Time use during the life course in the USA, Norway, and the Netherlands: a HAPC-analysis

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Time use during the life course in the USA, Norway, and the Netherlands: a HAPC-analysis *

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Abstract

This paper analyses life course variations by means of Hierarchical Age-Period-Cohort-modelling (HAPC) of time use data for thee welfare states: the USA, Norway, and the Netherlands. By means of analyzing time use data insight is gained in the (relative) importance of various life spheres as paid work, household work, volunteer aid, care, anc education in and over people's life. The relevance of an integrated insight in the relation between paid work and these other life spheres seems to have grown with the introduction and (policy) application of the idea of "transitional labour markets". This paper aims to find out the relevance of age, period and cohort as underlying factors in population ageing and change. The author compares the fixed versus the random-effects model specifications for APC-analysis. The random-effects HAPC-model appears the most appropriate specification. The HAPC analyses find evidence in support of quadratic age effects on time use. Furthermore, the HAPC analyses find proof in support of the contentions in the literature that both cohort and period effects should be distinguished in life course analyses. Finally, the analyses show clear differences in time use patterns during the life course between the welfare states. These may indicate a non-negligible sensitivity for welfare policies with respect to reconciling life domains during the life course.

Key-words Age-Period-Cohort analysis, hierarchical linear modeling, life course, time use, welfare states

JEL-codes J10, J22

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1. Introduction

During last years a number of papers appeared that discuss how work and family can be better reconciled by adopting a life-course perspective (for instance Bovenberg, 2005, Naegele et al., 2003, Klammer et al., 2005, Anxo et al., 2006). The life course perspective, rooted within academic traditions, can be described as an analytical framework that aims to highlight the developmental and dynamic components of human lives, institutions and organisations. One of the main features of the life course approach is to acknowledge the crucial role that time plays in the understanding of individual behaviour and structural changes in society. Another important dimension of the life course approach is its attempt to take a holistic view, so that the analysis no longer views specific events, phases or demographic groups as discrete and fixed but considers the entire life trajectory as the basic framework for analysis (following Anxo et al., 2006, p. 2).

One of the main hypotheses underlying the papers mentioned above is that life courses have changed during last decades (partly) as a result of individualization, industrialization and increased welfare, increased female labour market participation, and ageing of society. Starting from that idea, these papers focus on formulating ideas, concepts, and policies for a reallocation of time over (working) life. The (integrated) analysis of variations in life courses during last decades seems to receive far less attention in literature. The work of Liefbroer & Dykstra (2000) for the Netherlands forms an interesting exception however. They describe the life courses of Dutch men and women who grew up in the 20th century, in the light of social events and changes, and emphasize the importance of distinction between period and cohort related changes (following Kronjee, 1991). On this point they go further than Becker (1992, 1997), Easterlin (1980), and Inglehart (1977, 1997) who focus on cohort effects. These scholars argue that the circumstances people experience during their "formative phase" mainly determine their life course. According to Liefbroer and Dykstra period effects are of importance as well; historical changes influence cohorts on various moments in the life course and could be relevant in life phases that have to be passed through in the future.

In this paper we endeavour to throw some more light on the importance of period and cohort effects on variations in life courses by applying a mixed models approach to the age-period-cohort analysis of time use data for the USA, Norway, and the Netherlands, as recently developed by Yang & Land (2006a, 2006b). By means of this approach we are able to separate age, period, and cohort effects, to skirt the "identification problem" characteristic for *traditional* APC-analyses, and to use to the richness of micro data as the time use data we use are. By means of analyzing time use data we gain insight in variations in life courses during last decades, and the factors underlying these variations as time use data offer ample possibilities to gain insight in the (relative) importance of various life spheres as paid work, household work, volunteer work/aid, care, and education in and over people's lifes. The relevance of an integrated insight in the relation between paid work and these other life spheres seems to have grown with the introduction, acceptation and (policy) application of the idea of transitional labour markets (Schmid, 2000, Schmid and Gazier, 2002)[1].

[1] This idea forms one of the pillars underlying life course policies introduced in the Netherlands and Belgium recently.

2. The concepts of age, period, and cohort

For a number of decades, researchers have endeavoured to analyze data using *age* (A) and *time-period* (P) as explanatory variables to study phenomena that are time-specific. An analytic focus in which *cohort* (C) membership is taken into consideration is of interest whenever social change is studied from the angle of generation succession. During last 30 years, researchers have developed models for situations in which all three age, period, and cohort (APC) are potentially of importance to studying time-specific phenomena.

Age is synonymous with individual time (following Mulder, 1993). In a strictly operational sense, age is simply the time that has elapsed between the date of birth and the moment of observation. This definition is not of much interest however. As a substitute variable, it can be considered as an indicator of all kind of processes and events associated with growing up and becoming older. In that case it refers to biological phenomena. It can be used as a psychological variable also, as a substitute for increase or decrease of intellectual capacities, development of personality, changing reactions in stress situations, etc. Also it may refer to sociological phenomena: Not until a certain age it is permitted or appropriate to marry and have children; age has to do with the position and the length of participation in social systems (Hagenaars, 1990, Versantvoort, 2000). Thus, *age effects* represent the variation associated with different age groups brought about by physiological changes, accumulation of social experience, and/or role or status changes (Yang & Land, 2006a).

Period is synonymous with historical time. Period, or time, refers to the moments of observation in a purely operational sense. However, also period effects are used as an indicator for the effects of all kinds of discrete events occurring at or between the moments of observation and for the influence of long term processes such as industrialisation, modernization, economic trends, changes in educational standards, etc. So *period effects* represent variation over time periods that affect all age groups simultaneously – often resulting from shifts in social, cultural, economic, or physical environments (Yang & Land, 2008)..

A birth *cohort* is a group of people born in the same period and experiencing individual time in the same historical time context. There may be compositional differences with regard to background characteristics between cohorts. Cohorts may differ from each other in size also. Some cohorts will differ from each other because they have experienced different events before the first moment of observation. Other cohort differences are caused by the fact that cohorts are affected by the same events and trends but at a different age, and therefore with a different lasting impact (Versantvoort, 2000, Hagenaars, 1990). In general, *cohort effects* are associated with changes across groups of individuals who experience an initial event such as birth or marriage in the same period; these may reflect the effects of having different formative experiences for successive age groups in successive time periods (Yang & Land, 2006a, based on Robertson et al., 1999, Glenn, 2003).

The age-period-cohort (APC) accounting/ multiple classification model developed by Mason et al. (1973) has been used for over three decades as a general methodology for estimating age, period, and cohort effects in demographic and social research. This general methodology focuses on the APC analysis of data in the form of tables of percentages or occurrence/ exposure rates of events. A major methodological "problem" with the APC analysis of tabulated data is that at the operational level there is an exact linear relation among age, period, and cohort: A = P – C. Age

is exactly the difference between the moment of observation and data of birth. Once the scores on two of the three components A, P, C are known, the score on the third variable is fixed. It is impossible to let one of the factors vary independently of the other two and to have at one particular point in time two persons who have the same age but are "assigned" to different cohorts (see Hagenaars, 1990, p. 326, Versantvoort, 2000). Thus, analyses in which all three key variables are included cannot be carried out without further restrictions; the separate effects of age, period, and cohort are not identifiable. This identification problem has drawn great attention in statistical studies of human populations. Various methodological contributions to the specification and estimation of APC models have appeared in recent decades (see for instance, Glenn, 1976, Hobcraft et al., 1982, Hagenaars, 1990, Fu, 2000, O'Brien, 2000).

