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NEPS TECHNICAL REPORT FOR WEIGHTING: WEIGHTING THE SAMPLE OF STARTING COHORT 4 OF THE NATIONAL EDUCATIONAL PANEL STUDY (WAVE 1 TO 6)

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NEPS Technical Report for Weighting: Weighting the Sample of Starting Cohort 4 of the National Educational Panel Study (Wave 1 to 6)

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NEPS Technical Report for Weighting: Weighting the Sample of Starting Cohort 4 of the National Educational Panel Study (Wave 1 to 6)

Abstract

The sample of Grade 9 students in the National Educational Panel Study (NEPS) focuses on the pathways through higher secondary and vocational education tracks. When entering the vocational track, students will leave their institutional context in which they were originally sampled and surveyed. Thus, from then onwards they are individually surveyed. Students passing into the academic track are very likely to remain in their institutional context, which means that they are surveyed in groups. This report provides details on the sampling design, the derivation of design weights and the wave-specific nonresponse adjustments to provide cross-sectional as well as longitudinal weights. For the students participating in the panel study we find sampling school type information, migration background, native language and previous waves participation to influence their participation propensities.

Keywords

stratified two-stage cluster sampling, unit nonresponse, weighting adjustments, NEPS SC4

1. Introduction

Starting Cohort 4 (SC4) of the National Educational Panel Study (NEPS) focuses on students in Grade 9 and their pathway through higher secondary education and vocational education training.[1] For this purpose, a stratified sample of Grade 9 students in different types of regular schools and special-need schools was set up.[2]
A two-stage sampling approach has been used to gain access to the target population. The sample of students participating in the panel study (i.e., the panel members) are followed up over time. In Germany, students usually decide after Grade 10 to enter either the academic track or the vocational track, see Figure 1. Students entering the academic track mostly remain within their institutional context, while students entering the vocational track leave for a vocational school or training. The majority of students enters the vocational track after Grade 10. However, also other pathways are possible, that is, students enter the vocational track earlier or later in their educational career. Figure 1 illustrates this transition pattern.

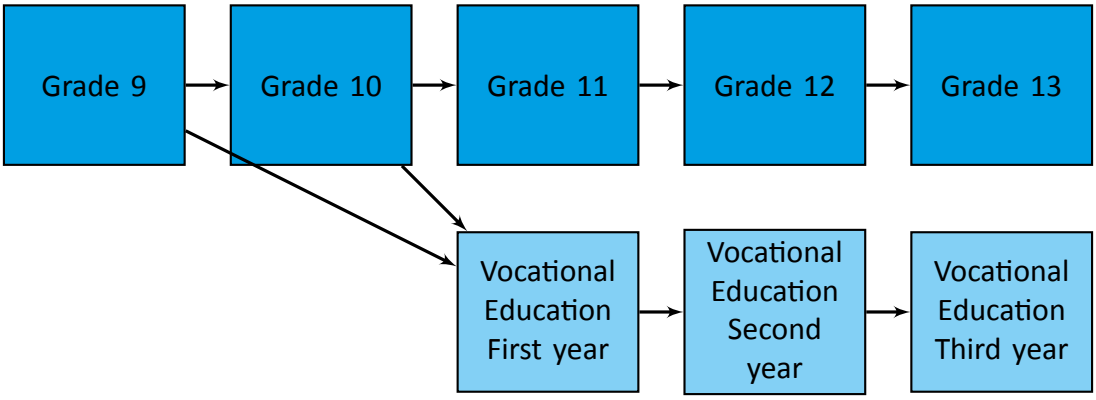

Figure 1: Ideal pathways through upper secondary and vocational education.

The sampling units of stratified multistage designs are very likely subject to unequal selection probabilities. Disregarding this aspect in statistical analysis may lead to biased population estimates and misleading research conclusions. A common way to compensate for unequal selection probabilities is the usage of weights; see for example Särndal, Swensson, and Wretman (2003) or Pfeffermann and Rao (2009). The participation in the SC4 survey is voluntary, which means that at each of the two stages of sampling schools as well as students might refuse or not respond. To this end, usually nonresponse adjustments of design weights are used. When computing weights for the panel members of SC4, the different processes leading to the participation decision in a particular wave have to be considered. These decision processes include

1. the schools initial decision to participate in the survey,
2. the students initial decision to participate in the panel,
3. and lastly the students successive decisions to participate in each panel wave.

[1] This report refers to Scientific Use File (SUF; DOI:10.5157/NEPS:SC4:6.0.0). For more specific information on research topics in the NEPS, see Blossfeld, Roßbach, and von Maurice (2011).
[2] Regular schools are all ``allgemeinbildende Schulen´´, that is, schools of general education according to the definition of the Kultusministerkonferenz (2012).

Cell weighting is used to adjust the design weights for school nonparticipation. Response propensity re-weighting has been applied to compensate for students refusing to take part in the panel and for wave nonresponse among students.
The sample design together with the schools and students decision to participate in the panel study (as stated above) leading to nonresponse adjusted design weights before Wave 1 are documented in detail by Steinhauer, Aßmann, Zinn, Goßmann, and Rässler (2015). Wave nonresponse, the decisions of students to participate in particular waves, and the derivation of the corresponding wave-specific cross-sectional and longitudinal weights are the focus of this paper. When a student decides not to participate we distinguish two cases. Generally, students who do not respond in one particular wave are considered as temporary dropouts. Students are treated as final dropouts if they explicitly refuse further participation in the panel, or if tracking efforts fail, or if no information[3] is available on the student for a time period longer than two years.
Additionally, information arising from surveying and testing students is enriched by a computer assisted telephone interview (CATI) with one parent. By this multi-informant perspective NEPS collects additional information on the students family and social background. For the group of participating students for whom an interview with their parents was conducted we provide an additional cross-sectional weight for Wave 1. To this end, the decision of students and parents to participate in the study is modeled jointly, since the two decisions are likely to be correlated.
In the progress of the panel, it is possible that students cannot further be surveyed within their institutional context. Reasons might be students switching to another school or the refusal of schools to further cooperate. In such cases students are surveyed in their individual contexts. That is, the questionnaires are sent to their home address or they are invited to a CATI. In the following, surveying students in their individual context is referred to as the field of individual retracking.
The remainder of this report is structured as follows: Section 2 provides an overview on the population definition, the sampling design, and the derivation of the sampling weights. Section 3 shortly presents weighting adjustments to account for the initial nonresponse at the school and at the student level. Wave-specific weighting adjustments are the topic of Section 4. The calibration of weights is described in Section 5. The trimming procedure applied is documented in Section 6 together with the scaling of weights. Finally, Section 8 concludes with some recommendations concerning the usage of the weights provided.

