Advanced analysis of longitudinal data

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Preface

Alternatives for advanced longitudinal analysis

Below is a proposal of the different analysis that could be done on the longitudinal survey data. They are ordered by complexity and also by the value of the results for informing responses and policy development. Publications-wise, all of these could be shaped into regional analysis, country analysis or thematic analysis.

1. **Cross-sectional trend analysis:** Looking at changes over time in key indicators such as living conditions, economic status, integration, needs, intentions and return conditions. This can identify both short-term fluctuations and long-term trends.
2. **Cohort analysis:** Despite not having the same respondents every time, you can track specific cohorts based on shared characteristics (e.g., X,Y,Z round participation, age, location, origin, or time of displacement) to see how their experiences and responses change over time.
3. **Survival analysis:** the probability that a subject will survive (not experience the event) past a certain time. In the context of Ukraine's displaced population, for example, to understand those who have returned to Ukraine, the duration of displacement and factors that contribute to the likelihood of return or not, or the likelihood to be employed and integrated abroad.
4. **Predictive modelling:** Using the data to predict future trends in refugee movements or returnees, on evolutions of intentions, or to anticipate the needs of these populations, based on past patterns and current responses.
5. **Change-point analysis:** Identifying points in time when significant shifts in responses occurred, which could be linked to external events or changes in the situation in Ukraine, shelling campaigns, TP extensions, etc.
6. **Impact assessment:** Analys the impact of specific events (e.g., changes in conflict intensity, policy changes, or humanitarian interventions) on the well-being of refugees and returnees.
7. **Path analysis:** doing multiple regressions analysis to generate a complex model of refugee and returnee behaviour, to understand how context and individual factors interact to affect outcomes, such as integration process in different locations, or based on

certain household or individual characteristics. For example, mapping the complex relations between employment, language proficiency, previous employment categories and education (employment status directly affects integration, while language proficiency affects both employment status and integration directly, and education affects language proficiency, which in turn affects employment and integration). To understand the direct and indirect relations between variables, testing basic hypothesis about Ukraine refugees.

8. **Natural language processing (NLP)** on open-ended questions from the longitudinal survey, through a)thematic analysis to identify common themes or topics that emerge from the survey responses and how they evolved over time, b)sentiment analysis: This involves assessing the sentiment or emotional tone behind the responses. You can determine whether the overall sentiment about a certain aspect of refugee life, such as living conditions or access to services, is positive, negative, or neutral, c)keyword extraction, and d) predictive analysis to predict outcomes or trends based on language used (language used before actually returning, or for those staying). Overall, analysing the qualitative answers would allow for better understanding the experiences and perceptions of Ukrainian refugees and returnees, while contextualizing the quantitative findings and giving a voice to the personal stories behind the numbers.

9. **Panel attrition analysis and addressing/filling missing values:** To understand the nature of the panel data better, analysing the patterns of drop-out or non-response among participants and assessing how this might affect the results. Also adjusting for missing values and exploring strategies to fill missing values based on other responses.

10. **Mixed-methods analysis:** Combining the quantitative data with the qualitative data from the open-ended survey questions to provide a more nuanced understanding of the refugees' and returnees' experiences.

1 Introduction

2 Predictive modeling

To date, a scheme has been developed to find statistically significant predictors of categorical dependent variables based on chi-square criterion, analysis of residuals, and effect size determination for cross-tabulation tables. The individual predictors are then combined into an overall prediction model using logistic regression. The most recent application of such a scheme is the prediction of household debt in Round 21. Applying this scheme to analyze the data for Poland did not reveal any important differences.

Challenges: The predicted criterion and predictors must be measured in the same round or be not too far apart in time, because otherwise the sample size starts to shrink significantly.

To account for the longitudinal nature of our data, I developed an algorithm to find the most recent records for each respondent when a change in their status occurred. In the process of applying the algorithm, some problematic issues emerged - for example, there are a significant number of respondents who have never been interviewed as refugees, the number of returnees in later rounds is very small, which makes it difficult to infer statistically significant trends, in some rounds a significant number of new respondents are recruited, which interferes with the processes of natural status change. All these features significantly affect the efficiency of longitudinal analysis methods.

3 Trajectory mining

3.1 General description of Traminer use in LS, specificities of LS data

3.1.1 How blanks/missing values are filled

3.1.2 Why this is necessary

3.1.3 Method chosen

3.1.4 Bias/limits

3.2 How number of states are reduced

3.2.1 Why this is necessary

3.2.2 Rationale/justification for choice of aggregation of states

3.2.3 Bias/limits

3.2.4 Example (with visuals and written analysis) to walk reader through this

4 Trajectories of accommodation in Germany

The data were prepared for analysis as follows: the longitudinal data format was converted into a wide format for two variables: country and accommodation for rounds 4, 10, 16, 21/22. The converted data are stored in the file "wide-accomm.rds" for further analysis of trajectories.

,

accommodation.

```
library(TraMineR)
```

```
TraMineR stable version 2.2-9 (Built: 2024-04-27)

Website: http://traminer.unige.ch

Please type 'citation("TraMineR")' for citation information.
```

```
library(TraMineRextras)
```

```
TraMineRextras stable version 0.6.7 (Built: 2024-04-27)

Functions provided by this package are still in test

    and subject to changes in future releases.
```

```
library(seqimpute)
library(dplyr)
```

```
Attaching package: 'dplyr'
```

```
The following objects are masked from 'package:stats':

    filter, lag

The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

```
wide <- readRDS("wide-accomm.rds")
```

Fill only internal gaps in the data using Multiple Imputation.

