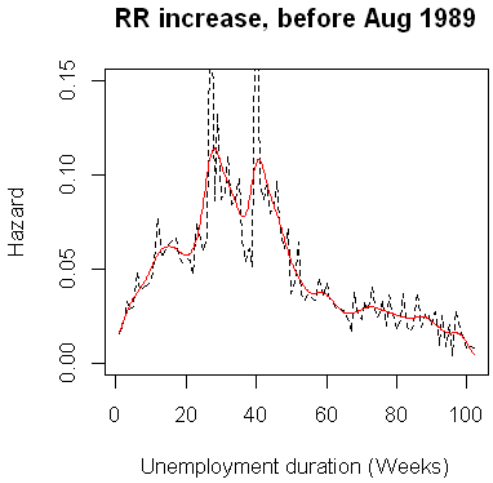
In [24]:
```
# Estimating hazard based on estimated survivor function S(t)
hazard = list()
local_regress = list()
for (i in (1:length(hist_surv))) { #loop 8 datasets PBD, RR, PBD and RR, control
    S = hist_surv[[i]]
    t = hist_dur[[i]]
    F = 1 - S
    weeks = seq(1, length(t), length.out = 104) # pick a smaller number of points
    S_week = S[weeks]
    F_week = F[weeks]
    t_week = t[weeks]
    f_week = (F_week[2:104] - F_week[1:103])/(t_week[2:104] - t_week[1:103])
    # computing approximation to f(t) = dF(t)/dt
    lambda = f_week[1:102]/S_week[1:102] # estimate hazard
    hazard[[i]] <- lambda
    # using local polynomial regression smoother
    local_regress[[i]] <- locpoly(c(1:102), lambda, bandwidth = 2)
}
```

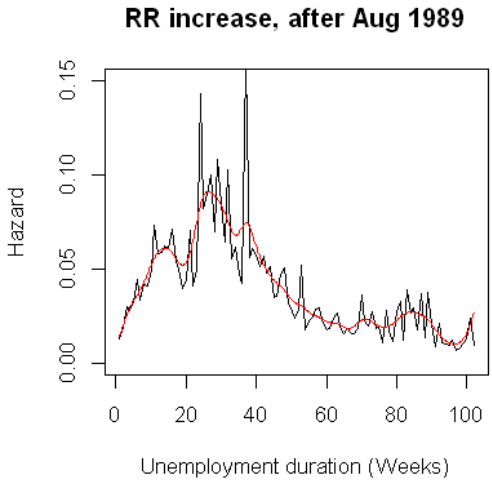
In [25]:
```
# Plotting the results
par(mfrow = c(2, 2))

# PBD increase, before Aug 1989
plot(hazard[[1]], type = 'l', lty = "dashed",
     main="PBD increase, before Aug 1989", ylim = c(0, 0.15),
     xlab="Unemployment duration (Weeks)", ylab="Hazard")
par(new = TRUE)
lines(local_regress[[1]], col = 'red')

# PBD increase, after Aug 1989
plot(hazard[[2]], type = 'l', lty = "solid",
     main="PBD increase, after Aug 1989", ylim = c(0, 0.15),
     xlab="Unemployment duration (Weeks)", ylab="Hazard")
par(new = TRUE)
lines(local_regress[[2]], col = 'red')

# RR increase, before Aug 1989
plot(hazard[[3]], type = 'l', lty = "dashed",
     main="RR increase, before Aug 1989", ylim = c(0, 0.15),
     xlab="Unemployment duration (Weeks)", ylab="Hazard")
par(new = TRUE)
lines(local_regress[[3]], col = 'red')

# RR increase, after Aug 1989
plot(hazard[[4]], type = 'l', lty = "solid",
     main="RR increase, after Aug 1989", ylim = c(0, 0.15),
```

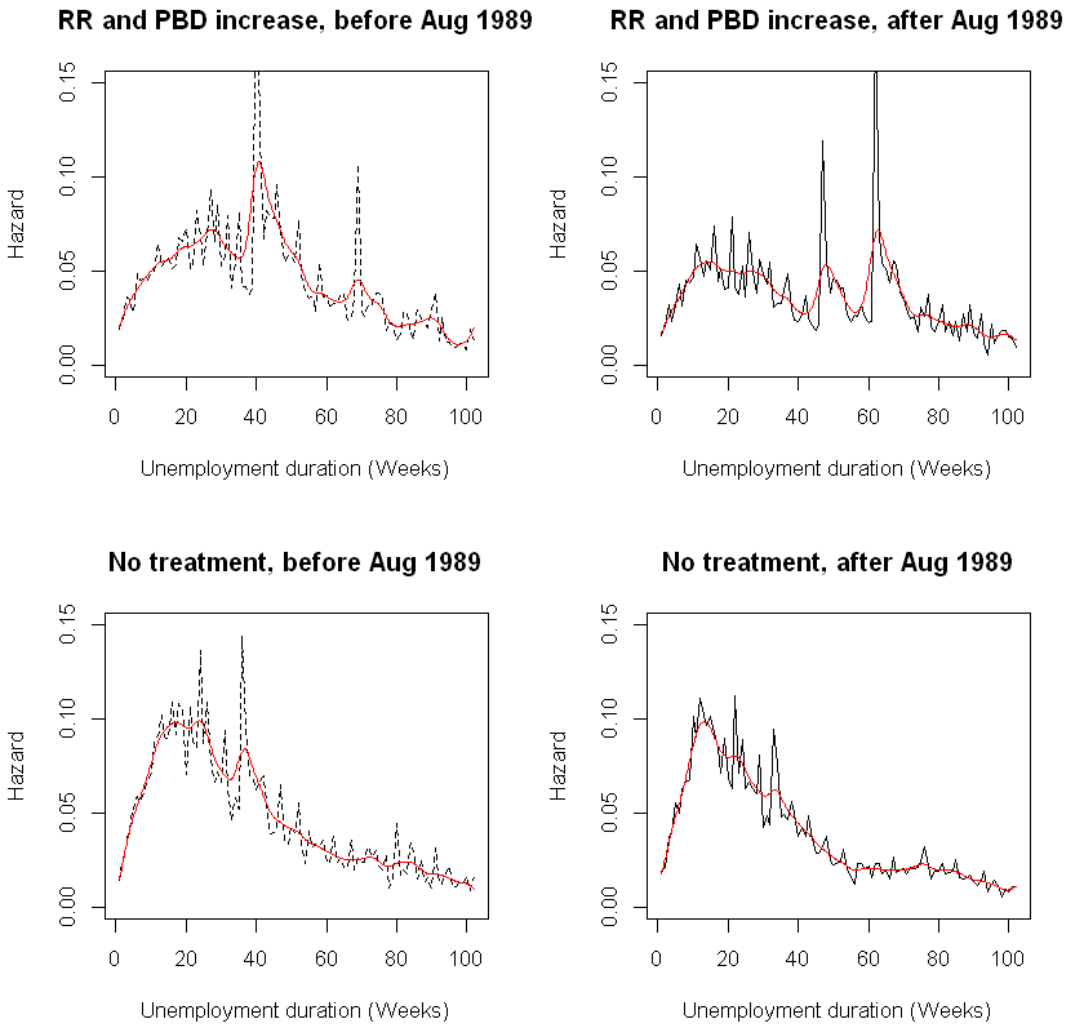
```
     xlab="Unemployment duration (Weeks)", ylab="Hazard")
par(new = TRUE)
lines(local_regress[[4]], col = 'red')

# RR and PBD increase, before Aug 1989
par(mfrow = c(2, 2))
plot(hazard[[5]], type = 'l', lty = "dashed",
     main="RR and PBD increase, before Aug 1989", ylim = c(0, 0.15),
     xlab="Unemployment duration (Weeks)", ylab="Hazard")
par(new = TRUE)
lines(local_regress[[5]], col = 'red')