This literature has identified three conventional strategies for identification and estimation (see for a more extensive overview and explanation Yang & Land, 2006a, p.83, Hagenaars, 1990): (1) constraining two or more of the remaining age, period, or cohort coefficients to be equal by placing at least one additional identifying constraint on the parameter vector; (2) using a "proxy" variable for the cohort or period effects and presuming a linear relation between these variables and the selected dependent variables; (3) changing at least one of the age, period, or cohort variables so that its relationship to the other age, period or cohort variables is nonlinear.

As said we follow the approach recently proposed by Yang & Land (2008, 2006a, 2006b). In recognition of the multilevel structure of individual-level responses in repeated cross-section, Yang & Land present a mixed (fixed and random) effects model approach. In particular, they introduce cross-classified hierarchical linear models (HLM) to represent variations in individual-level responses by periods and cohorts. This leads to the identification and estimation of random effects for period and cohorts that then can become the objects of explanation. This HAPC modeling framework has enhanced the ability to estimate separate age, period, and cohort effects through the estimation of variance components (Yang & Land, 2006, p. 77).

This approach has a number of advantages compared to the strategies mentioned above. First, it takes advantages of the nested data structure presented in repeated cross-section surveys in contrast to "traditional" APC-analysis which focuses on aggregate population-level data. Besides that, it addresses the heterogeneity problem characteristic for general APC regression models. Furthermore, using micro data as the method proposes offers possibilities to deal with the identification problem. By means of grouping the age, period, and/ or cohort data of respondents into time intervals of different length the underidentification problem is broken. For instance, after grouping cohorts in cohorts of durations longer than single years, in a given year (period), respondents may be of (slightly) different ages but within the same cohort (see Smith, 2008). Besides that, the identification problem is "solved" by the introduction of a quadratic polynomial to capture the age pattern.

3. Time use data

Data

Time use data are analyzed from several cross-sections of the Multinational Time Use Study (MTUS [2]), 1965-2003, of three different countries: the United States, Norway, and the Netherlands (see table 1). These countries are selected since each of them represents a type of welfare state (see for instance Esping-Anderson (1990)), and for each of them a similar range of survey years is available[3]. Because of that the results of the countries/welfare states types can be compared. For the United States the data include 31,527 respondents who had measures on time use and several covariates across all survey years, for Norway 23,870, and for the Netherlands 13,635.

Table 1 Countries and years in MTUS-selection

	Period 1 1965-69	Period 2 1970-74	Period 3 1975-79	Period 4 1980-84	Period 5 1985-89	Period 6 1990-94	Period 7 1995-99	Period 8 2000-04
USA	1965		1975		1985		1998	2003
Norway		1971		1981		1990		2000
Netherlands			1975	1980	1985	1990	1995	2000

Source: MTUS

Variables

Besides age, period, and cohort, we distinguish a number of covariates. Time use is measured in minutes per day (with a maximum of 1440 minutes a day). It is assumed to depend on gender, educational level[4], care for children, civic status, and weekend day. Table 2 presents the covariates and matching descriptive statistics. As table 1 shows, the main time use categories for people in the USA, Norway, and the Netherlands are time on leisure, paid work, and household work.

Centering

In multilevel regression attention should be paid to "centering", i.e. choosing the location of the individual-level explanatory variables (Raudenbush & Bryk, 2002, Yang & Land, 2006a). Different ways of centering the variables are available: using grand mean centering by subtracting the complete sample or grand mean from the observed values; using the natural metric of the variables; using group mean centering; and using the coefficient of variation (Plewis, 1989, Paccagnella, 2006). Each of these has different implications in terms of intercept interpretation, mean and variance form of the dependent variable and statistical properties. As the minimum value of the age variables does not include zero, we applied centering on the grand mean for each of the individual level variables.

[2] The Multinational Time Use Study (MTUS) was first developed in the early 1980s at the University of Bath, and adapted and harmonized at the Universities of Essex and Oxford afterwards. The MTUS has grown to encompass over 50 datasets from 19 countries, and is now incorporating recent data from the HETUS, ATUS, and other national level time use projects (http://www.timeuse.org/mtus/).

[3] Although several South European and former communistic countries are included in MTUS, none of these countries has comparable data ranges/years in MTUS with the ones included for the USA, Norway, and the Netherlands. Because of that these countries were not taken into account in the analysis.

[4] For Norway this variable is excluded since no information on education level was available for Period 2.

Table 2 Descriptive statistics, data 1965-2004, MTUS selection USA, Norway, the Netherlands

Variables	Definition	USA				Norway				The Netherlands			
		Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
PAID WORK[a]	Time spent on paid work (minutes/ day)	192.19	263.48	0.00	1420.00	2513.03	258.81	0.00	1311.00	160.90	183.12	0.00	1.00
EDUCATION[b]	Time spent on education (minutes/day)	14.20	61.99	0.00	1040.00	17.34	82.04	0.00	1130.00	21.93	63.97	0.00	615.00
CHILD CARE[c]	Time spent on child care (minutes/day)	28.75	71.76	0.00	1151.00	29.64	67.53	0.00	690.00	29.72	54.26	0.00	460.71
HOUSEHOLD[d]	Time spent on household duties (minutes/day)	176.75	155.78	0.00	1343.00	168.27	147.63	0.00	920.00	171.74	110.10	0.00	606.43
OTHER CARING[e]	Time spent on caring for acquaintances and relatives outside the household (minutes/day)	33.43	78.33	0.00	1085.00	28.07	69.51	0.00	825.00	34.14	42.74	0.00	567.86
VOLUNTARY[f]	Time spent on voluntary work (minutes/day)	8.63	43.35	0.00	875.00	6.01	35.78	0.00	660.00	11.67	29.11	0.00	486.43
LEISURE[g]	Time spent on leisure activities (minutes/day)	320.16	206.09	0.00	1382.00	299.07	180.28	2.00	1413.00	322.01	116.07	0.86	1003.71
FEMALE	Gender: 1 = female, 0 = male	0.56	0.50	0.00	1.00	0.53	0.50	0.00	1.00	0.58	0.49	0.00	1.00
EDUC1	No secondary education	0.17	0.38	0.00	1.00					0.54	0.50	0.00	1.00
EDUC2	Secondary education completed	0.38	0.47	0.00	1.00					0.25	0.43	0.00	1.00
EDUC3	Higher education	0.49	0.50	0.00	1.00					0.21	0.41	0.00	1.00
NOCHILD	No children living at home or unknown	0.55	0.50	0.00	1.00	0.51	0.49	0.00	1.00	0.48	0.50	0.00	1.00
CHILD04	Children living at home below age 5	0.17	0.38	0.00	1.00	0.19	0.39	0.00	1.00	0.02	0.13	0.00	1.00
CHILD5	Children living at home, age 5 or older	0.28	0.45	0.00	1.00	0.30	0.46	0.00	1.00	0.50	0.50	0.00	1.00
AGE	Age at survey year	45.29	16.32	18.00	80.00	43.06	15.81	18	80	41.13	15.22	18	80
CIVSTATUS	Living with a partner or not	0.66	0.47	0.00	1.00	0.73	0.46	0.00	1.00	0.75	0.43	0.00	1.00
WEEKEND	Weekend day	0.45	0.50	0.00	1.00	0.29	0.45	0.00	1.00				
PERIOD	5-year periods			1965-1969	2000-2004			1970-1974	2000-2004			1975-1979	2000-2004
COHORT	5-year birth cohorts			1895-1899	1985-1989			1895-1899	1980-1984			1895-1899	1980-1984