```
sequence <- seqimpute(
  wide, var = 6:9, m = 1, timing = TRUE,
  npt = 0, nfi = 0
)
```

```
iteration : 1 / 1
[1] "Imputation of the internal gaps..."
[1] "Step 1/2"
[1] "Step 2/2"
```

Define sequence object. Five states

```
sequence.alphabet <- c(
  'authorities',
  'rented',
  'other',
  'in Ukraine',
  'in other country'
)

sequence.scode <- c(
  "AUTHOR",
  "RENTED",
  "OTHACC",
  "IN.UKR",
  "IN.OTH"
)

sequence.lab <- c(
```

```
  'Provided by authorities',
  'Rented',
  'Other types of accommodation',
  'in Ukraine',
  'in other country'
)

sequence.seq <- seqdef(
  data = sequence$imp$imp1,
  var = 1:4,
  alphabet = sequence.alphabet,
  states = sequence.scode,
  labels = sequence.lab,
  xtstep = 1,
  cpal = rainbow(5),
  left = NA, right = NA
)
```

```
 [>] found missing values ('NA') in sequence data

 [>] preparing 1193 sequences

 [>] coding void elements with '%' and missing values with '*'

 [>] state coding:

       [alphabet]       [label]  [long label]

     1  authorities      AUTHOR   Provided by authorities

     2  rented           RENTED   Rented

     3  other            OTHACC   Other types of accommodation

     4  in Ukraine       IN.UKR   in Ukraine

     5  in other country IN.OTH   in other country

 [>] 1193 sequences in the data set

 [>] min/max sequence length: 4/4
```

4.1 Frequency tables

All existing sequences of accommodation trajectories, sorted from the most frequent to the least frequent.