# RR and PBD increase, after Aug 1989
plot(hazard[[6]], type = 'l', lty = "solid",
     main="RR and PBD increase, after Aug 1989", ylim = c(0, 0.15),
     xlab="Unemployment duration (Weeks)", ylab="Hazard")
par(new = TRUE)
lines(local_regress[[6]], col = 'red')

# No treatment, before Aug 1989
plot(hazard[[7]], type = 'l', lty = "dashed",
     main="No treatment, before Aug 1989", ylim = c(0, 0.15),
     xlab="Unemployment duration (Weeks)", ylab="Hazard")
par(new = TRUE)
lines(local_regress[[7]], col = 'red')

# No treatment, after Aug 1989
plot(hazard[[8]], type = 'l', lty = "solid",
     main="No treatment, after Aug 1989", ylim = c(0, 0.15),
     xlab="Unemployment duration (Weeks)", ylab="Hazard")
par(new = TRUE)
lines(local_regress[[8]], col = 'red')
```


PBD increase, before Aug 1989
Hazard
0.00
0.05
0.10
0.15
0
20
40
60
80
100
Unemployment duration (Weeks)


PBD increase, after Aug 1989
Hazard
0.00
0.05
0.10
0.15
0
20
40
60
80
100
Unemployment duration (Weeks)


RR increase, before Aug 1989
Hazard
0.00
0.05
0.10
0.15
0
20
40
60
80
100
Unemployment duration (Weeks)


RR increase, after Aug 1989
Hazard
0.00
0.05
0.10
0.15
0
20
40
60
80
100
Unemployment duration (Weeks)



5 Estimate the causal treatment effect in a PH model

- dur: duration of unemployment spell (weeks)
- bdur: potential benefit duration (weeks)
- uncc =1: if spell not censored
- tr =1 if replacement rate change
- t39 = 1 if PBD 30-39 change
- t52 = 1 if PBD 30-52 change
- t39_tr = t39 * tr
- t52_tr = t52 * tr
- tr_a0 = tr * after0
- t39_a0 = t39 * after0
- t52_a0 = t52 * after0
- t39tra0 = t39 * tr * after0
- t52tra0 = t52 * tr * after0
- after = 1 if spell starts after Aug 1, 1989
- after0 = 1 if interval 0 after Aug 1, 1989

```
In [26]: udat$all <- udat$tr * (udat$t39 + udat$t52)

In [27]: breaks <- seq(from=3,to=59, by=4)

In [28]: labels <- paste("(", c(0,breaks), ",", c(breaks,104), "]",sep="")

In [29]: gux <- survSplit(Surv(dur104,uncc) ~., data=udat, cut = breaks,
                end = "time", event="death", start="start", episode="interval")

In [30]: gux <- mutate(gux, exposure = time - start,
                interval = factor(interval + 1, labels = labels))

In [31]: # Creating interaction terms