[a] Consists of the MTUS categories: av1, av2, av3, and av5.
[b] Consists of the MTUS categories: av4 and av33.
[c] Consists of the MTUS category: av11.
[d] Consists of the MTUS categories: av6, av7, av9, av10, and av12.
[e] Consists of the MTUS category: av8.
[f] Consists of the MTUS category: av23.
[g] Consists of the MTUS categories: av17, av18, av19, av20, av21, av24, av25, av26, av27, av28, av29, av30, av31, av32, av34, av35, av36, av38, av39, and av40.
Source: MTUS

4. Model and results

4.1 General framework

In linear regression form the structure of the classical age-period-cohort accounting/ multiple classification model / fixed-effects regression model (see Mason et al., 1973) is as follows:

$$Y = Xb + \varepsilon, \tag{1}$$

Y is a vector of event/ exposure rates or log-transformed rates from population tabular data, *X* is the regression design matrix consisting of "dummy variable" column vectors for the vector of model parameters *b*:

$$B = (\mu, \alpha_1, \ldots \alpha_{a-1}, \beta_1, \ldots \beta_{\beta-1}, \gamma_1, \ldots, \gamma_{a+p-2})^T \tag{2}$$

For $i = 1, \ldots, a$ age groups, $j = 1, \ldots, p$ periods, and μ denotes the intercept or adjusted mean rate; α_i denotes the *i*th row age effect or the coefficient for the *i*th age group; β_j denotes the *j*the column period effect or the coefficient for the *j*th time period; γ_k denotes the *k*th diagonal cohort effect or the coefficient for the *k*th cohort for $k = 1, \ldots, (a+p-1)$, with $k = a-i+j$; and ε is a vector of random errors with mean 0 and constant diagonal variance matrix $\sigma^2 I$, where *I* is an identity matrix. Usually one of each of the α_i, β_j, and γ_k coefficients is set to zero. Then the OLS estimator of the matrix regression model (1) is the solution $\hat{b}$ of the normal equations (see Yang and Land, 2006a, p.82):

$$\hat{b} = (X^T X)^{-1} X^T Y \tag{2a}$$

Considering the identification problem typical for this kind of analysis, as well as the possibilities hierarchical APC-analysis of micro time use data may offer, we specify and test both fixed and random effects models of time use as a quadratic function of age. The fixed-effects specification of the equations we estimate is as follows:

$$\begin{aligned} PAIDWORK_i = {} & \beta_0 + \beta_1 AGE_i + \beta_2 AGE_i^2 + \beta_3 FEMALE_i + \beta_4 CIVSTATUS_i + \beta_5 CHILD04_i \\ & + \beta_6 NOCHILD_i + \beta_7 EDUC2_i + \beta_8 EDUC3_i + \beta_9 WEEKEND_i + \varepsilon_i \end{aligned} \tag{3a}$$

$$\begin{aligned} EDUCATION_i = {} & \beta_0 + \beta_1 AGE_i + \beta_2 AGE_i^2 + \beta_3 FEMALE_i + \beta_4 CIVSTATUS_i + \beta_5 CHILD04_i \\ & + \beta_6 NOCHILD_i + \beta_7 EDUC2_i + \beta_8 EDUC3_i + \beta_9 WEEKEND_i + \varepsilon_i \end{aligned} \tag{3b}$$

$$\begin{aligned} CHILDCARE_i = {} & \beta_0 + \beta_1 AGE_i + \beta_2 AGE_i^2 + \beta_3 FEMALE_i + \beta_4 CIVSTATUS_i + \beta_5 CHILD04_i \\ & + \beta_6 NOCHILD_i + \beta_7 EDUC2_i + \beta_8 EDUC3_i + \beta_9 WEEKEND_i + \varepsilon_i \end{aligned} \tag{3c}$$

$$\begin{aligned} HOUSEHOLD_i = {} & \beta_0 + \beta_1 AGE_i + \beta_2 AGE_i^2 + \beta_3 FEMALE_i + \beta_4 CIVSTATUS_i + \beta_5 CHILD04_i \\ & + \beta_6 NOCHILD_i + \beta_7 EDUC2_i + \beta_8 EDUC3_i + \beta_9 WEEKEND_i + \varepsilon_i \end{aligned} \tag{3d}$$

$$\begin{aligned} OTHERCARING_i = {} & \beta_0 + \beta_1 AGE_i + \beta_2 AGE_i^2 + \beta_3 FEMALE_i + \beta_4 CIVSTATUS_i + \beta_5 CHILD04_i \\ & + \beta_6 NOCHILD_i + \beta_7 EDUC2_i + \beta_8 EDUC3_i + \beta_9 WEEKEND_i + \varepsilon_i \end{aligned} \tag{3e}$$

$$VOLUNTARY_i = \beta_0 + \beta_1 AGE_i + \beta_2 AGE_i^2 + \beta_3 FEMALE_i + \beta_4 CIVSTATUS_i + \beta_5 CHILD04_i + \beta_6 NOCHILD_i + \beta_7 EDUC2_i + \beta_8 EDUC3_i + \beta_9 WEEKEND_i + \varepsilon_i \quad (3f)$$

$$LEISURE_i = \beta_0 + \beta_1 AGE_i + \beta_2 AGE_i^2 + \beta_3 FEMALE_i + \beta_4 CIVSTATUS_i + \beta_5 CHILD04_i + \beta_6 NOCHILD_i + \beta_7 EDUC2_i + \beta_8 EDUC3_i + \beta_9 WEEKEND_i + \varepsilon_i \quad (3g)$$

for i = 1, 2, … ,N.

Respondent *i*'s time use is modeled as a function of his or her age, age-squared, educational attainment, gender, presence of young children, civic status, and weekendday. In this model the possibility that the effects of cohort and period may have random, as well as, or instead of, fixed effects on time use is ignored. However, respondents in the same cohort and/or period may spend their time in similar ways because they share random error components unique to their cohorts or periods. Because of that the standard errors of estimated coefficients of conventional fixed-effects regression models may be underestimated. This *heterogeneity problem* can be addressed by modifying the fixed effects specification of the general APC regression model toward a random effects model (see Yang & Land, 2006a, p.86). This implies that we should modify the fixed-effects APC regression model to a mixed effects model.