```
seqtab(
  sequence.seq, idxs = 0
)
```

	Freq	Percent
*/1-AUTHOR/3	132	11.065
*/3-AUTHOR/1	120	10.059
*/1-AUTHOR/1	54	4.526
*/2-AUTHOR/2	51	4.275
OTHACC/1	45	3.772
*/1-RENTED/1-AUTHOR/2	44	3.688
*/1-AUTHOR/2	42	3.521
*/2-AUTHOR/1	37	3.101
AUTHOR/1	31	2.598
*/1-RENTED/3	28	2.347
*/1-OTHACC/1	27	2.263
*/1-RENTED/1	27	2.263
*/1-OTHACC/3	26	2.179
*/3-RENTED/1	26	2.179
*/3-OTHACC/1	25	2.096
*/2-OTHACC/2	18	1.509
*/1-OTHACC/1-IN.UKR/2	16	1.341
AUTHOR/4	14	1.174
OTHACC/1-AUTHOR/3	14	1.174
RENTED/1	14	1.174
*/1-AUTHOR/1-IN.UKR/2	13	1.090
*/1-OTHACC/1-AUTHOR/2	12	1.006
*/2-OTHACC/1	12	1.006
*/1-OTHACC/2	11	0.922
*/1-RENTED/1-AUTHOR/1	10	0.838
OTHACC/4	10	0.838
*/1-OTHACC/1-AUTHOR/1	9	0.754
*/1-OTHACC/2-AUTHOR/1	9	0.754
OTHACC/1-AUTHOR/2	9	0.754
*/2-RENTED/2	8	0.671
OTHACC/1-IN.UKR/3	8	0.671
OTHACC/2-AUTHOR/2	8	0.671

*/1-OTHACC/1-RENTED/2	7	0.587
RENTED/2-AUTHOR/2	7	0.587
*/1-AUTHOR/1-IN.UKR/1	6	0.503
*/1-RENTED/1-IN.UKR/2	6	0.503
AUTHOR/3	6	0.503
OTHACC/2	6	0.503
RENTED/2	6	0.503
*/1-IN.OTH/2-AUTHOR/1	5	0.419
*/1-RENTED/1-AUTHOR/1-RENTED/1	5	0.419
IN.OTH/2-OTHACC/2	5	0.419
OTHACC/1-IN.UKR/2	5	0.419
OTHACC/1-RENTED/1-AUTHOR/2	5	0.419
RENTED/1-AUTHOR/3	5	0.419
*/1-RENTED/2	4	0.335
*/2-RENTED/1	4	0.335
*/2-RENTED/1-AUTHOR/1	4	0.335
AUTHOR/2	4	0.335
IN.OTH/1-AUTHOR/3	4	0.335
IN.OTH/1-OTHACC/1-AUTHOR/2	4	0.335
IN.OTH/3-AUTHOR/1	4	0.335
OTHACC/1-RENTED/1-AUTHOR/1	4	0.335
OTHACC/2-AUTHOR/1	4	0.335
OTHACC/2-IN.UKR/2	4	0.335
RENTED/1-IN.UKR/3	4	0.335
RENTED/3	4	0.335
*/1-AUTHOR/1-RENTED/2	3	0.251
*/1-AUTHOR/2-RENTED/1	3	0.251
*/1-IN.OTH/1-OTHACC/2	3	0.251
*/1-IN.OTH/2-OTHACC/1	3	0.251
*/1-RENTED/2-AUTHOR/1	3	0.251
AUTHOR/2-IN.UKR/2	3	0.251
OTHACC/1-AUTHOR/1	3	0.251
OTHACC/3	3	0.251
RENTED/1-IN.UKR/1	3	0.251
RENTED/4	3	0.251
*/1-AUTHOR/1-OTHACC/2	2	0.168
*/1-AUTHOR/2-IN.UKR/1	2	0.168
*/1-IN.OTH/1-AUTHOR/1	2	0.168
*/1-IN.OTH/1-AUTHOR/2	2	0.168
*/1-IN.OTH/1-OTHACC/1-AUTHOR/1	2	0.168
*/1-OTHACC/1-IN.UKR/1-IN.OTH/1	2	0.168
*/1-OTHACC/1-RENTED/1	2	0.168
*/1-RENTED/1-AUTHOR/1-IN.UKR/1	2	0.168

*/2-OTHACC/1-AUTHOR/1	2	0.168
*/2-OTHACC/1-IN.UKR/1	2	0.168
*/2-OTHACC/1-RENTED/1	2	0.168
AUTHOR/1-IN.UKR/2	2	0.168
AUTHOR/1-RENTED/1-AUTHOR/1	2	0.168
AUTHOR/1-RENTED/1-AUTHOR/2	2	0.168
IN.OTH/1-OTHACC/1-RENTED/2	2	0.168
IN.OTH/1-OTHACC/3	2	0.168
IN.UKR/1-OTHACC/3	2	0.168
OTHACC/1-IN.OTH/3	2	0.168
*/1-AUTHOR/1-IN.UKR/1-OTHACC/1	1	0.084
*/1-AUTHOR/1-OTHACC/1-AUTHOR/1	1	0.084
*/1-AUTHOR/1-RENTED/1	1	0.084
*/1-AUTHOR/1-RENTED/1-AUTHOR/1	1	0.084
*/1-AUTHOR/2-IN.OTH/1	1	0.084
*/1-IN.OTH/1-AUTHOR/1-IN.OTH/1	1	0.084
*/1-IN.OTH/1-AUTHOR/1-OTHACC/1	1	0.084
*/1-IN.OTH/1-IN.UKR/1-AUTHOR/1	1	0.084
*/1-IN.OTH/1-IN.UKR/1-OTHACC/1	1	0.084
*/1-IN.OTH/1-OTHACC/1-IN.OTH/1	1	0.084
*/1-IN.UKR/1-AUTHOR/1	1	0.084
*/1-IN.UKR/1-AUTHOR/1-OTHACC/1	1	0.084
*/1-IN.UKR/1-AUTHOR/2	1	0.084
*/1-IN.UKR/1-OTHACC/1-AUTHOR/1	1	0.084
*/1-IN.UKR/1-OTHACC/1-IN.UKR/1	1	0.084
*/1-IN.UKR/1-OTHACC/2	1	0.084
*/1-IN.UKR/2-AUTHOR/1	1	0.084
*/1-OTHACC/1-AUTHOR/1-RENTED/1	1	0.084
*/1-OTHACC/1-IN.UKR/1-OTHACC/1	1	0.084
*/1-OTHACC/1-RENTED/1-IN.UKR/1	1	0.084
*/1-OTHACC/2-IN.UKR/1	1	0.084
*/1-RENTED/1-AUTHOR/1-OTHACC/1	1	0.084
*/1-RENTED/1-IN.UKR/1	1	0.084
*/1-RENTED/1-IN.UKR/1-AUTHOR/1	1	0.084
*/1-RENTED/2-IN.UKR/1	1	0.084
*/2-AUTHOR/1-IN.OTH/1	1	0.084
*/2-AUTHOR/1-RENTED/1	1	0.084
*/2-IN.OTH/1-OTHACC/1	1	0.084
*/2-IN.UKR/1-OTHACC/1	1	0.084
AUTHOR/1-IN.OTH/1-IN.UKR/2	1	0.084
AUTHOR/1-IN.UKR/1-AUTHOR/2	1	0.084
AUTHOR/1-IN.UKR/1-IN.OTH/1	1	0.084
AUTHOR/1-IN.UKR/3	1	0.084

AUTHOR/1-OTHACC/1-AUTHOR/2	1	0.084
AUTHOR/1-OTHACC/1-IN.OTH/1-AUTHOR/1	1	0.084
AUTHOR/1-OTHACC/1-IN.UKR/1-OTHACC/1	1	0.084
AUTHOR/1-OTHACC/2	1	0.084
AUTHOR/1-OTHACC/2-RENTED/1	1	0.084
AUTHOR/1-OTHACC/3	1	0.084
AUTHOR/1-RENTED/2	1	0.084
AUTHOR/1-RENTED/3	1	0.084
IN.OTH/1-AUTHOR/1	1	0.084
IN.OTH/1-AUTHOR/1-IN.UKR/1	1	0.084
IN.OTH/1-AUTHOR/2-RENTED/1	1	0.084
IN.OTH/1-IN.UKR/1-IN.OTH/1-AUTHOR/1	1	0.084
IN.OTH/1-IN.UKR/1-OTHACC/1	1	0.084
IN.OTH/1-IN.UKR/2-AUTHOR/1	1	0.084
IN.OTH/1-OTHACC/1-IN.OTH/2	1	0.084
IN.OTH/1-OTHACC/1-IN.UKR/1-AUTHOR/1	1	0.084
IN.OTH/1-OTHACC/1-IN.UKR/2	1	0.084
IN.OTH/1-OTHACC/2-AUTHOR/1	1	0.084
IN.OTH/1-OTHACC/2-IN.UKR/1	1	0.084
IN.OTH/1-RENTED/2-AUTHOR/1	1	0.084
IN.OTH/2-AUTHOR/1	1	0.084
IN.OTH/2-AUTHOR/2	1	0.084
IN.OTH/2-IN.UKR/1-AUTHOR/1	1	0.084
IN.OTH/2-IN.UKR/1-OTHACC/1	1	0.084
IN.OTH/2-OTHACC/1	1	0.084
IN.OTH/2-OTHACC/1-AUTHOR/1	1	0.084
IN.UKR/1-AUTHOR/1-RENTED/2	1	0.084
IN.UKR/1-AUTHOR/3	1	0.084
IN.UKR/1-OTHACC/1-AUTHOR/2	1	0.084
IN.UKR/1-OTHACC/1-IN.UKR/1-AUTHOR/1	1	0.084
IN.UKR/1-OTHACC/1-IN.UKR/1-OTHACC/1	1	0.084
IN.UKR/2-AUTHOR/1	1	0.084
IN.UKR/2-OTHACC/1-AUTHOR/1	1	0.084
OTHACC/1-AUTHOR/1-IN.UKR/1-OTHACC/1	1	0.084
OTHACC/1-AUTHOR/1-IN.UKR/2	1	0.084
OTHACC/1-AUTHOR/1-RENTED/1	1	0.084
OTHACC/1-AUTHOR/2-IN.UKR/1	1	0.084
OTHACC/1-AUTHOR/2-RENTED/1	1	0.084
OTHACC/1-IN.OTH/1	1	0.084
OTHACC/1-IN.OTH/1-OTHACC/1	1	0.084
OTHACC/1-IN.OTH/1-OTHACC/1-IN.OTH/1	1	0.084
OTHACC/1-IN.UKR/1-IN.OTH/1-OTHACC/1	1	0.084
OTHACC/1-IN.UKR/1-OTHACC/2	1	0.084