2. Population and Sample

The target population of SC4 covers all students in Grade 9 educated in regular and special-need (focusing on learning disabilities) schools in Germany in the school year 2010/2011. Students in vocational schools or students in schools with a predominant teaching language other than German hindering the realization of a complete survey procedure with the available test instruments are excluded, see Aßmann et al. (2011). To get access to the students, a stratified two-stage cluster sampling procedure was applied. Stratification according to school types yielded six different strata, concretized in Table 1.
For sampling the school types IG and FW have been joined into one stratum. Furthermore, in order to reach a meaningful number of observations students in HS, FS, FW and IG have

[3] This information comprises contact update information and survey data of the target or a context person, i.e., one parent or the teacher.

Table 1: Strata and abbreviations for school types

Stratum	Abbreviation	School type
1	GY	schools leading to upper secondary education and university entrance qualification (*Gymnasium*)
2	HS	schools for basic secondary education (*Hauptschule*)
3	RS	intermediate secondary schools (*Realschule*)
4	IG	comprehensive schools (*Integrierte Gesamtschule*)
4	FW	Rudolf Steiner schools (*Freie Waldorfschule*)
5	MB	schools with several courses of education (*Schule mit mehreren Bildungsgängen*)
6	FS	schools offering schooling to students with special educational needs in the area of learning (*Förderschule*)

been oversampled. To enhance precision, the population of schools was additionally implicitly stratified according to the following three criteria: Federal State, regional classification, and funding. Thereafter, sampling was conducted at two stages. At the first stage, a sample of all officially recognized and state approved schools providing schooling to students in Grade 9 has been drawn systematically with probability proportional to size. Thereafter, at the second stage, two classes within the sampled schools were selected randomly (if at least three classes were present), otherwise all classes were taken. In the classes, all students were asked whether they are willing to participate in the survey. See Steinhauer et al. (2015) for more details on the sampling design.

The sampling design determines the inclusion probability of each sampled unit, that is, of each sampled school, class, and student. In the considered case, the inclusion probabilities differ at the different stages of the sample. Hence, the SC4 sample is not a self-weighted sample. In other words, design information and weights, respectively, have to be accounted for in statistical inference. The design weights of the sampled units (i.e., of the schools, classes, and students) are defined as the inverse of their inclusion probabilities. By design, these probabilities depend on the number of schools, classes, and students available in the corresponding strata. The concrete derivation of the design weights is given in very detail in Steinhauer et al. (2015).

3. Initial Nonresponse Adjustments

To account for nonresponse in the initial sample, the design weights of the sampling units are adjusted. To this end, the two stages of sampling have to be considered. Nonresponse among schools was compensated for by cell weighting adjustments. For this purpose, cells were formed using the sampling strata, Federal States, and funding. A response propensity re-weighting approach was used to adjust for students not participating in the panel. This approach means to model response behavior in dependence of individual, contextual, and institutional factors. Concretely, for the initial nonresponse adjustments on the students level, last maths grade, gender, age group, and the size of the test group had been considered. See Steinhauer et al. (2015) for more details on this.

4. Wave and Group Specific Nonresponse Adjustments

4.1 Panel members, temporary and final dropouts, tracks of survey context

Over the course of the panel, a non-negligible number of panel members failed to participate in one or more waves. That is, wave-specific nonresponse occurred. Table 2 summarizes the participation status of the panel members in each wave together with the corresponding study numbers.[4] In sum, the sample of SC4 comprises 16,425 panel members. In Waves 1, 2, 3, and 5 all panel members have been asked for participation (unless they have refused before the survey or dropped-out because of other reasons). Waves 4 and 6 were only targeted to panel members on the vocational track, to update personal data and contact information. To enter the respective studies, the students had to participate in the previous wave (i.e., either in Wave 3 or in Wave 5). In other words, to enter study B38 and B40, respectively, students on the vocational track had to participate in B37 and B39, respectively. Note that most students participating in study B39 do an apprenticeship, i.e., are assigned to the vocational track. However, few of the B39 respondents belong to the academic track, that is, they are students visiting an upper secondary school which is not part of the sample of NEPS schools. Hence, opposed to the students educated in NEPS schools, these students are not surveyed in an institutional context, but individually. Note further that the number of final dropouts given in Table 2 is the sum of the number of dropouts from all previous waves, the number of dropouts between the last and the current wave, and the number of dropouts occurring in the particular wave. Furthermore, beware of the fact that the numbers of final dropouts in the academic and the vocational track do not sum up to the numbers of final dropouts in the corresponding waves. This is because students who drop-out from the panel between two waves might not yet assigned to a specific track.