         mf <- death ~ interval*tr + interval*t39 + interval*t52 + interval*all +
                       interval*after0 + interval*tr_a0 + interval*t39_a0 +
                       interval*t52_a0 + interval*t39tra0 + interval*t52tra0 +
                       age + married + single + divorced + f_marr + f_single +
                       f_divor + med_educ + hi_educ + lehre + nwage_pj + bc +
                       lwage + ten72 + pnon_10 + seasonal + manuf + y1988 +
                       y1989 + y1990 + y1991 + q2 + q3 + q4

In [32]: # Estimating PWE PH model
         pwe <- glm(mf, offset = log(exposure), data = gux, family = poisson)

In [33]: # Performing the results
         summary(pwe)


Call:
glm(formula = mf, family = poisson, data = gux, offset = log(exposure))

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.4745  -0.7107  -0.5210  -0.3314   4.2496

Coefficients:
                          Estimate Std. Error z value Pr(>|z|)
(Intercept)             -5.119e+00  1.341e-01 -38.175  < 2e-16 ***
interval(3,7]            6.443e-01  2.243e-02  28.728  < 2e-16 ***
interval(7,11]           1.098e+00  2.202e-02  49.872  < 2e-16 ***
interval(11,15]          1.334e+00  2.289e-02  58.305  < 2e-16 ***
interval(15,19]          1.375e+00  2.511e-02  54.764  < 2e-16 ***
interval(19,23]          1.500e+00  2.747e-02  54.599  < 2e-16 ***
interval(23,27]          1.201e+00  3.412e-02  35.206  < 2e-16 ***
interval(27,31]          1.328e+00  3.669e-02  36.181  < 2e-16 ***
interval(31,35]          1.195e+00  4.467e-02  26.762  < 2e-16 ***
interval(35,39]          8.210e-01  5.910e-02  13.891  < 2e-16 ***
interval(39,43]          6.890e-01  6.909e-02   9.972  < 2e-16 ***
interval(43,47]          5.786e-01  7.938e-02   7.289 3.12e-13 ***
interval(47,51]          4.472e-01  9.102e-02   4.913 8.96e-07 ***
interval(51,55]          3.203e-01  1.032e-01   3.102 0.001920 **
interval(55,59]          2.304e-01  1.141e-01   2.020 0.043397 *
interval(59,104]         3.013e-01  4.704e-02   6.405 1.50e-10 ***
```

```
tr                      1.112e-01  3.419e-02   3.253 0.001142 **
t39                     7.035e-02  2.575e-02   2.731 0.006307 **
t52                    -7.359e-02  3.767e-02  -1.954 0.050732 .