```
OTHACC/1-IN.UKR/2-AUTHOR/1              1   0.084
OTHACC/1-RENTED/1                       1   0.084
OTHACC/1-RENTED/1-AUTHOR/1-IN.UKR/1     1   0.084
OTHACC/1-RENTED/1-IN.UKR/2              1   0.084
OTHACC/1-RENTED/3                       1   0.084
OTHACC/2-AUTHOR/1-OTHACC/1              1   0.084
OTHACC/2-AUTHOR/1-RENTED/1              1   0.084
OTHACC/2-IN.UKR/1                       1   0.084
OTHACC/2-IN.UKR/1-AUTHOR/1              1   0.084
OTHACC/2-RENTED/1                       1   0.084
OTHACC/3-IN.UKR/1                       1   0.084
OTHACC/3-RENTED/1                       1   0.084
RENTED/1-AUTHOR/1-RENTED/1              1   0.084
RENTED/1-AUTHOR/2                       1   0.084
RENTED/1-IN.UKR/1-AUTHOR/2              1   0.084
RENTED/1-OTHACC/3                       1   0.084
RENTED/2-AUTHOR/1                       1   0.084
RENTED/2-IN.UKR/2                       1   0.084
RENTED/3-AUTHOR/1                       1   0.084
```

4.2 Most frequent sequences plot

The legend that will be used for the sequence charts that follow

```
seqlegend(sequence.seq)
```

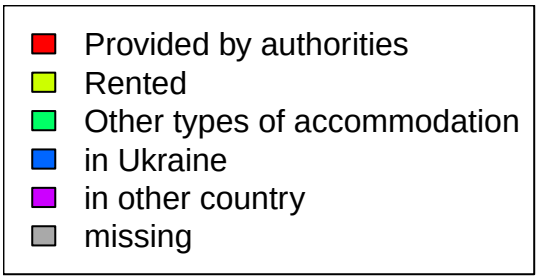
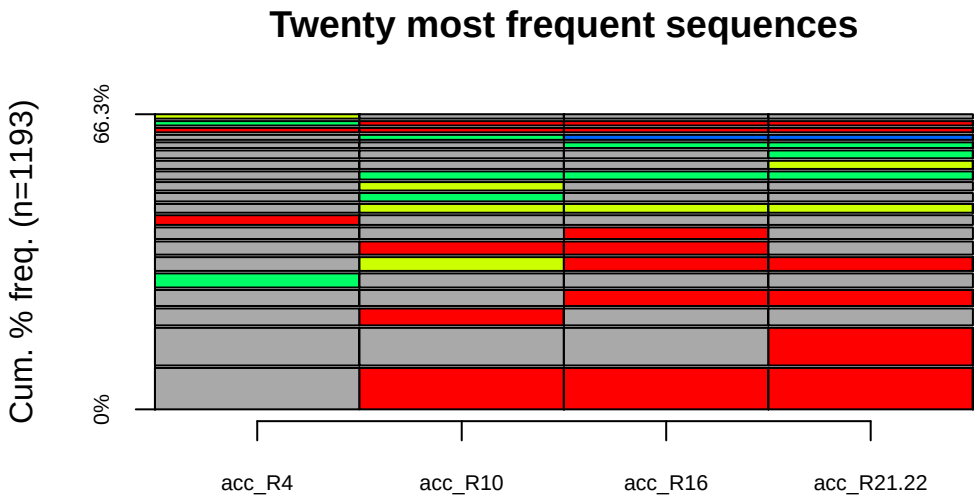


Figure 4.1: Legend for charts

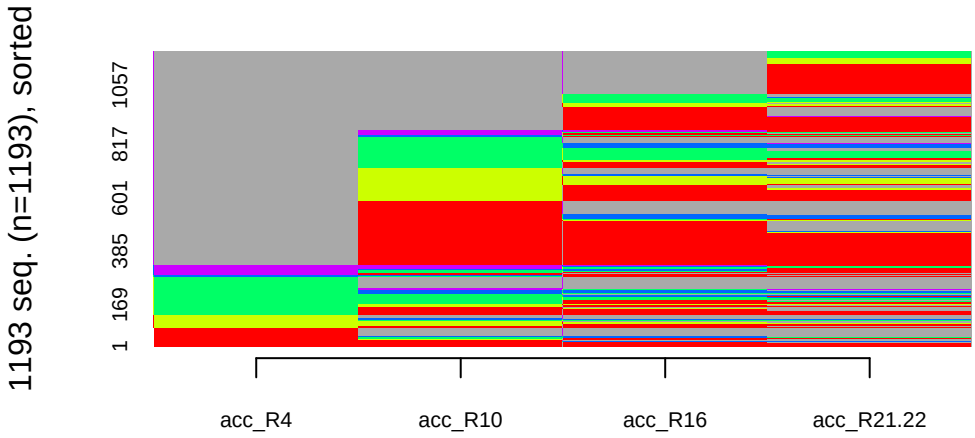
Frequency tables contain too much information. A graphical representation allows you to focus on the trajectories that occur most often. The following graph shows 20 sequences that represent 66.2% of all sequences in the data. The frequency of the particular sequence in the chart corresponds to the height of the row.

```
seqfplot(
  sequence.seq, idxs = 1:20,
  with.legend = FALSE, cex.axis = 0.65,
  border = TRUE, pbarw = TRUE,
  main = "Twenty most frequent sequences"
)
```



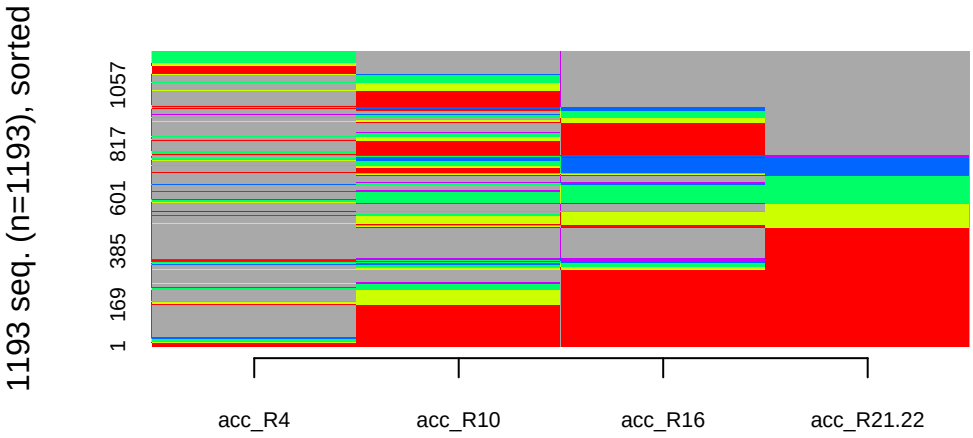
To see all the picture we can plot

```
seqplot(
  seqdata = sequence.seq, type = "I", # idxs = 1:100,
  with.legend = FALSE, cex.axis = 0.65,
  sortv = sortv(sequence.seq, start = "beg")
  # sortv = tran.seq$acc_R4
)
```



Sorting is possible by final state, which allows you to trace sequences that end in a specific way. Sorting is also possible by any other important feature that describes the household.