Figure 2 in Appendix B details possible pathways between the distinct tracks of education. Here, each column corresponds to one wave. The first row (i.e., the dark blue boxes) refers to the academic track and the second row (i.e., the light blue boxes) to the vocational track. The bottom part of each box gives the number of participants, the number of temporary and final dropouts (top and middle row). The bottom row of the figure depicts the number of final dropouts. Here, the number of final dropouts given in the top part of each box is the sum of the number of final dropouts from the previous waves, the number of final dropouts occurring between the preceding and the current wave, and the number of final dropouts from each track in the corresponding wave. Thus, for the Waves 1, 2, 3, and 5 the totals in the two tracks (given in the upper part of the corresponding boxes) together with the previous waves dropouts add up to the panel cohort size of 16,425 students.

In Wave 1 (Fall 2010) and Wave 2 (Spring 2011) (i.e., in the school year 2010/2011) students were surveyed and tested in Grade 9 within their schools (institutional context). In Wave 3 (Fall 2011) (i.e., in the school year 2011/2012) a small part of 2,549 students left the school, in which they were originally sampled, and entered the vocational track.[5] However, the majority (13,815 students) remained in their schools. Between Wave 2 and Wave 3 there were 61 students who refused further participation in the panel or could not be tracked due to missing addresses. Up to Wave 3 the entire panel cohort (excluding final dropouts) was surveyed. Because students in vocational education leave their original institutional context they are ex-

[4] Field reports (in German language) for each study are available on the homepage.

[5] Throughout this report, the vocational track comprises persons in vocational education and in the transition system.

Table 2: Participation status by wave and educational track (i.e., academic and vocational track)

Wave Nr.	Time	Study number	Total	Participants	Dropouts Temporary	Dropouts Final
Initial sample			26,868	16,425	-	10,443
1	Fall 2010	A46, A60, A67, A83, A86	16,425	15,629	796	0
2	Spring 2011	A47, A61, A68, A84, A87	16,425	15,214	1,211	0
3	Fall 2011	A48, A62, A69, A85, A88, B37	16,425	13,957	2,296	172
	of these: academic track		13,815	11,897	1,896	22
	of these: vocational track		2,549	2,060	400	89
4	Spring 2012	B38	1,821	1,351	463	7
5	Fall 2012	A49, B39	16,425	12,982	2,644	799
	of these: academic track		6,305	5,768	522	15
	of these: vocational track		9,804	7,214	2,122	468
6	Spring 2013	B40	6,119	5,392	667	60

Notes: In the weights file (part of the SUF), the variable `tx80220` indicates the participation status of a panel member. The assignment to the educational track is indicated by the variable `track_3` and `track_5` for Wave 3 and Wave 5, respectively.

pected to drop out easier. Thus, these students are additionally surveyed in two intermediate waves (i.e., Wave 4 and 6), where they get follow up surveys for the previous CATI. Concretely, in Wave 4 (Spring 2012) only students on the vocational track were asked to participate for whom sufficient contact information was available and who provided a valid CATI in Wave 3. At the same time, students on the academic track were not surveyed in Wave 4. Between Wave 3 and Wave 5, 7,370 students left the academic track and entered the vocational track. In fall 2015 (i.e., in Wave 5), the entire cohort was then surveyed again. Here, students on the academic track were expected to be in Grade 11. In Wave 5, the majority of the panel cohort (in sum, 9,804 students) were on the vocational tack. The remaining 6,305 students were still on the academic track.[6] The vocational track in Wave 5 contains 9,804 panel members, namely those switching tracks between Wave 3 and Wave 5 (in sum, 7,370 students) and those who already were on the vocational track in Wave 3 and did not drop out so far or switched back to academic education (in sum, 2,434 students[7]). In Wave 5, 6,305 students were on the academic track. These students are the 6,288 panel members[8] from the previous Wave 3, who remained on the academic track, and the 17 students switching back from the vocational track. Alike in

[6]The percentage of students switching to the vocational track is higher than the numbers given in official statistics because of oversamplings in the strata related to students in lower secondary education. For details see Steinhauer et al. (2015).

[7]This number results from the 2,549 participants and temporary dropouts of Wave 3 minus the 89 final dropouts in Wave 3, minus the 7 final dropouts in Wave 4, minus 2 dropouts between Wave 4 and Wave 5, and minus 17 students switching back to academic education.

[8]In sum, 7,527 of the 13,815 panel members of Wave 3 (i.e., participants and temporary dropouts) left the academic track, either because of entering the vocational track (in sum, 7,370 students) or because of finally dropping out (22 students in Wave 3 and 135 students in Wave 5). Thus, 6,288 remained in the academic track.

Wave 4, in Wave 6 only those students on the vocational track were asked to participate who provided a valid CATI in the previous wave together with sufficient contact details.

4.2 Wave 1 and Wave 2 and between Wave 2 and Wave 3

In Wave 1 and Wave 2, all students are surveyed in their schools. Concretely, Wave 1 took place in fall 2010 and Wave 2 in spring 2011 in the school year of 2010/2011, when all target students were in Grade 9. Their individual participation propensities in the distinct panel waves have been estimated by means of random intercept probit models. The binary values of the dependent variable mark the participation status (i.e., yes or no), and the random effect aims at capturing the effect of the school in which a student had been sampled. Table 4 shows the explanatory variables that have been considered. The columns one and two of Table 5 (in Appendix A) show the results of the variables found to have a significant effect. In summary, students who are educated in schools belonging to the sampling strata FS and HS show in both waves a significantly lower participation propensity then their counterparts educated in schools of the remaining strata. The participation propensity in Wave 2 is negatively influenced by being part of the (explicit) stratum MB and of the implicit stratum of schools in urban areas. Likewise, in both waves missing information on the migrational background and on the native language has a negative effect on the participation propensities. Furthermore, in both waves the younger half of the panel members have a higher propensity to participate. The variance estimate for the random intercepts considerably increases from Wave 1 to Wave 2, indicating a strong school effect. By means of the models estimated for each panel member a participation probability can be derived. The inverse of this serves a correction factor multiplied to the initial (nonresponse adjusted) design weight. In the end, every participant is assigned such a weight. For previous versions of these weighting adjustments see Steinhauer, Zinn, and Aßmann (2016). Starting from Wave 3, students might either stay in the academic context, or they might begin a vocational training or they might pass to the transition system. Both latter transitions mean changing onto the vocational track. At a later point in time, students on the vocational track might switch back to the academic track. From there, they might again pass to the vocational track at a later time, and so on. That is, when studying the participation propensities of the sampled students and the panel members, the two distinct survey tracks have to be regarded. To account for this fact, from Wave 3 on wave participation is modeled in a stepwise manner. First, the probability to enter the vocational track is determined. Then, the participation propensities of students on the academic and on the vocational track, respectively, are estimated. The inverse of the estimated transition probabilities (first step) and the estimated participation propensities (second step) constitute the two adjustment factors used to compensate for nonresponse and attrition. To yield wave or subgroup[9] specific weights both factors are multiplied to the (nonresponse adjusted) design weights of each panel members. Table 3 shows the weights derived that way. The subsequent paragraphs deal with the estimation of the respective transition probabilities and participation propensities.