all                     2.120e-01  4.800e-02   4.416 1.01e-05 ***
after0                  5.266e-02  2.715e-02   1.940 0.052429 .
tr_a0                  -2.467e-02  4.849e-02  -0.509 0.610893
t39_a0                  1.176e-02  3.554e-02   0.331 0.740664
t52_a0                  7.361e-02  5.115e-02   1.439 0.150168
t39tra0                -1.198e-01  7.548e-02  -1.587 0.112424
t52tra0                -2.967e-01  1.074e-01  -2.761 0.005762 **
age                    -1.314e-02  6.251e-04 -21.027  < 2e-16 ***
married                 1.784e-01  1.262e-02  14.143  < 2e-16 ***
single                  4.288e-02  1.407e-02   3.047 0.002309 **
divorced               -8.127e-02  1.496e-02  -5.433 5.54e-08 ***
f_marr                 -1.153e-01  6.507e-03 -17.713  < 2e-16 ***
f_single                8.672e-02  1.192e-02   7.278 3.38e-13 ***
f_divor                 1.670e-03  1.252e-02   0.133 0.893957
med_educ               -1.565e-01  1.095e-02 -14.284  < 2e-16 ***
hi_educ                -2.477e-01  1.257e-02 -19.701  < 2e-16 ***
lehre                  -4.243e-02  4.928e-03  -8.610  < 2e-16 ***
nwage_pj               -8.448e-06  1.190e-06  -7.102 1.23e-12 ***
bc                      4.027e-01  6.556e-03  61.422  < 2e-16 ***
lwage                   2.667e-01  2.255e-02  11.831  < 2e-16 ***
ten72                  -4.687e-03  5.212e-04  -8.994  < 2e-16 ***
pnon_10                -6.674e-02  1.271e-02  -5.249 1.53e-07 ***
seasonal                3.678e-01  5.323e-03  69.096  < 2e-16 ***
manuf                  -1.102e-01  6.447e-03 -17.097  < 2e-16 ***
y1988                   6.410e-02  7.750e-03   8.271  < 2e-16 ***
y1989                   5.086e-02  1.028e-02   4.946 7.58e-07 ***
y1990                  -1.236e-02  1.399e-02  -0.884 0.376856
y1991                  -6.473e-02  1.657e-02  -3.906 9.38e-05 ***
q2                     -1.761e-02  6.782e-03  -2.597 0.009408 **
q3                     -2.420e-01  7.847e-03 -30.843  < 2e-16 ***
q4                     -2.118e-01  6.907e-03 -30.660  < 2e-16 ***
interval(3,7]:tr       -1.831e-01  4.129e-02  -4.434 9.24e-06 ***
interval(7,11]:tr      -2.329e-01  4.027e-02  -5.785 7.26e-09 ***
interval(11,15]:tr     -3.728e-01  4.175e-02  -8.930  < 2e-16 ***
interval(15,19]:tr     -4.091e-01  4.459e-02  -9.174  < 2e-16 ***
interval(19,23]:tr      2.452e-01  4.401e-02   5.572 2.52e-08 ***
interval(23,27]:tr      2.275e-01  5.318e-02   4.279 1.88e-05 ***
interval(27,31]:tr      2.071e-01  5.723e-02   3.619 0.000296 ***
interval(31,35]:tr      2.025e-01  6.961e-02   2.910 0.003619 **
interval(35,39]:tr      1.533e-01  9.282e-02   1.651 0.098655 .
interval(39,43]:tr     -1.986e-01  1.190e-01  -1.668 0.095285 .