```
seqplot(
  seqdata = sequence.seq, type = "I",
  with.legend = FALSE, cex.axis = 0.65,
  sortv = sortv(sequence.seq, start = "end")
)
```



4.3 Transition Types

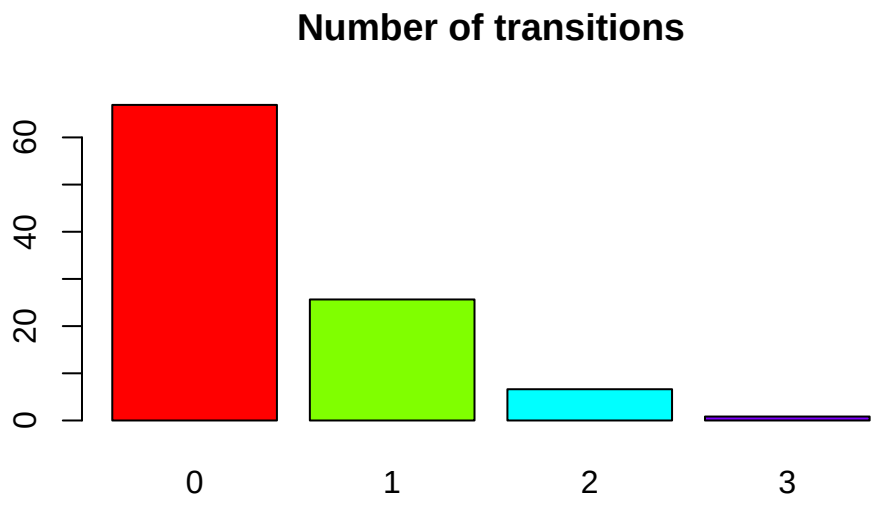
Even after reducing the number of sequence states, there are too many combinations due to various patterns of missing values to clearly identify the most important trends. To simplify the analysis, it makes sense to combine the sequences into groups (types). One approach proposed in the literature is to use cluster analysis. However, the hierarchical cluster analysis did not allow me to obtain logical clear groups, so I decided to go the other way: to classify the sequences based on the type of transitions from one state to another. To this end, the number of transitions in our data is first determined:

```
transitions <- as.numeric(seqtransn(sequence.seq))

(tb <- 100 * prop.table(table(transitions)))
```

```
transitions
        0         1         2         3
66.890193 25.649623  6.621961  0.838223
```

```
barplot(
  tb, col = rainbow(4),
```

```
  main = "Number of transitions"
)
```



As you can see, the bulk of the sequences are those without transitions, which can be called stable trajectories.

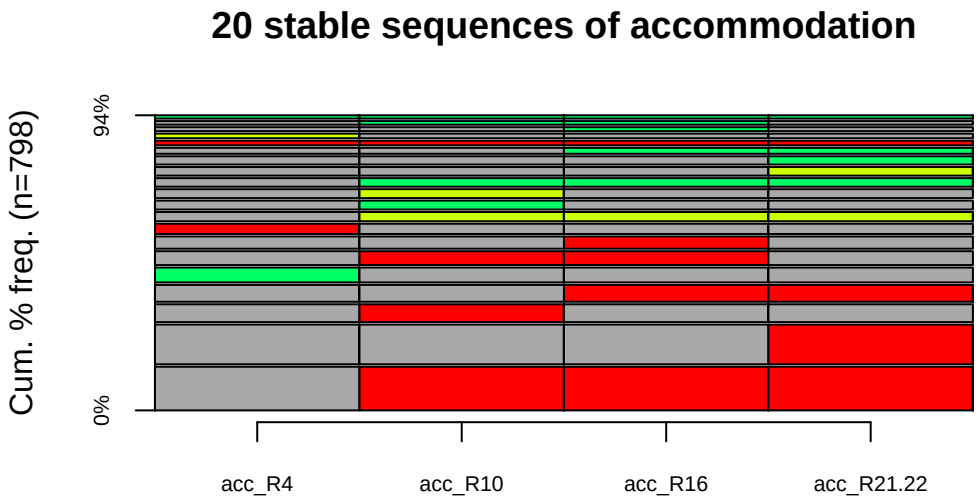
Now you can distinguish groups of sequences based on the number of transitions: no transitions, one transition, two transitions, more than one transition, and so on:

```
sequence.seq %>%
  filter(transitions == 0) -> tran0.seq

sequence.seq %>%
  filter(transitions == 1) -> tran1.seq

sequence.seq %>%
  filter(transitions == 2) -> tran2.seq

sequence.seq %>%
  filter(transitions >= 1) -> tran.seq
```

4.4 Stable sequences

Twenty most frequent sequences cover 93.8% of time-stable sequences.