4.2 Random effects APC model

The individuals in MTUS are nested within cells created by the cross-classification of two types of context: periods of survey and birth cohorts. Thus, respondents are members in cohorts and periods simultaneously. Table 3 shows this data structure for the USA, Norway, and the Netherlands.

In this table each row is a birth cohort and each column a 5 years period. The number of birth cohorts is indicated as *J* and the number of periods as *K.* The numbers in this *J* by *K* matrix are the sample sizes, n_{jk}; the numbers of individuals who belonged to a given birth cohort and were surveyed in a given period.

Table 3 Two-way cross-classified data structure in MTUS: number of observations in each cohort-by-period cell

Panel (a): USA

	Period					
Cohort	1965-69	1975-79	1985-89	1995-99	2000-04	Total
1895-99	2	121	0	0	0	123
1900-04	96	237	0	0	0	333
1905-09	149	491	100	0	0	740
1910-14	176	381	143	0	0	700
1915-19	231	419	210	11	0	871
1920-24	248	509	264	31	833	1885
1925-29	217	427	292	46	804	1786
1930-34	221	436	288	41	957	1843
1935-39	253	667	285	39	1006	2250
1940-44	248	804	311	43	1199	2605
1945-49	70	878	432	70	1551	3001
1950-54	0	688	528	79	1727	3022
1955-59	0	192	504	122	2036	2854
1960-64	0	0	400	114	2222	2736
1965-69	0	0	192	97	2011	2300
1970-74	0	0	0	84	1898	1982
1975-79	0	0	0	63	1267	1330
1980-84	0	0	0	10	929	939
1985-89	0	0	0	0	227	227
Total	1911	6250	3949	850	18567	31527

Panel (b): Norway

	Period				
Cohort	1970-74	1980-84	1990-94	2000-04	Total
1895-99	233	0	0	0	233
1900-04	294	2	0	0	296
1905-09	381	138	0	0	519
1910-14	473	312	109	0	894
1915-19	578	398	251	0	1227
1920-24	566	526	319	160	1571
1925-29	569	453	346	204	1572
1930-34	514	429	325	316	1584
1935-39	515	403	381	582	1881
1940-44	623	552	462	430	2067
1945-49	585	724	630	574	2513
1950-54	427	613	595	574	2209
1955-59	0	630	583	723	1936
1960-64	0	480	696	804	1980
1965-69	0	0	687	854	1541
1970-74	0	0	420	749	1169
1975-79	0	0	0	436	436
1980-84	0	0	0	242	242
Total	5758	5660	5804	6648	23870

Panel (c): the Netherlands

	Period						
Cohort	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04	Total
1895-99	6	0	0	0	0	0	6
1900-04	27	19	0	0	0	0	46
1905-09	45	48	41	0	0	0	134
1910-14	54	101	102	49	0	0	306
1915-19	52	116	139	81	24	0	412
1920-24	65	136	181	180	82	44	688
1925-29	84	130	167	176	111	71	739
1930-34	90	156	164	178	151	85	824
1935-39	94	135	157	138	159	118	801
1940-44	151	241	210	178	176	106	1062
1945-49	214	384	419	276	239	144	1676
1950-54	152	402	463	371	331	153	1872
1955-59	60	289	437	438	420	155	1799
1960-64	0	124	308	401	446	202	1481
1965-69	0	0	144	288	412	175	1019
1970-74	0	0	0	129	275	149	553
1975-79	0	0	0	0	95	94	189
1980-84	0	0	0	0	0	28	28
Total	1094	2281	2932	2883	2921	1524	13635

Source: MTUS selection

To determine the relative importance of cohort and period in factors underlying individual differences in time use (paid work, education, child care, household work, care for others, voluntary work, and leisure activities), we have estimated cross-classified random effects APC models. These models are specified as follows:

Level-1 or "within-cell" model:

$$PAIDWORK_{ijk} = \beta_{0jk} + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + e_{ijk} \quad (4a)$$

$$EDUCATION_{ijk} = \beta_{0jk} + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + e_{ijk} \quad (4b)$$

$$CHILDCARE_{ijk} = \beta_{0jk} + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + e_{ijk} \quad (4c)$$

$$HOUSEHOLD_{ijk} = \beta_{0jk} + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + e_{ijk} \quad (4d)$$

$$OTHERCARING_{ijk} = \beta_{0jk} + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + e_{ijk} \quad (4e)$$

$$VOLUNTARY_{ijk} = \beta_{0jk} + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + e_{ijk} \quad (4f)$$

$$LEISURE_{ijk} = \beta_{0jk} + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + e_{ijk} \quad (4g)$$

$$e_{ijk} \sim N(0, \sigma^2)$$

Level-2 or "between-cell" model:

$$\beta_{0jk} = \gamma_0 + u_{0j} + v_{0k}, u_{0j} \sim N(0, \tau_u), \quad v_{0k} \sim N(0, \tau_v) \quad (4h)$$

Combined model:

$$PAIDWORK_{ijk} = \gamma_0 + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + u_{i0} + v_{0k} + e_{ijk} \quad (4i)$$

$$EDUCATION_{ijk} = \gamma_0 + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + u_{i0} + v_{0k} + e_{ijk} \quad (4j)$$

$$CHILDCARE_{ijk} = \gamma_0 + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + u_{i0} + v_{0k} + e_{ijk} \quad (4k)$$

$$HOUSEHOLD_{ijk} = \gamma_0 + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + u_{i0} + v_{0k} + e_{ijk} \quad (4l)$$

$$OTHERCARING_{ijk} = \gamma_0 + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + u_{i0} + v_{0k} + e_{ijk} \quad (4m)$$

$$VOLUNTARY_{ijk} = \gamma_0 + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + u_{i0} + v_{0k} + e_{ijk} \quad (4n)$$

$$LEISURE_{ijk} = \gamma_0 + \beta_1 AGE_{ijk} + \beta_2 AGE^2_{ijk} + \beta_3 FEMALE_{ijk} + \beta_4 CIVSTATUS_{ijk} + \beta_5 CHILD04_{ijk} + \beta_6 NOCHILD_{ijk} + \beta_7 EDUC2_{ijk} + \beta_8 EDUC3_{ijk} + \beta_9 WEEKEND_{ijk} + u_{i0} + v_{0k} + e_{ijk} \quad (4o)$$

for i = 1, 2, ..., n_{jk} individuals within cohort j and period k;
j = 1, …, 19 birth cohorts;
k = 1, …, 9 time periods;
where, within each birth cohort j and period k, respondent i's time use is modeled as a function of his or her age, age-squared, educational attainment, gender, presence of young children, civic status, and weekendday.