interval(43,47]:tr     -1.320e-02  1.281e-01  -0.103 0.917940
interval(47,51]:tr     -3.306e-01  1.613e-01  -2.050 0.040365 *
interval(51,55]:tr     -1.116e-02  1.645e-01  -0.068 0.945928
interval(55,59]:tr      4.397e-02  1.797e-01   0.245 0.806723
interval(59,104]:tr    -1.223e-01  7.781e-02  -1.572 0.116021
interval(3,7]:t39      -8.442e-03  3.076e-02  -0.274 0.783725
interval(7,11]:t39     -2.339e-02  3.019e-02  -0.775 0.438582
```

```
interval(11,15]:t39       7.466e-03  3.123e-02   0.239 0.811076
interval(15,19]:t39       5.431e-02  3.409e-02   1.593 0.111119
interval(19,23]:t39      -3.365e-01  3.881e-02  -8.669  < 2e-16 ***
interval(23,27]:t39      -2.411e-01  4.700e-02  -5.131 2.89e-07 ***
interval(27,31]:t39       4.303e-02  4.796e-02   0.897 0.369621
interval(31,35]:t39      -1.385e-02  5.874e-02  -0.236 0.813582
interval(35,39]:t39       1.180e-01  7.553e-02   1.562 0.118305
interval(39,43]:t39       1.534e-01  8.814e-02   1.741 0.081761 .
interval(43,47]:t39       9.108e-02  1.021e-01   0.892 0.372132
interval(47,51]:t39       1.024e-01  1.166e-01   0.879 0.379621
interval(51,55]:t39       1.299e-01  1.301e-01   0.999 0.317980
interval(55,59]:t39      -5.248e-02  1.492e-01  -0.352 0.725067
interval(59,104]:t39     -4.013e-03  6.146e-02  -0.065 0.947940
interval(3,7]:t52         6.730e-02  4.402e-02   1.529 0.126300
interval(7,11]:t52        7.335e-02  4.308e-02   1.703 0.088649 .
interval(11,15]:t52       2.366e-01  4.373e-02   5.411 6.25e-08 ***
interval(15,19]:t52       3.252e-01  4.703e-02   6.914 4.70e-12 ***
interval(19,23]:t52      -3.330e-02  5.315e-02  -0.627 0.530956
interval(23,27]:t52      -2.978e-02  6.396e-02  -0.466 0.641572
interval(27,31]:t52       1.013e-01  6.475e-02   1.565 0.117651
interval(31,35]:t52      -3.230e-01  8.407e-02  -3.842 0.000122 ***
interval(35,39]:t52      -1.777e-01  1.040e-01  -1.709 0.087397 .
interval(39,43]:t52      -4.916e-01  1.312e-01  -3.747 0.000179 ***
interval(43,47]:t52      -4.009e-01  1.417e-01  -2.830 0.004651 **
interval(47,51]:t52      -2.937e-01  1.544e-01  -1.903 0.057090 .
interval(51,55]:t52       6.997e-01  1.387e-01   5.044 4.56e-07 ***
interval(55,59]:t52       2.380e-01  1.686e-01   1.411 0.158121
interval(59,104]:t52      2.941e-01  7.060e-02   4.165 3.11e-05 ***
interval(3,7]:all        -1.250e-01  5.974e-02  -2.092 0.036481 *
interval(7,11]:all       -2.293e-01  5.868e-02  -3.908 9.29e-05 ***
interval(11,15]:all      -2.736e-01  6.059e-02  -4.516 6.31e-06 ***
interval(15,19]:all      -2.659e-01  6.434e-02  -4.133 3.58e-05 ***
interval(19,23]:all      -4.908e-01  6.627e-02  -7.406 1.30e-13 ***
interval(23,27]:all      -4.293e-01  7.808e-02  -5.498 3.85e-08 ***
interval(27,31]:all      -3.051e-01  7.882e-02  -3.871 0.000109 ***
interval(31,35]:all      -1.586e-01  9.573e-02  -1.656 0.097648 .
interval(35,39]:all      -2.069e-01  1.246e-01  -1.660 0.096837 .