4.3 Student and parent weight

In Wave 1 and in Wave 5 information collected on students was enriched by surveying one of their parents. In Wave 1 there were 9,173 and in Wave 5 there were 3,597 parents partici-

[9] Examples of such subgroups are students who have attended all surveys up to a specific wave or the group of students for whom a parent interview is available.

pating in the telephone interview. For Wave 1 we modelled the participation of parents using a probit framework with random intercept on the school level. The inverse of this estimated participation propensities together with the students estimated propensities were used as an adjustment factor to provide nonresponse adjusted weights for students and parents participating jointly in Wave 1. Table 6 displays the significant estimates of the estimated model. Table 4 gives the variables considered in the model. Parents of students are, compared to parents of students sampled in stratum GY (reference category), less willing to participate in the Wave 1 survey. Also parents of a girl and parents of a child with migration background or missing information on migration background have a lower propensity to participate. In contrast parents of a child belonging to the younger part of the cohort's age group have a higher propensity to participate.

4.4 Staying on the same track and switching between tracks

Before estimating a student's propensity of participating in a specific wave, his/her allocation has to be clarified. That is, in a first step the probability of switching onto the vocational track is modeled. To this end, for each (explicit) sampling stratum a probit model has been estimated. Here, the dependent variable determines whether a student enters the vocational track (yes or no). The set of explanatory variables used is given in Table 4. Table 7 (in Appendix A) shows the results that have been found to be significant in Wave 3. The (significant) results corresponding to Wave 5 are given in Table 8 (in Appendix A). In the strata IG and RS, students from the younger half of the panel members have a significantly lower propensity to enter the vocational education than the older ones in Wave 3 and Wave 5. The same applies also to students in the strata FS and MB in Wave 3 and to students in the strata HS and GY in Wave 5. In Wave 3, students who are educated in a HS or FS school in a predominantly rural area show a higher propensity to enter the vocational track than students in schools in a predominantly semiurban area. The opposite is the case for students sampled in the strata GY and MB. In comparison to students in schools in a predominantly semiurban area, students in schools in a predominantly urban area show a lower tendency to enter the vocational track.[10] No comparable relationship could be found for Wave 5. In Wave 3, students attending a school receiving a public funding school have a higher propensity to enter the vocational track in stratum HS. Equally, having a migrational background as well as missing information on it, have a significantly positive effect on the individual propensities to enter the vocational track for students in stratum MB. In Wave 5, female students and students with a migrational background have a significantly lower propensity to enter the vocational track in stratum RS as compared to male students and students without migrational background or with missing information. The propensity to switch to the vocational track at Wave 5 is lower for students in stratum GY who participated in Wave 2 and Wave 3.

4.5 Academic track (Wave 3 and Wave 5)

Students remaining on the academic track are surveyed in Wave 3 (Fall 2011, students in Grade 10) and Wave 5 (Fall 2012, students in Grade 11). In order to determine their propensity to participate in the two distinct surveys a probit model has been estimated. Here, opposed to the models corresponding to Wave 1 to Wave 3, no random effect on the school level had been considered in Wave 5. The reason is that over the panel a non-negligible part of the students

[10] This result does not apply to students of the strata HS and MB. However, the related estimates are insignificant.

had left the schools in which they have originally been sampled. Thus, they entered the field of individual retracking. These students cannot be assigned to school clusters in a reasonable way. The variables considered in the probit models are given in Table 4. The estimation results of the significant variables are given in column three and four of Table 5 in Appendix A. Summarized, in Wave 3 students belonging to the younger half of the panel members have a significantly a higher participation propensity than the older ones. This interrelation is reversed in Wave 5, that is, here the older ones are more prone to participate. In both waves (i.e., in Wave 3 and in Wave 5), students in schools located in a predominantly rural area have a significantly higher participation propensity than students in schools in a predominantly semiurban area. Furthermore, students not having been sampled in a Gymnasium tend to have a lower willingness to attend in the panel. Equally, preceding nonparticipation is found to effect the propensity of further participation negatively. Having no information on the migrational background negatively effects individual participation propensities in Wave 3, whereas it has no effect in Wave 5. Likewise, being in the field of individual retracking has a negative effect on the participation propensity of a student in Wave 3 and a positive effect in Wave 5.