This random-intercepts model specification allows only the level-1 intercept to vary randomly from cohort-to-cohort and period-to-period, but not the level-1 slopes. In this model, β_{0jk} is the intercept or "cell mean" – that is, the mean time use of individuals who belong to birth cohort j and surveyed in period k; $\beta_{1,} \ldots. \beta_{11,}$ are the level-1 fixed effects; e_{ijk} is the random individual effect – that is, the deviation of individual ijk's score from the cell mean, which are assumed normally distributed with mean 0 and a within-cell variance σ^2; γ_0 is the model intercept, or grand-mean time use of all individuals; u_{0j} is the residual random effect of cohort j that is, the contribution of cohort j averaged over all periods on β_{0jk}, assumed normally distributed with mean 0 and variance τ_u ; and v_{0j} is the residual random effect of period k – that is, the contribution of period k averaged over all cohorts, assumed normally distributed with mean 0 and variance τ_v . In addition, $\beta_{0j} = \gamma_0 + u_{0j}$ is the cohort effect averaged over all periods; and $\beta_{0k} = \gamma_0 + v_{0k}$ is the period effect averaged over all cohorts (see Yang and Land, 2008, 2006a, 2006b).

4.3 Results

Fixed effects
Table 4 and Table A1 in the appendix show the empirical estimates for regression models on the MTUS-data for the USA, Norway and the Netherlands. Table 4 contains baseline ordinary least squares estimates of regression models for the three welfare states without controls for period and cohort effects (equations 3). Estimates of seven regression models, one for each time use category, are given in the table.
Spending time on paid work seems to rise with age as well as spending time on household work and caring for others for all selected welfare states. Growing older negatively affects time spent on education and leisure activities in each of the countries. Differences between the countries can be observed for time spent on childcare and on voluntary work. Spending time on childcare increases with age in the Netherlands and the USA, but decreases with age in Norway. Spending time on voluntary work increases with age in Norway and the Netherlands. For the USA we find a non-significant negative relation. Except for childcare in the Netherlands, and household work in Norway, the estimates confirm the assumed nonlinear effect of age.
Compatible with prior research, being female is negatively associated with spending time on paid work, and positively with spending time on household work and child care for each of the countries. For each of the countries it is negatively associated with spending time on caring for

others also[5]. The countries differ with respect to the effect of gender on time spent on voluntary work. For the Netherlands and Norway being female is negatively associated with spending time on voluntary work, for the USA positively.

A higher education relates positively to spending time on paid work, education, child care, and voluntary work in both the USA and the Netherlands. It appears to relate negatively to spending time on household work, especially in the Netherlands. The USA and the Netherlands differ on the effect of educational level on time spent on caring for others. People who are higher educated appear to spend more time on caring for others than people who are low educated in the USA. For the Netherlands we found an opposite relation.

In each of the welfare states people who do not have young children to care for appear to spend more time on paid work and leisure activities, and less time on child care and household work than people who have children. With respect to time spent on education, the countries show differences. People who do not have children to care for spend less time on education than people with children to care for in the Netherlands. For Norway the relation appears opposite and for the USA the effect of not having children appears nonsignificant. Also in each of the welfare states people who have children in the ages 0-4 spend less time on paid work, voluntary work, and leisure activities and more time on child care and household work[6] than people with children in the age of 5 or older or people without children to care for.

Persons who live with a spouse tend to spend more time on childcare, household work, and care for others, and less time on education and leisure than persons who do not live with a spouse in each of the countries. With respect to time spent on paid work and voluntary work, the countries show different results. In the USA persons who live with a spouse spend less time on paid work and more time on voluntary work than persons who do not live with a spouse. In the Netherlands, living with a spouse tend to increase time spent on voluntary work. For the other effects, the regression coefficients appear not significant.

[5] Although for the Netherlands non-significant.
[6] Although the effects are not significant for each of the countries.

Table 4: Fixed-Effects Regression Models for Various Time Use Categories, MTUS Data, Without Controls for Period and Cohort Effects, three Panels, USA, Norway, and the Netherlands

Panel (a): USA

Independent	Dependent Paid work	Education	Childcare	Household	Othercaring	Voluntary	Leisure
Intercept	197.94***	14.23***	26.40***	175.29***	33.49***	9.04***	317.06***
Age	13.38***	-3.97***	0.61***	2.93***	0.83***	-0.04	-9.43***
Age^2	-0.18***	0.03***	-0.01***	-0.02***	-0.01**	0.002**	0.12***
Female	-118.49***	-4.28***	19.52***	100.32***	-5.03***	1.68**	-29.72***
Educ2	23.38***	-1.95	3.14**	2.99	4.51***	2.99***	-9.02**
Educ3	38.45***	13.12***	6.80***	-4.78*	5.03***	6.07***	-34.10***
Married	-9.15**	-11.78***	4.19***	31.51***	4.15***	2.54***	-24.49***
Child04	-25.96***	-16.18***	58.01***	10.15***	-1.20	-4.46***	-19.01***
NoChild	12.46***	1.80	-27.82***	-16.03***	3.70**	-4.84***	20.70***
Weekend	-216.61	-9.30***	-5.29***	31.08***	11.62***	0.80***	116.05***
AIC	408586	335724	320339	376824	339925	307104	392896

Panel (b): Norway

Independent	Dependent Paid work	Education	Childcare	Household	Othercaring	Voluntary	Leisure
Intercept	213.29***	17.69***	29.33***	168.37***	28.02***	6.04***	298.15***
Age	18.14***	-5.92***	-0.90***	1.89***	0.49**	0.28**	-7.24***
Age^2	-0.23***	0.049***	0.006**	0.002	-0.004*	-0.003**	0.09***
Female	-131.49***	0.28	21.16***	135.02***	-22.47***	-2.11***	-20.04***
Married	0.647	-10.39***	4.76***	21.04***	6.35***	0.46	-27.33***
Child04	-33.08***	-23.34**	81.59***	3.83	0.64	-1.77**	-13.14***
NoChild	32.45***	5.88***	-21.71***	-34.41***	4.81***	-0.51	24.22***
Weekend	-200.91***	-15.54***	0.85	-9.09***	3.51***	-2.13***	149.61***
AIC	342496	291245	268446	313895	283534	250574	326751

Panel (c): the Netherlands

Independent	Dependent Paid work	Education	Childcare	Household	Othercaring	Voluntary	Leisure
Intercept	171.79***	22.93***	22.21***	165.47***	33.47***	12.02***	321.05***
Age	8.51***	-7.35***	15.94***	3.92***	5.35***	1.01***	-2.65***
Age^2	-0.14***	0.068***	0.004**	-0.02***	-0.01***	-0.01***	0.05***
Female	-153.64***	-3.44***	17.93***	126.57***	-0.78	-3.28***	-14.02***
Educ2	33.03***	13.33***	4.04***	-24.32***	-2.15*	2.08**	-11.18***
Educ3	26.78***	32.03***	4.5***	-33.52***	-5.41***	4.26***	-13.74***
Married	0.60	-21.60***	15.94***	22.13***	5.35***	-2.52***	-31.29***
Child04	-17.91***	-31.98***	71.93***	4.72	-7.65*	-7.40*	-49.22***
Childno	0.86	-12.27***	-20.37***	-12.12***	-1.90*	-1.18	30.50***
AIC	171395	146372	134458	154791	137582	129818	162322