interval(39,43]:all      -1.798e-02  1.584e-01  -0.114 0.909599
interval(43,47]:all      -1.269e-01  1.738e-01  -0.730 0.465447
interval(47,51]:all       1.561e-01  2.094e-01   0.745 0.456216
interval(51,55]:all      -8.980e-02  2.066e-01  -0.435 0.663779
interval(55,59]:all      -6.554e-02  2.384e-01  -0.275 0.783390
interval(59,104]:all     -2.091e-01  1.049e-01  -1.993 0.046245 *
interval(3,7]:after0     -1.306e-03  3.087e-02  -0.042 0.966272
interval(7,11]:after0     9.369e-02  3.013e-02   3.109 0.001876 **
interval(11,15]:after0    6.526e-02  3.142e-02   2.077 0.037796 *
interval(15,19]:after0   -1.703e-01  3.517e-02  -4.841 1.29e-06 ***
interval(19,23]:after0   -1.594e-01  3.800e-02  -4.194 2.75e-05 ***
interval(23,27]:after0   -9.750e-02  4.644e-02  -2.099 0.035791 *
interval(27,31]:after0   -2.475e-01  5.070e-02  -4.881 1.06e-06 ***
interval(31,35]:after0   -3.032e-01  6.127e-02  -4.949 7.47e-07 ***
```

```
interval(35,39]:after0   -1.671e-01  7.793e-02  -2.144 0.032032 *
interval(39,43]:after0   -2.190e-01  9.133e-02  -2.398 0.016497 *
interval(43,47]:after0   -3.430e-01  1.065e-01  -3.221 0.001276 **
interval(47,51]:after0   -4.347e-01  1.231e-01  -3.530 0.000415 ***
interval(51,55]:after0   -2.599e-01  1.334e-01  -1.947 0.051479 .
interval(55,59]:after0   -2.672e-01  1.471e-01  -1.816 0.069317 .
interval(59,104]:after0  -1.369e-01  5.934e-02  -2.307 0.021045 *
interval(3,7]:tr_a0      -2.158e-02  5.987e-02  -0.360 0.718476
interval(7,11]:tr_a0     -4.956e-02  5.799e-02  -0.855 0.392735
interval(11,15]:tr_a0    -5.292e-02  6.027e-02  -0.878 0.379912
interval(15,19]:tr_a0     9.966e-03  6.543e-02   0.152 0.878931
interval(19,23]:tr_a0    -3.454e-02  6.369e-02  -0.542 0.587626
interval(23,27]:tr_a0     7.907e-02  7.501e-02   1.054 0.291798
interval(27,31]:tr_a0    -2.856e-02  8.264e-02  -0.346 0.729660
interval(31,35]:tr_a0    -1.069e-01  1.001e-01  -1.069 0.285274
interval(35,39]:tr_a0    -1.083e-01  1.274e-01  -0.850 0.395522
interval(39,43]:tr_a0     1.928e-01  1.576e-01   1.224 0.221104
interval(43,47]:tr_a0     9.283e-02  1.749e-01   0.531 0.595515
interval(47,51]:tr_a0     3.563e-01  2.141e-01   1.664 0.096118 .
interval(51,55]:tr_a0    -2.514e-02  2.206e-01  -0.114 0.909232
interval(55,59]:tr_a0    -5.358e-02  2.403e-01  -0.223 0.823558
interval(59,104]:tr_a0    1.544e-01  1.008e-01   1.532 0.125612
interval(3,7]:t39_a0     -7.963e-03  4.309e-02  -0.185 0.853403
interval(7,11]:t39_a0    -1.662e-02  4.207e-02  -0.395 0.692729
interval(11,15]:t39_a0    7.023e-03  4.369e-02   0.161 0.872309
interval(15,19]:t39_a0   -4.168e-02  4.893e-02  -0.852 0.394240
interval(19,23]:t39_a0   -9.053e-02  5.568e-02  -1.626 0.103990
interval(23,27]:t39_a0   -1.518e-01  6.651e-02  -2.283 0.022431 *
interval(27,31]:t39_a0   -5.680e-01  7.153e-02  -7.941 2.00e-15 ***
interval(31,35]:t39_a0   -4.445e-01  8.495e-02  -5.233 1.67e-07 ***
interval(35,39]:t39_a0    5.208e-02  9.967e-02   0.523 0.601264
interval(39,43]:t39_a0    2.898e-01  1.150e-01   2.520 0.011720 *
interval(43,47]:t39_a0    3.749e-01  1.346e-01   2.786 0.005342 **
interval(47,51]:t39_a0    2.680e-01  1.565e-01   1.712 0.086872 .