```
tran0.seq %>%
  seqfplot(
    idxs = 1:20,
    with.legend = F,
    cex.axis = 0.65,
    pbarw = T,
    main = "20 stable sequences of accommodation"
  )
```



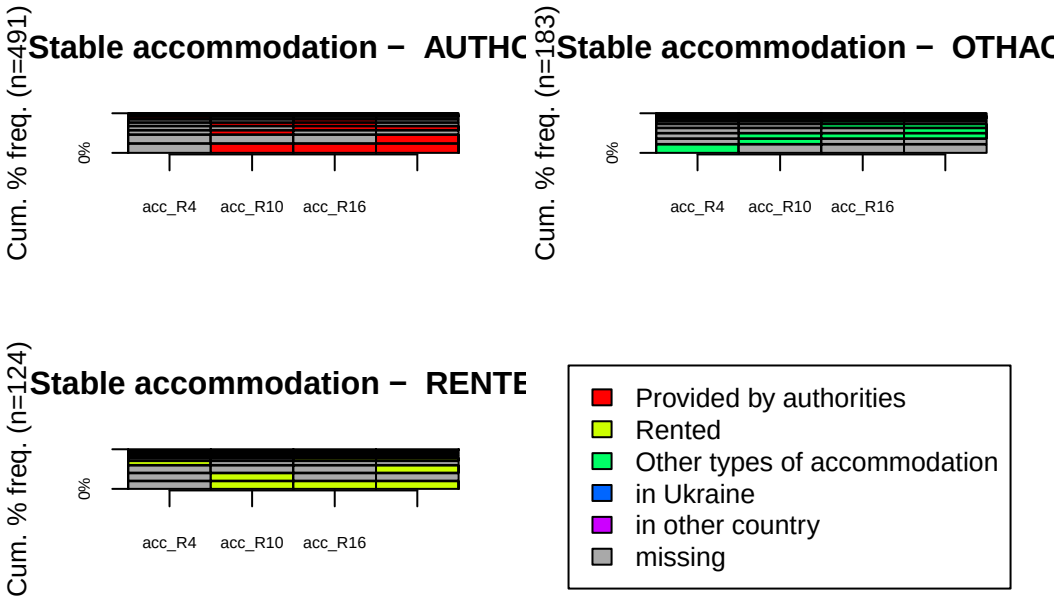
We can simplify the presentation of information about time-stable sequences by ignoring their differences in the location of missing values:

```
## Stable frequencies
u <- tran0.seq
u[u == "*" | u == "%"] <- NA

apply(
  X = u, MARGIN = 1, first, na_rm = TRUE
) %>% sjmisc::frq()
```

```
x <character>
# total N=798 valid N=798 mean=1.54 sd=0.75

Value   |   N | Raw % | Valid % | Cum. %
--------------------------------------
AUTHOR | 491 | 61.53 |   61.53 |  61.53
OTHACC | 183 | 22.93 |   22.93 |  84.46
RENTED | 124 | 15.54 |   15.54 | 100.00
<NA>   |   0 |  0.00 |    <NA> |   <NA>
```

Now you can group time-stable sequences by accommodation type in one chart:

```r
## Grouped
grp <- apply(
  X = u, MARGIN = 1, first, na_rm = TRUE
)

tran0.seq %>%
  seqfplot(
    idxs = 0,
    with.legend = TRUE, cex.axis = 0.65, pbarw = TRUE,
    main = "Stable accommodation",
    group = grp
  )
```



4.5 Sequences with transitions

Now you can look at sequences with any number of transitions separately. For example, this table contains sequences with one or more state transitions:

```
seqtab(
  tran.seq, idxs = 0
)
```

```
                                Freq Percent
*/1-RENTED/1-AUTHOR/2             44   11.14
*/1-OTHACC/1-IN.UKR/2             16    4.05
OTHACC/1-AUTHOR/3                 14    3.54
*/1-AUTHOR/1-IN.UKR/2             13    3.29
*/1-OTHACC/1-AUTHOR/2             12    3.04
*/1-RENTED/1-AUTHOR/1             10    2.53
*/1-OTHACC/1-AUTHOR/1              9    2.28
*/1-OTHACC/2-AUTHOR/1              9    2.28
OTHACC/1-AUTHOR/2                  9    2.28
OTHACC/1-IN.UKR/3                  8    2.03
OTHACC/2-AUTHOR/2                  8    2.03
```

*/1-OTHACC/1-RENTED/2	7	1.77
RENTED/2-AUTHOR/2	7	1.77
*/1-AUTHOR/1-IN.UKR/1	6	1.52
*/1-RENTED/1-IN.UKR/2	6	1.52
*/1-IN.OTH/2-AUTHOR/1	5	1.27
*/1-RENTED/1-AUTHOR/1-RENTED/1	5	1.27
IN.OTH/2-OTHACC/2	5	1.27
OTHACC/1-IN.UKR/2	5	1.27
OTHACC/1-RENTED/1-AUTHOR/2	5	1.27
RENTED/1-AUTHOR/3	5	1.27
*/2-RENTED/1-AUTHOR/1	4	1.01
IN.OTH/1-AUTHOR/3	4	1.01
IN.OTH/1-OTHACC/1-AUTHOR/2	4	1.01
IN.OTH/3-AUTHOR/1	4	1.01
OTHACC/1-RENTED/1-AUTHOR/1	4	1.01
OTHACC/2-AUTHOR/1	4	1.01
OTHACC/2-IN.UKR/2	4	1.01
RENTED/1-IN.UKR/3	4	1.01
*/1-AUTHOR/1-RENTED/2	3	0.76
*/1-AUTHOR/2-RENTED/1	3	0.76
*/1-IN.OTH/1-OTHACC/2	3	0.76
*/1-IN.OTH/2-OTHACC/1	3	0.76
*/1-RENTED/2-AUTHOR/1	3	0.76
AUTHOR/2-IN.UKR/2	3	0.76
OTHACC/1-AUTHOR/1	3	0.76
RENTED/1-IN.UKR/1	3	0.76
*/1-AUTHOR/1-OTHACC/2	2	0.51
*/1-AUTHOR/2-IN.UKR/1	2	0.51
*/1-IN.OTH/1-AUTHOR/1	2	0.51
*/1-IN.OTH/1-AUTHOR/2	2	0.51
*/1-IN.OTH/1-OTHACC/1-AUTHOR/1	2	0.51
*/1-OTHACC/1-IN.UKR/1-IN.OTH/1	2	0.51
*/1-OTHACC/1-RENTED/1	2	0.51
*/1-RENTED/1-AUTHOR/1-IN.UKR/1	2	0.51
*/2-OTHACC/1-AUTHOR/1	2	0.51
*/2-OTHACC/1-IN.UKR/1	2	0.51
*/2-OTHACC/1-RENTED/1	2	0.51
AUTHOR/1-IN.UKR/2	2	0.51
AUTHOR/1-RENTED/1-AUTHOR/1	2	0.51
AUTHOR/1-RENTED/1-AUTHOR/2	2	0.51
IN.OTH/1-OTHACC/1-RENTED/2	2	0.51
IN.OTH/1-OTHACC/3	2	0.51
IN.UKR/1-OTHACC/3	2	0.51

OTHACC/1-IN.OTH/3	2	0.51
*/1-AUTHOR/1-IN.UKR/1-OTHACC/1	1	0.25
*/1-AUTHOR/1-OTHACC/1-AUTHOR/1	1	0.25
*/1-AUTHOR/1-RENTED/1	1	0.25
*/1-AUTHOR/1-RENTED/1-AUTHOR/1	1	0.25
*/1-AUTHOR/2-IN.OTH/1	1	0.25
*/1-IN.OTH/1-AUTHOR/1-IN.OTH/1	1	0.25
*/1-IN.OTH/1-AUTHOR/1-OTHACC/1	1	0.25
*/1-IN.OTH/1-IN.UKR/1-AUTHOR/1	1	0.25
*/1-IN.OTH/1-IN.UKR/1-OTHACC/1	1	0.25
*/1-IN.OTH/1-OTHACC/1-IN.OTH/1	1	0.25
*/1-IN.UKR/1-AUTHOR/1	1	0.25
*/1-IN.UKR/1-AUTHOR/1-OTHACC/1	1	0.25
*/1-IN.UKR/1-AUTHOR/2	1	0.25
*/1-IN.UKR/1-OTHACC/1-AUTHOR/1	1	0.25
*/1-IN.UKR/1-OTHACC/1-IN.UKR/1	1	0.25
*/1-IN.UKR/1-OTHACC/2	1	0.25
*/1-IN.UKR/2-AUTHOR/1	1	0.25
*/1-OTHACC/1-AUTHOR/1-RENTED/1	1	0.25
*/1-OTHACC/1-IN.UKR/1-OTHACC/1	1	0.25
*/1-OTHACC/1-RENTED/1-IN.UKR/1	1	0.25
*/1-OTHACC/2-IN.UKR/1	1	0.25
*/1-RENTED/1-AUTHOR/1-OTHACC/1	1	0.25
*/1-RENTED/1-IN.UKR/1	1	0.25
*/1-RENTED/1-IN.UKR/1-AUTHOR/1	1	0.25
*/1-RENTED/2-IN.UKR/1	1	0.25
*/2-AUTHOR/1-IN.OTH/1	1	0.25
*/2-AUTHOR/1-RENTED/1	1	0.25
*/2-IN.OTH/1-OTHACC/1	1	0.25
*/2-IN.UKR/1-OTHACC/1	1	0.25
AUTHOR/1-IN.OTH/1-IN.UKR/2	1	0.25
AUTHOR/1-IN.UKR/1-AUTHOR/2	1	0.25
AUTHOR/1-IN.UKR/1-IN.OTH/1	1	0.25
AUTHOR/1-IN.UKR/3	1	0.25
AUTHOR/1-OTHACC/1-AUTHOR/2	1	0.25
AUTHOR/1-OTHACC/1-IN.OTH/1-AUTHOR/1	1	0.25
AUTHOR/1-OTHACC/1-IN.UKR/1-OTHACC/1	1	0.25
AUTHOR/1-OTHACC/2	1	0.25
AUTHOR/1-OTHACC/2-RENTED/1	1	0.25
AUTHOR/1-OTHACC/3	1	0.25
AUTHOR/1-RENTED/2	1	0.25
AUTHOR/1-RENTED/3	1	0.25
IN.OTH/1-AUTHOR/1	1	0.25

IN.OTH/1-AUTHOR/1-IN.UKR/1	1	0.25
IN.OTH/1-AUTHOR/2-RENTED/1	1	0.25
IN.OTH/1-IN.UKR/1-IN.OTH/1-AUTHOR/1	1	0.25
IN.OTH/1-IN.UKR/1-OTHACC/1	1	0.25
IN.OTH/1-IN.UKR/2-AUTHOR/1	1	0.25
IN.OTH/1-OTHACC/1-IN.OTH/2	1	0.25
IN.OTH/1-OTHACC/1-IN.UKR/1-AUTHOR/1	1	0.25
IN.OTH/1-OTHACC/1-IN.UKR/2	1	0.25
IN.OTH/1-OTHACC/2-AUTHOR/1	1	0.25
IN.OTH/1-OTHACC/2-IN.UKR/1	1	0.25
IN.OTH/1-RENTED/2-AUTHOR/1	1	0.25
IN.OTH/2-AUTHOR/1	1	0.25
IN.OTH/2-AUTHOR/2	1	0.25
IN.OTH/2-IN.UKR/1-AUTHOR/1	1	0.25
IN.OTH/2-IN.UKR/1-OTHACC/1	1	0.25
IN.OTH/2-OTHACC/1	1	0.25
IN.OTH/2-OTHACC/1-AUTHOR/1	1	0.25
IN.UKR/1-AUTHOR/1-RENTED/2	1	0.25
IN.UKR/1-AUTHOR/3	1	0.25
IN.UKR/1-OTHACC/1-AUTHOR/2	1	0.25
IN.UKR/1-OTHACC/1-IN.UKR/1-AUTHOR/1	1	0.25
IN.UKR/1-OTHACC/1-IN.UKR/1-OTHACC/1	1	0.25
IN.UKR/2-AUTHOR/1	1	0.25
IN.UKR/2-OTHACC/1-AUTHOR/1	1	0.25
OTHACC/1-AUTHOR/1-IN.UKR/1-OTHACC/1	1	0.25
OTHACC/1-AUTHOR/1-IN.UKR/2	1	0.25
OTHACC/1-AUTHOR/1-RENTED/1	1	0.25
OTHACC/1-AUTHOR/2-IN.UKR/1	1	0.25
OTHACC/1-AUTHOR/2-RENTED/1	1	0.25
OTHACC/1-IN.OTH/1	1	0.25
OTHACC/1-IN.OTH/1-OTHACC/1	1	0.25
OTHACC/1-IN.OTH/1-OTHACC/1-IN.OTH/1	1	0.25
OTHACC/1-IN.UKR/1-IN.OTH/1-OTHACC/1	1	0.25
OTHACC/1-IN.UKR/1-OTHACC/2	1	0.25
OTHACC/1-IN.UKR/2-AUTHOR/1	1	0.25
OTHACC/1-RENTED/1	1	0.25
OTHACC/1-RENTED/1-AUTHOR/1-IN.UKR/1	1	0.25
OTHACC/1-RENTED/1-IN.UKR/2	1	0.25
OTHACC/1-RENTED/3	1	0.25
OTHACC/2-AUTHOR/1-OTHACC/1	1	0.25
OTHACC/2-AUTHOR/1-RENTED/1	1	0.25
OTHACC/2-IN.UKR/1	1	0.25
OTHACC/2-IN.UKR/1-AUTHOR/1	1	0.25