*indicates $p < 0.05$; **indicates $p < 0.01$; ***indicates $p < 0.001$, two-tailed test.
Source: own estimations based on MTUS selection

Random effects

Table A1 in the Appendix report the parameter estimates for the crossed random effects model (equations 4) estimated on the MTUS data[7]. These results are attained using the restricted maximum-likelihood-empirical Bayes estimated method (Raudenbush & Bryk, 2002). Examining the fit statistics and information criteria at the bottom of the table, it can be seen that the AIC-

[7] The model estimates were estimated by SPSS PROC mixed.

values[8] of the HAPC-models are lower than the AIC-values of the fixed-effect models (see table 4) which means that the HAPC-models fit the data better. The significant residuals in table A1 indicate that individual differences among the respondents remain after accounting for differences between cohorts and periods. The Intercept parameter is the variance in intercept across cohorts and periods. With a 1-tailed test at α = 0.05 there is evidence that intercepts (group means) do vary. These two estimates provide information for calculating the intraclass correlation, which determines the need for a higher level of analysis. The intraclass correlation (ρ) is the measure of differences between groups (cohorts, periods) relative to differences within groups[9]. High values means that the assumption of independence of errors is violated, and a hierarchical analysis is needed to avoid inflated Type I error rate. But, with large samples -as the MTUS sample is- even small values of ρ lead to inflated Type error I (see Tabachnick, 2005). Based on these indicators a need for higher order analyses can be seen.

USA

Considering effect coefficients for cohorts for the USA, it can be seen that the estimated effects on time spent on paid work are particularly positive for the latest birth cohorts, and more negative for the earliest birth cohorts. Also the 1930-1934 birth cohort spent relatively much time on paid work. With respect to time spent on training and schooling, the various birth cohorts do not seem to differ much, except for the youngest birth cohort. The estimated effect coefficient for cohorts with respect to time spent on child care differ substantially. A positive trend can be observed from the oldest birth cohort to the baby boom cohorts, and a negative trend from these cohorts to the 1960-1964 birth cohort. From that cohort, people seem to spend more time on caring for their children. Also the effect coefficients for cohorts with respect to household work differ substantially. People born in the fourties and fifties tend to spend more time on household work than people who belong to other birth cohorts. A negative trend can be observed from the 1965-1969 birth cohort to the youngest birth cohort. With respect to time spent on care for others, a slight negative trend can be observed from the oldest birth cohorts to the 1935-1939, and 1940-1944 birth cohort and a negative trend from these birth cohorts to the 1970-1974 birth cohorts. The very youngest birth cohorts seem to spend less time on care for others again. With respect to voluntary work, the various birth cohorts do not seem to differ substantially. Regarding time spent on leisure, we see a negative trend from the oldest birth cohorts to the 1945-1949 birth cohort and a positive trend from that cohort to the youngest birth cohorts.

Considering the estimated average effect coefficients for periods and time spent on paid work, a positive trend can be observed from the late sixties to the late eighties and a negative trend from the late eighties to the most recent years. Time spent on schooling and training decreased from the late sixties to the late seventies in the USA, increased from the late seventies to the late nineties and decreased afterwards. With respect to time spent on child care, table A1 shows a clear negative trend from the end of the sixties to the beginning of this century. Also with respect

[8] Akaike's Information criterion (AIC) is a general criterium for choice among regression models that can be applied to any model that can be estimated by maximum likelihood. It suggests minimizing (-2logL/n) + (2*k*/n), where *k* is the number of parameters *L* (see Maddala, 2001, p.488).

[9] $\rho = \frac{s_{l2}^2}{s_{l1}^2 + s_{l2}^2}$, s_{l1}^2 = level 1 variance (residual), s_{l2}^2 = level 2 variance (intercept)

tot time spent on household work a clear negative trend from the end of the seventies to the nineties can be observed. Since that period, people tend to spend more time on household work. Considering the effect coefficients for periods and time spent on care for others, we see that in the end of the eighties and the end of the nineties, people tend to spend more time on care for others than in other periods in the USA. During latest years people spend less time on care for others. With respect to voluntary work, people seem to spend least time on this activity in the late seventies. In the late eighties and the most recent years, people tend to spend more time on that activity. Considering leisure, we see a negative trend from the late sixties to the late eighties. From that period time spent on leisure increased again.
When we consider the estimated individual-level coefficients in table A1 and table 4 for the USA we see that the estimated regression coefficients and their standard errors are numerically quite similar between the two tables for the gender and civic status variables. Estimates for the components of the quadratic age curve are somewhat different for the fixed effects and the HAPC estimations. Also the estimated coefficients for educational level and the presence of (young) children are somewhat different for some of the activities. So, we could argue that a negligence to control for the effects of cohort and period variation in time use could lead to over- and underestimates of time use variations that are due to aging or related to (demographic) characteristics as the presence of (young) children, civic status, and educational level.

Norway
Considering the estimated average effect coefficients for cohorts for Norway in table A1, we see that the estimated effects on time spent on paid work are particularly negative for the oldest birth cohorts and the 1965-1969 birth cohort, and positive for the 1915-1919, 1925-1929, 1935-1939, and youngest birth cohorts. With respect to time spent on training and schooling, the various birth cohorts do not seem to differ much over time, except for the youngest birth cohort which spends less time on educational activities. The estimated effects on time spent on child care are particularly positive for the youngest birth cohorts as well as the 1925-1929, and 1945-1949 cohorts. With respect to time spent on household work, we see a slight negative trend, with the 1915-1919 and 1950-1954 birth cohorts as exception. Considering time spent on care for others, the youngest and oldest birth cohorts seem to spend more time on care for others than the other cohorts. A negative trend can be observed from the oldest birth cohorts to the 1935-1939 birth cohort, and a positive trend onwards. With respect to voluntary work, slight negative trend can be observed from the oldest birth cohort to the 1960-1964 cohort and a positive trend onwards. The very youngest and the 1965-1969 birth cohorts seem to spend most time on voluntary work. Regarding time spent on leisure, the estimated coefficients show a negative trend from the oldest birth cohorts to the 1935-1939 birth cohort and a slight positive trend onwards. From the 1965-1969 cohort, a negative trend can be observed again.
Considering the estimated average effect coefficients for periods and time spent on paid work in table A1, a negative trend can be observed from the early eighties to the most recent years. Also for time spent on schooling and training the estimated coefficients show a negative trend, even from the early seventies. With respect to time spent on child care table A1 shows a clear negative trend from the beginning of the eighties. Considering time spent on household work, a positive trend can be observed from the beginning of the seventies to the beginning of the nineties.