4.6 Vocational track (Wave 3 to Wave 6)

Alike in the case of students on the academic track, the participation propensities of students on the vocational track had been estimated by means of wave-specific probit models. In sum, four such models had been specified and estimated, one for each wave with students on the vocational track (i.e, for Wave 3 to Wave 6). As before, the dependent variable indicates the participation status and Table 4 summarized the explanatory variables. The estimated coefficients corresponding to the variables found to have a significant effect are given in columns five to eight of Table 5 (in Appendix A). In summary, students in the younger half of the panel group have a higher participation propensity in all waves concerned (i.e., in the Waves 3, 4 and 6). Only in Wave 3, students with missing information on the migrational background have a significantly lower participation than their counterparts. In the three remaining waves (i.e., in Waves 4 to 6), having a migrational background lowers the individual participation propensity. Students who participated in Wave 1 and/or in Wave 3 are more likely to participate also in Wave 5. For the other waves, no such effect could be detected. Participating in Wave 2 positively influences the participation in Wave 3, 5 and 6. Likewise, participating in Wave 4 has a positive effect on the participation propensity in Wave 5 and 6. Being on the vocational track in Wave 3 has already a significantly negative effect on the participation propensities in Wave 5 and 6. In Wave 6, female students are less prone to participate than male students.

5. Calibration

The nonresponse adjusted design weights of Wave 1 have been calibrated to correct for sampling errors and undercoverage. For this purpose, data of the school year 2010/2011 from Official Statistics have been used (Statistisches Bundesamt, 2011), that is, data refereing to Wave 1.[11] Concretely, raking (Deville, Särndal, & Sautory, 1993) has been applied on the number of students by Federal State and school type. In the weights data set of the SUF, the related (calibrated) variable is denoted as `w_t1_cal`. Beware that schools in the SC4 panel might

[11] The sampling frame used for establishing the sample of SC4 had also been formed by using data from Official Statistics, (for the school year 2008/2009). Thus, all reported quantities are measured in the same way, and calibration could be conducted without further data modification.

change their type over time (e.g., because of school reforms). Currently, the SC4 data contains not for all panel members time-dependent school type information.[12] Thus, official data of schools in the school year 2010/2011 does not mandatorily also apply to the same schools in the school year 2011/2012 or in a later school year. Currently, a calibrated weight is only available for Wave 1.

6. Trimming and Scaling

With the aim of increasing statistical efficiency of weighted analysis, the adjusted design weights were trimmed. The general goal of weight trimming is to reduce sampling variance and, at the same time, to compensate for potential increase in bias. Trimming was performed using the so-called "Weight Distribution" approach (Potter, 1990). Here, design weights are assumed to follow an inverse beta distribution with a cumulative distribution function F_w. Parameters of the sampling weight distribution are estimated using the sampling weights, and a trimming level τ is computed whose occurrence probability is 1%, that is, $1 - F_w(\tau) = 0.01$. Sampling weights in excess of τ are trimmed to this level and the excess is distributed among the untrimmed weights. The parameters for the sampling weight distribution are then estimated again using the trimmed adjusted weights, and a revised trimming level $\tilde{\tau}$ is computed. The trimmed adjusted weights are compared to the revised level $\tilde{\tau}$. If any weights are in excess of $\tilde{\tau}$, they are trimmed to this level, and the excess is distributed among the untrimmed weights. This procedure is iteratively repeated until no weights are in excess of a newly revised trimming level. To ease statistical analysis, the trimmed design weights are standardized with mean one.

7. Summary of Weights

Various kinds of weights for students are provided together with design information. Table 3 summarizes the design information given and the different weights provided; compare SUF release version DOI:10.5157/NEPS:SC4:6.0.0. Besides individual/target (`ID_t`) and institutional (`ID_i`) identifiers, design information for the entire cohort is made available.[13] This information covers the study number corresponding to the first survey in which a student had been surveyed, the explicit sampling strata (`stratum_exp`, see also Table 1) as well as the implicit sampling strata ``Federal States'' (`stratum_imp1`), ``regional classification'' (`stratum_imp2`) and ``funding'' (`stratum_imp3`).[14] The variables `track_3` and `track_5` allow for Wave 3 and Wave 5 an unique assignment of students to the distinct tracks.
Nonresponse adjusted design weights on the institutional (`w_i`) and the individual (`w_t`) level are given for the entire cohort.[15] For all participants in a particular wave, cross-sectional weights are provided. These apply to all participants in that wave. From Wave 3 on, subgroup-specific analyses for students on academic and vocational tracks can be conducted by separating by means of the variables `track_3` and `track_5` the weights for Wave 3 (`w_t3`) and Wave 5 (`w_t5`)

[12] Bayer, Goßmann, and Bela (2014) provide a generated school type variable based on different figures reported in the SC4. However, this variable is incomplete.

[13] Due to data protection, this information is not available in the download version of the SUF.

[14] In the SUF, these design variables are named differently, because of an error in data preparation. Here, variables `stratum_exp`, `stratum_imp1`, `stratum_imp2`, and `stratum_imp3` are named `stratum_imp1`, `stratum_imp2`, `stratum_imp3`, and `stratum_imp4`.

[15] The institutional weight as well as the explicit and implicit stratification variables belong to the institution and thus are equal for all cases within the institution.