interval(51,55]:t39_a0    1.353e-01  1.698e-01   0.797 0.425698
interval(55,59]:t39_a0    2.577e-01  1.924e-01   1.339 0.180521
interval(59,104]:t39_a0   4.214e-02  7.910e-02   0.533 0.594171
interval(3,7]:t52_a0     -6.462e-02  6.167e-02  -1.048 0.294745
interval(7,11]:t52_a0    -7.802e-02  5.998e-02  -1.301 0.193387
interval(11,15]:t52_a0   -1.670e-01  6.132e-02  -2.724 0.006449 **
interval(15,19]:t52_a0   -3.078e-01  6.782e-02  -4.539 5.65e-06 ***
interval(19,23]:t52_a0   -4.590e-01  7.760e-02  -5.915 3.31e-09 ***
interval(23,27]:t52_a0   -5.707e-01  9.290e-02  -6.143 8.08e-10 ***
interval(27,31]:t52_a0   -8.317e-01  9.891e-02  -8.409  < 2e-16 ***
interval(31,35]:t52_a0   -4.421e-01  1.203e-01  -3.675 0.000238 ***
interval(35,39]:t52_a0   -5.272e-01  1.429e-01  -3.689 0.000225 ***
interval(39,43]:t52_a0   -3.695e-02  1.683e-01  -0.220 0.826222
interval(43,47]:t52_a0    1.197e-01  1.817e-01   0.659 0.510130
interval(47,51]:t52_a0    4.985e-01  1.936e-01   2.575 0.010011 *
interval(51,55]:t52_a0    8.848e-01  1.707e-01   5.185 2.16e-07 ***
interval(55,59]:t52_a0    6.587e-01  2.071e-01   3.181 0.001466 **
```

```
interval(59,104]:t52_a0   1.458e-02  9.089e-02   0.160 0.872574
interval(3,7]:t39tra0     7.489e-02  9.412e-02   0.796 0.426247
interval(7,11]:t39tra0    1.173e-01  9.175e-02   1.278 0.201180
interval(11,15]:t39tra0   1.121e-01  9.517e-02   1.178 0.238710
interval(15,19]:t39tra0   2.271e-01  1.025e-01   2.215 0.026763 *
interval(19,23]:t39tra0   1.948e-01  1.060e-01   1.838 0.066052 .
interval(23,27]:t39tra0   2.171e-01  1.207e-01   1.798 0.072193 .
interval(27,31]:t39tra0   1.575e-01  1.313e-01   1.200 0.230014
interval(31,35]:t39tra0   5.856e-02  1.546e-01   0.379 0.704903
interval(35,39]:t39tra0   1.841e-01  1.762e-01   1.045 0.296140
interval(39,43]:t39tra0   3.073e-01  2.093e-01   1.468 0.142072
interval(43,47]:t39tra0  -4.062e-03  2.417e-01  -0.017 0.986590
interval(47,51]:t39tra0  -1.342e-01  2.893e-01  -0.464 0.642833
interval(51,55]:t39tra0   3.084e-01  2.937e-01   1.050 0.293700
interval(55,59]:t39tra0   1.309e-01  3.377e-01   0.388 0.698260
interval(59,104]:t39tra0  5.579e-02  1.496e-01   0.373 0.709169
interval(3,7]:t52tra0     9.462e-02  1.331e-01   0.711 0.477234
interval(7,11]:t52tra0    1.354e-01  1.287e-01   1.052 0.292589
interval(11,15]:t52tra0   1.780e-01  1.314e-01   1.354 0.175629
interval(15,19]:t52tra0   1.996e-01  1.416e-01   1.410 0.158529
interval(19,23]:t52tra0   2.410e-01  1.465e-01   1.645 0.099971 .
interval(23,27]:t52tra0   4.843e-01  1.599e-01   3.028 0.002459 **
interval(27,31]:t52tra0   2.018e-01  1.793e-01   1.125 0.260579
interval(31,35]:t52tra0  -1.709e-01  2.178e-01  -0.785 0.432701
interval(35,39]:t52tra0   2.760e-01  2.361e-01   1.169 0.242342
interval(39,43]:t52tra0   8.565e-02  2.676e-01   0.320 0.748934
interval(43,47]:t52tra0   7.694e-02  2.874e-01   0.268 0.788910
interval(47,51]:t52tra0  -3.267e-01  3.166e-01  -1.032 0.302204
interval(51,55]:t52tra0   5.062e-01  2.800e-01   1.808 0.070630 .
interval(55,59]:t52tra0   4.275e-01  3.293e-01   1.298 0.194221
interval(59,104]:t52tra0  3.140e-01  1.671e-01   1.879 0.060206 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 1016945  on 1057905  degrees of freedom
Residual deviance:  943809  on 1057706  degrees of freedom
AIC: 1376895

Number of Fisher Scoring iterations: 6
```