During most recent years, people seem to spend less time on household work again. Taking into account time spent on care for others, we see a negative trend from the beginning of the seventies to the beginning of the nineties and a positive trend onwards. People in Norway seem to spend equally amounts of time on care for others in the beginning of this century as they did in the beginning of the seventies. With respect to time spent on voluntary work and on leisure a clear negative trend can be observed from the beginning of the seventies to the most recent years.
The estimated individual-level coefficients in table A1 and table 4 show that the estimated regression coefficients and their standard errors are numerically quite similar between the two tables for gender. However, in line with the results for the USA, estimates for the components of the quadratic age curve are different for some of the activities, particularly for time spent on household work. For the linear component of this curve, the estimated coefficient for time spent on household work is increased from 1.89 for the fixed effects model to a 3.30 for the HAPC. The coefficient of the quadratic component of the age curve changed also after cohort and period effects are taken into account. For time spent on household work, the estimated coefficient changed from a 0.002 in table 6 to a -0.01 in table A1 (although both not significant). Besides the age-effects, also the estimated coefficients for the presence of (young) children and civic status are quite different for some of the activities. The coefficient for the presence of young children changed sign for care for others.

Netherlands
Examining the estimated average effect coefficients for cohorts for the Netherlands, it can be seen that the estimated effects on time spent on paid work are particularly positive for the latest birth cohorts, and more negative for the earliest birth cohorts. Also the 1925-1929, 1930-1934, and 1935-1940 birth cohorts spend relatively much time on paid work. With respect to time spent on training and schooling, the various birth cohorts seem to differ also. From the 1955-1959 through the 1975-1979 cohort a negative trend can be observed as well as from the 1895 through the 1945 cohort. The estimated effects on time spent on child care are particularly positive for the youngest birth cohorts as well as the 1940-1944 and 1945-1949 cohorts. We also see a positive trend from the oldest birth cohorts to the 1940-1944 and 1945-1949 cohorts, and a negative trend from the baby boom cohorts to the 1965-1969 cohort. The 1970-1974, and 1975-1979 birth cohorts appear to spend relatively much time on household work as well as the 1940-1944, 1945-1949, 1900-1904, and 1905-1909 birth cohorts. With respect to time spent on care for others, the youngest (except for the very youngest) and oldest birth cohorts seem to spend time on care for others to the same extent. Furthermore, we observe a slight positive trend from the 1955-1959 birth cohort to the 1975-1979 birth cohort. With respect to voluntary work, the oldest birth cohorts (1900-1904, 1905-1909 and 1910-1914) seem to spend most time on that activity. For the other cohorts no clear differences can be observed. Regarding time spent on leisure, we see that the estimated effects are particularly positive for the oldest and youngest birth cohorts (except the 1975-1979 cohort).

Considering the estimated average effect coefficients for periods and time spent on paid work, a negative trend can be observed from the late eighties to the most recent years. Apparently,

people in the Netherlands spend less time on paid work every year since the late eighties. Time spent on schooling and training has become more favorite since the eighties as the average effect coefficients for periods show a positive trend. With respect to time spent on child care table A1 shows a clear negative trend from the beginning of the eighties. In the late seventies and beginning of the eighties people seem to spend relatively much time on household work as well. Considering time spent on care for others, people seem to spend more time on care for others in the beginning of the nineties and the beginning of this century than in the other periods. Considering the effect coefficients for periods and time spent on voluntary work, no clear differences an be observed between the various cohorts, except the youngest birth cohort which seems to spend relatively much time on voluntary work. This cohort deviates from the others with respect to time spent on leisure also, although in an opposite direction.
Comparing next the estimated individual-level coefficients in table A1 and Table 4 it can be seen that the estimated regression coefficients and their standard errors are numerically quite similar between the two tables for the gender and education variables. Estimates for the components of the quadratic age curve are quite different however, particularly for time spent on childcare, on household work, and on care for others. For instance, for the linear component of this curve, the estimated coefficient for time spent on child care is reduced from a highly significant 15.94 of table 4 to a nonsignificant 0.13 in table A1, after cohort and time period effects are taken into account. Also for time spent on care for others the coefficient for that term is reduced substantially, from 5.35 for the fixed effects model to 1.48 for the HAPC. The coefficients of the quadratic component of the age curve change also after cohort and period effects are taken into account. For instance for time spent on childcare, the estimated coefficient changed from a significant 0.004 in table 4 to a nonsignificant -0.002 in table A1. For time spent on household work, the coefficient changed from -0.02 in table 4 to 0.004 in table 4. Besides the age-effects, also the estimated coefficients for the presence of (young) children and civic status are quite different for some of the activities. The coefficient for civic status even changed sign for paid work. These findings imply that a failure to control for the effects of cohort and period variation in time use could lead to substantial over- and underestimates of time use variations that are due to aging and also to substantial over- and underestimates of time use variations that are related to demographic characteristics as the presence of (young) children and civic status.

5. Welfare states compared

Comparing the results of the HAPC-analyses for the three countries, we see similarities regarding the course of the effect coefficients over the cohorts, especially with respect to time spent on paid work, childcare, and leisure. In each of the countries we see a top in time spent on paid work for people born in the twenties and beginning of the thirties, and a decrease for people born later. The estimated effect coefficients and marginal means (see figures in Appendix II) also show an increase from the baby boom generation in each of the countries, although this trend is much steeper for the USA and Norway than for the Netherlands. The estimated marginal means for childcare also show some remarkable similarities. Each of the countries shows an increase in time spent on childcare from the oldest birth cohorts to the 1940-1944 birth cohort, and a decrease from that birth cohort to the 1960-1964 birth cohort (the 1955-1959 cohort for the Netherlands). From that birth cohort an increase can be observed again for each of the countries. With respect

to leisure we see a negative trend from the oldest birth cohorts to the 1920- and 1930 birth cohorts, and a positive trend onwards. In Norway and the Netherlands we see a small negative trend from the 1960-1964 birth cohort. In the Netherlands, this trend seems to have come to a stop as the youngest birth cohort spends more time on leisure again. With respect to care for others the USA and Norway show remarkable similarities. For both countries a negative trend can be observed from the oldest birth cohorts to the 1930-1934 and 1935-1939 birth cohorts, and a positive trend from these birth cohorts to the youngest ones. In the Netherlands, no clear trends can be observed for care for others. The 1965-1969 birth cohort seems to spend roughly as much time on care for others than the 1935-1939 and the 1915-1919 birth cohort for instance. When we compare the countries with respect to time spent on education by cohort, we see a relatively stable pattern over the birth cohorts with a steep decrease in time spent on education for the youngest birth cohorts in the USA. Norway shows similar patterns with a steep decrease from the 1960-1964 birth cohort. In the Netherlands a negative trend can be observed from the oldest birth cohorts to the 1930-1934 birth cohort and a positive trend onwards. However, from the 1955-1959 birth cohort a negative trend can be observed again, which stops with the youngest birth cohort.