Table 3: Variables included in the weighting data of SC4 SUF version 6.0.0

Variable	Applies to	Content
Identifier		
ID_t	16,425	Identifier for target person (students)
ID_i	16,425	Identifier for the institution (648 schools)
Design information		
tstud_st	16,425	Study number the target person was first surveyed in (A46, A60, A67, A83, A86)
stratum_exp	16,425	Explicit sampling stratum referring to the school (school type according to sampling frame)
stratum_imp1	16,425	Implicit sampling stratum (Federal State the school is located in according to sampling frame)
stratum_imp2	16,425	Implicit sampling stratum (regional classification according to sampling frame)
stratum_imp3	16,425	Implicit sampling stratum (funding according to sampling frame)
track_3	16,364	Educational track for students in Wave 3
track_5	16,109	Educational track for students in Wave 5
Design weights adjusted for initial nonresponse		
w_i	16,425	Weight for institution
w_t	16,425	Weight for target
Weights adjusted for wave-specific nonresponse, standardized		
w_t1	15,629	Cross-sectional weight for targets participating in Wave 1
w_t1_cal	15,629	Cross-sectional weight for targets participating in Wave 1, calibrated
w_t2	15,214	Cross-sectional weight for targets participating in Wave 2
w_t3	13,957	Cross-sectional weight for targets participating in Wave 3
w_t4	1,351	Cross-sectional weight for targets participating in Wave 4
w_t5	12,982	Cross-sectional weight for targets participating in Wave 5
w_t6	5,392	Cross-sectional weight for targets participating in Wave 6
w_tp1	8,813	Cross-sectional weight for targets jointly participating with one parent in Wave 1
w_t12	14,578	Longitudinal weight for targets participating in Wave 1 and 2
w_t123	12,783	Longitudinal weight for targets participating in Wave 1, 2, and 3
w_t1234	1,169	Longitudinal weight for targets participating in Wave 1, 2, 3, and 4
w_t1235	10,700	Longitudinal weight for targets participating in Wave 1, 2, 3, and 5
w_t12356	4,894	Longitudinal weight for targets participating in Wave 1, 2, 3, 5, and 6

according to the track considered. Note, that by design in Wave 4 and Wave 6 all students are on the vocational track. Thus, there no separation into tracks is needed.
Longitudinal weights are provided for those students of the cohort continuously participating in all successive waves. Students participating in Wave 1 and Wave 2 can be weighted using the weight (`w_t12`). As with the cross-sectional weights, also the longitudinal weights can be separated from Wave 3 on to regard the corresponding educational track using the variable `track_3` for weight `w_t123`. Again, there is no need for separating the weight `w_t1234` because Wave 4 includes students in the vocational track only. As before, the weight `w_t1235` can be correctly assigned using the variables `track_3` and `track_5`. Again there is no need of differentiating tracks when using the weight `w_t12356` since Wave 6 only includes students on the vocational track.

8. Comments regarding the Usage of Weights

No general recommendation for the usage of weights can be given. Whether and how weights have to be used depends on the problem to be studied. If the focus is on a population at a particular point in time (e.g., a specific school year) weighted analysis are reasonable. However, if the research objective is studying processes weighted analysis might not give the intended result. Concretely, weights always refer to a specific population. In the case of SC4, they refer to all students in Grade 9 educated in regular and special-need schools in Germany in the school year 2010/2011; compare Section 2. Thus, all weighted analyses give a representative picture of these students, and not, for example, of all students in vocational training.
If the focus of the study is on the target population of SC4, it is recommended to apply corresponding weights when conducting descriptive statistics. Beware that weights are only meaningful as a whole. The reason is that weights facilitate capturing the variability emerging due to sampling, attrition, and unit-nonresponse. As a direct consequence, item-nonresponse among the studied population has to be quantified and reported. For analytical analysis, models focusing on the population of SC4 have to be tested for their dependence on the sampling design. Concretely, this means that the user has to ensure that the way of sampling has no or only a negligible effect on the model results or that the sampling design is considered in the model definition adequately. A general description of how to test and account for the sampling design is given in, for example, Snijders and Bosker (2012). Here, as a guideline, it is recommended to include the basic design variables (i.e., school type as sampled, Federal State, regional classification, funding) into the model under consideration. Additionally, also those variables should be included as explanatory variables that have found to have a significant effect on the propensity to participate in a specific wave and (if applicable) on the probability to switch tracks. The related information is detailed in Section 4 of this report. If the effects of these variables and of the SC4 design variables are found to be insignificant or negligible in the model under study, the corresponding variables might be omitted in statistical inference. This kind of analysis is denoted as model-based inference. However, model-based inference should be used with caution. The dependent variable of a regression model might be a function of the explanatory variables (of interest) and the (nonresponse adjusted) design weights. Ignoring this relationship likely results in biased parameter estimates. Besides this, the intermingling of design information and model parameters (to be studied) is generally difficult, since the interpretation of the estimated coefficients might be difficult with respect to the research objective.
Alternatively, one might go with a pure design-based approach and conduct weighted regression analysis by including the corresponding weights. Beware that here standard errors are

expected to be (much) larger than in an unweighted analysis, possibly obscuring otherwise significant effects. The *survey* package of Stata allows defining the survey design of the sample at hand, and thus conducting design-based inference in an appropriate way (Kreuter & Valliant, 2007). The accordant command for analyzing the participants in Wave 1 of the SC4 sample is:

```
svyset ID_i [pweight = w_t1], strata(stratum_exp) || ID_cc
```

In this command, `ID_i` determines the cluster membership of a sampled student, and `w_t1` describes the corresponding survey weight (to be part of the SC4 sample). The term `stratum` is self-explanatory. All subsequent analysis has to be preceded by the prefix `svy`. Also the statistical software R provides a survey package to deal with design-based inference, see Lumley (2004). Here, the definition of a design object is similar to the one asked for in Stata.

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Appendix

A. Tables

Table 4: Information used in modelling participation propensities

Variable name	Information
stratum_exp	Explicit sampling stratum referring to the school (school type according to sampling frame)
stratum_imp1	Implicit sampling stratum (Federal State the school is located in according to sampling frame)
stratum_imp2	Implicit sampling stratum (regional classification according to sampling frame)
stratum_imp3	Implicit sampling stratum (funding according to sampling frame)
Age group	Median split for age of the cohort (younger half, older half)
Migration background	Migration background (yes, no, missing)
Native language	Native language (German, other, missing)
Student in individual re-tracking	Student is individually re-tracked (individual re-tracking, in school)
Student participated	Student participated in a previous Wave t
Educational track	Education track of the student in Wave t (academic, vocational)
Gender	Gender (male, female)
Nationality	Nationality (German, other, missing)

Table 5: Models estimating the individual participation propensities for students in Wave 1 up to Wave 6 of SC4 used to derive adjustment factors for adjusted wave-specific cross-sectional and longitudinal weights