```
OTHACC/2-RENTED/1                          1    0.25
OTHACC/3-IN.UKR/1                          1    0.25
OTHACC/3-RENTED/1                          1    0.25
RENTED/1-AUTHOR/1-RENTED/1                 1    0.25
RENTED/1-AUTHOR/2                          1    0.25
RENTED/1-IN.UKR/1-AUTHOR/2                 1    0.25
RENTED/1-OTHACC/3                          1    0.25
RENTED/2-AUTHOR/1                          1    0.25
RENTED/2-IN.UKR/2                          1    0.25
RENTED/3-AUTHOR/1                          1    0.25
```

The most informative way to represent such sequences is in the form of a table of transitions between individual states. Such tables can also be built for transitions between individual rounds:

```
## Table of transitions
seqtrate(tran1.seq, with.missing = TRUE) %>%  # , time.varying = TRUE
  round(digits = 2)
```

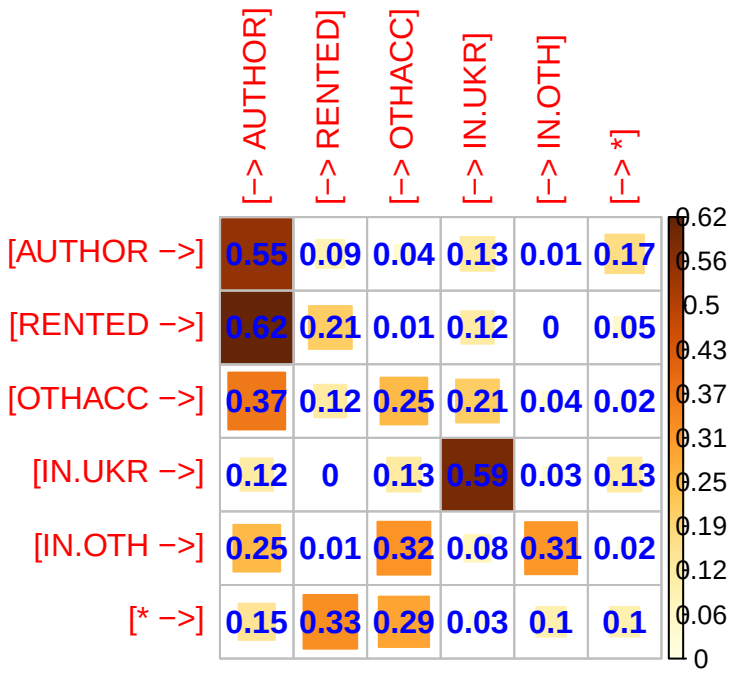
```
 [>] computing transition probabilities for states AUTHOR/RENTED/OTHACC/IN.UKR/IN.OTH/* ...
```

```
            [-> AUTHOR] [-> RENTED] [-> OTHACC] [-> IN.UKR] [-> IN.OTH] [-> *]
[AUTHOR ->]        0.62        0.04        0.02        0.12        0.01   0.19
[RENTED ->]        0.59        0.23        0.01        0.12        0.00   0.05
[OTHACC ->]        0.38        0.08        0.30        0.21        0.02   0.01
[IN.UKR ->]        0.05        0.00        0.04        0.74        0.00   0.17
[IN.OTH ->]        0.31        0.00        0.23        0.00        0.44   0.02
[* ->]             0.16        0.33        0.30        0.02        0.08   0.11
```

You can visualize transition tables using heatmaps:

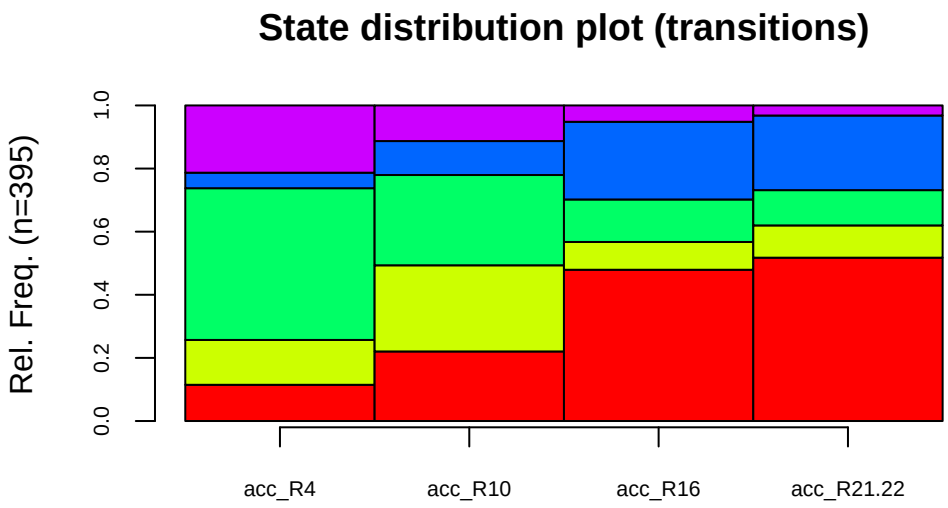
```
seqtrate(tran.seq, with.missing = TRUE) %>%
  round(digits = 2) %>%
  corrplot::corrplot(
    method = "square", is.corr = FALSE, addCoef.col = "blue"
  )
```

```
 [>] computing transition probabilities for states AUTHOR/RENTED/OTHACC/IN.UKR/IN.OTH/* ...
```



A chronograph chart shows the dynamics of state distributions between rounds for sequences with transitions:

```
seqdplot(
  tran.seq, main = "State distribution plot (transitions)",
  with.legend = F, cex.axis = 0.65
)
```


State distribution plot (transitions)
Rel. Freq. (n=395)
0.0
0.2
0.4
0.6
0.8
1.0
acc_R4
acc_R10
acc_R16
acc_R21.22

5 Summary

In summary, this book has no content whatsoever.

```
1 + 1
```

```
[1] 2
```