			Academic education			Vocational education		
	Wave 1	**Wave 2**	**Wave 3**	**Wave 5**	**Wave 3**	**Wave 4**	**Wave 5**	**Wave 6**
(Intercept)	1.859***	1.793***	1.067***	1.156***	0.514***	0.670***	−0.253**	1.050***
	(0.089)	(0.090)	(0.069)	(0.103)	(0.085)	(0.045)	(0.088)	(0.086)
stratum_exp	−0.191*	−0.483***	−0.280***	4.017				
FS	(0.086)	(0.085)	(0.082)	(112.320)				
stratum_exp	−0.195**	−0.210**	−0.118	−0.580**				
HS	(0.063)	(0.070)	(0.062)	(0.126)				
stratum_exp	−0.108	−0.100	−0.077	−0.183*				
IG	(0.083)	(0.094)	(0.077)	(0.068)				
stratum_exp	−0.125	−0.204*	−0.058	−0.025				
MB	(0.091)	(0.101)	(0.087)	(0.216)				
stratum_exp	−0.082	−0.002	0.092	3.825				
RS	(0.068)	(0.079)	(0.063)	(44.429)				
stratum_imp2		−0.012		−0.130				
predominantly rural		(0.083)		(0.095)				
stratum_imp2		−0.133*		−0.250***				
predominantly urban		(0.055)		(0.055)				
Age group	0.083*	0.165***	0.072*	−0.114**	0.191**	0.269***		0.154***
younger half	(0.041)	(0.035)	(0.034)	(0.048)	(0.068)	(0.072)		(0.045)
Migration background	−2.449***	−0.515*	−0.561***		−0.406**	0.099	0.210	0.009
missing	(0.197)	(0.222)	(0.126)		(0.154)	(0.242)	(0.121)	(0.180)
Migration background	0.094	0.005	−0.094*		−0.117	−0.266***	−0.123***	−0.107*
yes	(0.052)	(0.043)	(0.037)		(0.061)	(0.066)	(0.030)	(0.046)
Native language	0.076	−0.048						
German	(0.072)	(0.061)						
Native language	−1.081***	−1.267***						
missing	(0.247)	(0.236)						
Individual re-tracking			−1.826***	0.429***				
yes			(0.046)	(0.090)				
Student participated in							0.183*	
Wave 1							(0.071)	
Student participated in			0.566***	0.429***	0.423***		0.244***	0.245**
Wave 2			(0.057)	(0.091)	(0.087)		(0.051)	(0.083)
Student participated in							0.644***	
Wave 3							(0.037)	
Student participated in							1.103***	0.395***
Wave 4							(0.064)	(0.094)
Educational track in Wave 3							−0.474***	−0.560***
vocational							(0.042)	(0.087)
Gender								−0.118**
female								(0.042)
Random intercept	0.068	0.194	0.100					
on the school level								
Number of students	16,425	16,425	13,815	6,305	2,549	1,821	9,804	6,119

Notes: Reference categories are: stratum_exp (GY), stratum_imp2 (intermediate), Age group (older half), Migration background (no), Native language (German), Student in individual re-tracking (no), Student participated in Wave 1/2/3/4 (no), Educational track in Wave 3 (academic), Gender (male). To model individual participation, the `glmer` function with a probit link provided by `lme4` package (Bates, Maechler, & Bolker, 2012) and the `glm` function with a probit link provided in R (R Core Team, 2015) was used.

***, **, and * denote significance at the 0.1%, 1%, and 5% level, respectively. Standard errors are given in parentheses.

Table 6: Models estimating the participation propensities for parents participating in Wave 1 of SC4 used to derive adjustment factors for adjusted weights

	Wave 1
(Intercept)	0.742***
	(0.073)
stratum_exp	−0.513***
FS	(0.060)
stratum_exp	−0.463***
HS	(0.046)
stratum_exp	−0.293***
IG	(0.062)
stratum_exp	−0.550***
MB	(0.066)
stratum_exp	−0.289***
RS	(0.050)
stratum_imp3	−0.187**
public	(0.070)
Age group	0.076***
younger half	(0.022)
Gender	−0.072***
female	(0.021)
Migration background	−0.706***
missing	(0.084)
Migration background	−0.368***
yes	(0.024)
Random intercept	0.095
on the school level	
Number of parents	16,425

Table 7: Models estimating the individual propensities to enter vocational education in Wave 3 of SC4

	Entering the vocational education track from sampling stratum					
	FS	**GY**	**HS**	**IG/FW**	**MB**	**RS**
(Intercept)	−0.065	−1.939 ***	−1.318 ***	−0.773 ***	−0.599 ***	−1.935 ***
	(0.071)	(0.060)	(0.223)	(0.098)	(0.076)	(0.062)
stratum_imp2	0.533 ***	−0.906 **	0.495 ***	0.107	−0.421 ***	
predominantly rural	(0.131)	(0.324)	(0.072)	(0.141)	(0.111)	
stratum_imp2	−0.407 ***	−0.559 ***	0.009	−0.651 ***	0.040	
predominantly urban	(0.084)	(0.102)	(0.044)	(0.109)	(0.098)	
Age group	−0.423 ***			−0.520 ***	−0.627 ***	−0.524 ***
younger half	(0.093)			(0.097)	(0.093)	(0.129)
stratum_imp3			1.082 ***			
public			(0.221)			
Migration Background					0.866 **	
missing					(0.298)	
Migration Background					0.374 ***	
yes					(0.109)	
Number of students	1179	5283	3768	1700	1187	3247

Notes: Reference categories are: stratum_imp2 (intermediate), Age group (olderHalf), stratum_imp3 (independent), Migration background (no). To model individual decisions, the `glm` function with a probit link provided by R (R Core Team, 2015) was used.

***, **, and * denote significance at the 0.1%, 1%, and 5% level, respectively. Standard errors are given in parentheses.

Table 8: Models estimating the individual propensities to enter vocational education in Wave 5 of SC4

	Entering the vocational education track from sampling stratum					
	FS	**GY**	**HS**	**IG/FW**	**MB**	**RS**
(Intercept)	1.308 ***	−0.127	1.334 ***	0.299 ***	1.160 ***	1.297 ***
	(0.064)	(0.097)	(0.046)	(0.046)	(0.053)	(0.052)
Age group		−0.280 ***	−0.239 **	−0.390 ***		−0.194 ***
younger half		(0.050)	(0.075)	(0.065)		(0.056)
Student participated in		−0.301 **				
Wave 2		(0.092)				
Student participated in		−0.900 ***				
Wave 3		(0.067)				
Gender						−0.165 **
female						(0.055)
Migration background						−0.390
missing						(0.256)
Migration background						−0.263 ***
yes						(0.061)
Number of students	734	5191	2144	1537	910	3142

Notes: Reference categories are: Age group (olderHalf), Student participated in Wave 2/3 (no), Gender (male), Migration background (no). To model individual decisions, the `glm` function with a probit link provided by R (R Core Team, 2015) was used.

***, **, and * denote significance at the 0.1%, 1%, and 5% level, respectively. Standard errors are given in parentheses.

B. Figures

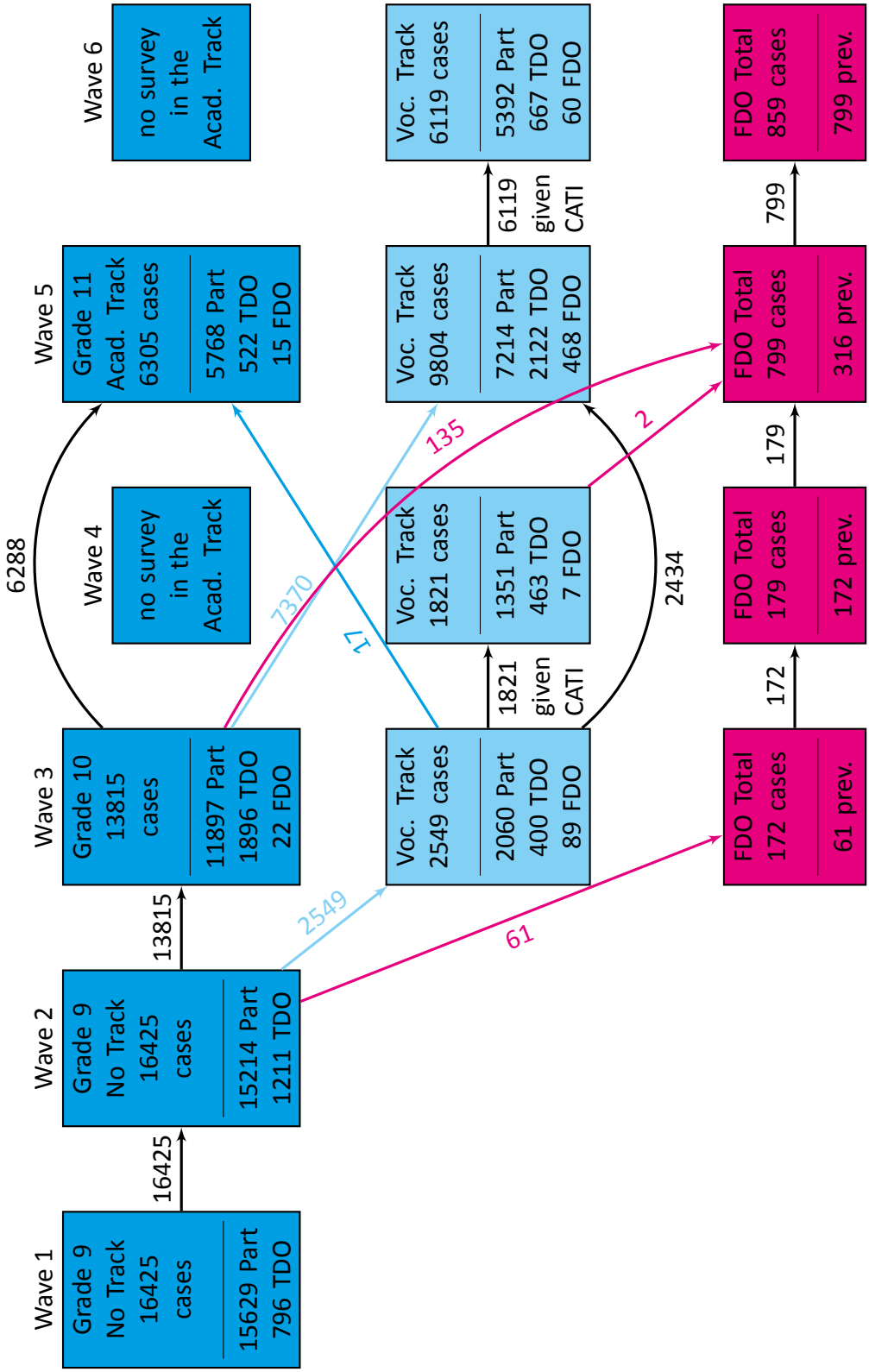

Figure 2: Observed pathways through upper secondary and vocational education NEPS SC4.

Notes: Abbreviations are: Part = Participants, TDO = temporary dropout, FDO = final dropout (coloured in magenta), prev. = previous wave dropout, Acad. = Academic (coloured in cyan), Voc. = Vocational (coloured in light blue). Black arrows and annotations indicate cases staying in the corresponding track or staying FDO. Arrows and annotations in cyan indicate cases switching from vocational to academic track. Light blue arrows and annotations indicate cases switching form academic to vocational track. Arrows and annotations in magenta indicate cases finally dropping out between waves.