When we compare the results of the HAPC analyses, we also see some similarities regarding the development of the effect coefficients over the periods, especially for time spent on paid work and child care. The average amount of time spent on paid work increased until the eighties and decreased afterwards for each of the countries. The average amount of time spent on childcare decreased since the sixties in the United States, since the seventies in Norway, and since the eighties in the Netherlands. With respect to education we see some opposite developments. While the average amount of time spent on education decreased since the seventies in the USA and Norway, it increased since that time in the Netherlands. Also with respect to care for others and voluntary work, clear differences between the countries can be observed. While the average amount of time spent on voluntary work increased from the sixties to the eighties in the USA and continued from that time, and also increased from the late eighties in the Netherlands, it decreased since the seventies in Norway. Also the estimated marginal means for care for other increased from the late eighties in the Netherlands, while it decreased since that period in the USA. In Norway we see a decrease from the early seventies to the early nineties and an increase since that time. With respect to leisure clear differences can be observed also. While an increase in estimated marginal means can be observed since the late eighties in the Netherlands, a steep decline can be observed from the early seventies to the beginning of this century in Norway. No clear trends can be observed for the USA with respect to this activity.

6. Conclusion

In this paper we have applied a procedure for mixed regression models to the hierarchical analysis of individual-level data from repeated cross-sections of MTUS, as proposed by Yang and Land (2008, 2006a, 2006b). HAPC regression models in the form of cross-classified random effects models have been used to find out whether or not there is significant heterogeneity in time use by cohorts and/or periods. Furthermore, these models have been used to solve the classical age-period-cohort problem, i.e. the fact that the APC model is underidentified due to a linear dependency among age, period, and cohort.

Growing older appears to negatively affect time spent on education and leisure activities in each of the countries. Differences in age-effects between the countries can be observed for time spent on childcare and on voluntary work in particular. Spending time on childcare increases with age in the Netherlands and the USA, but decreases with age in Norway. Spending time on voluntary work increases with age in Norway and the Netherlands. For the USA we find a non-significant negative relation. The HAPC analyses find evidence in support of quadratic age effects on time use. The positive effect of ageing on time spent on paid work decreases and the negative effect on time spent on educational activities and leisure increases during the (individual) life course for each of the countries included. For the Netherlands also significant quadratic age effects can be found for caring for others and for both the Netherlands and Norway these can be found for voluntary work. Although we do not find quadratic age effects for time spent on caring for others and voluntary work for the USA, we do find these for household work (contrary to the other countries).

Furthermore, the HAPC analyses find evidence in support of the contentions of Liefbroer & Dykstra (2000), and Kronjee (1990) that both cohort and period effects should be distinguished in life course analyses. The circumstances people experience during their "formative phase" appear to determine the time use -and as a result the weighing of activities (and life domains)- during their life course, but historical changes influence cohorts on various moments in the life course and appear to be relevant in the life phases that follow. Finally, the analyses show clear differences in time use patterns during the life course between the welfare states. These may indicate a non-negligible sensitivity for welfare policies with respect to reconciling life domains during the life course.

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Appendix I HAPC Models – Results for the USA, Norway, and the Netherlands

Table A1 HAPC Models for Various Time Use Categories, MTUS Data, Cross-classified Random Effects

Panel (a): USA

	Paid work	Education	Childcare	Household	Othercaring	Voluntary	Leisure
Fixed Effects							
Intercept	193.13***	13.69***	25.60***	182.75***	27.65***	9.27***	313.28***
Age	12.53***	-5.36***	0.96**	4.07***	0.71	-0.12	-8.97***
Age^2	-0.17***	0.04***	-0.01**	-0.03***	-0.01	0.002	0.11***
Female	-120.08***	-3.88***	19.60***	99.94***	-3.86***	1.67**	-28.59***
Educ2	21.43***	1.49	2.62***	3.95***	2.93**	3.36***	-14.43***
Educ3	34.20***	16.93***	4.17***	-1.03***	1.30	6.76***	-38.64***
Married	-10.96**	-8.35***	5.49***	29.39***	5.77***	2.38***	-25.98***
Child04	-27.84***	-10.67***	54.38***	8.41***	-3.14**	-4.00***	-19.30***
NoChild	14.63***	2.49*	-29.13***	-16.62***	2.34**	-4.48***	20.16***
Weekend	-219.66***	-9.46***	-4.74***	32.70***	11.47***	0.70	117.30***
Random Effects[a]							
Intercept	76.67***	-73.30***	7.36***	-1.64**	-3.97***	-2.71***	22.36***
Cohort							
1890-1894	-122.20***	72.86***	-18.49***	9.58**	8.69***	3.55***	41.72***
1895-1899	-71.94***	64.10***	-17.21***	23.48***	10.32***	1.14***	-5.09***
1900-1904	-64.65***	65.38***	-16.00***	-2.70***	-0.45*	3.00***	-7.18***
1905-1909	-63.48***	62.56***	-14.66***	1.88**	-1.21***	3.36***	-3.84***
1910-1914	-73.14***	63.34***	-11.43***	2.29***	2.12***	4.50***	-14.51***
1915-1919	-92.16***	72.60***	-9.60***	9.02***	3.83***	3.44***	-13.77**
1920-1924	-82.06***	69.96***	-7.96***	5.49***	0.93***	2.85***	-26.35***
1925-1929	-58.22***	68.66***	-7.43***	-1.36**	-0.78***	2.24***	-32.33***
1930-1934	-48.96***	67.65***	-5.41***	1.71**	-3.46***	2.48***	-41.41***
1935-1939	-75.69***	69.75***	-3.67***	6.73***	-6.51***	3.37***	-26.62***
1940-1944	-87.01***	72.26***	-3.03***	11.09***	-6.24***	2.90***	-25.49***
1945-1949	-89.15***	73.30***	-4.99***	10.51***	-1.31***	4.04***	-28.73***
1950-1954	-83.06***	70.83***	-8.01***	11.40***	-2.52***	3.15***	-25.38***
1955-1959	-78.90***	75.75***	-15.52***	7.92***	-1.00***	2.87***	-24.07***
1960-1964	-63.52***	70.65***	-23.78***	3.13***	0.57**	2.85***	-16.02***
1965-1969	-84.02***	78.59***	-20.50***	9.95***	2.21***	3.80***	-18.41***
1970-1974	-94.03***	78.36***	-10.47***	8.05***	2.55***	3.86***	-18.63***
1975-1979	-64.20***	59.16***	-4.92***	3.64***	-3.14***	3.03***	-12.30***
1980-1984	0	0	0	0	0	0	0
Period							
1965-1969	-32.28***	0.193***	7.43***	-9.21***	9.29***	-0.76***	16.54***
1975-1979	-5.74***	0.126***	6.60***	-2.84***	6.60***	-1.77***	-2.21***
1985-1989	19.98***	0.136***	0.91***	-25.25***	20.05***	0.04***	-5.00***
1995-1999	16.65***	0.262***	0.23	-22.08***	16.11***	-0.42**	11.98***
2000-2004	0	0	0	0	0	0	0
AIC	408215	334947	2784	376607	339617	307090	392748
Covariance parameters							
Residual	5487.56***	4639.82***	2783.55***	18924.88***	5439.21***	1821.63***	32614.42***
	(451.04)	(38.13)	(22.88)	(155.55)	(44.71)	(14.97)	(268.08)
Intercept	1523.33***	216.65***	74.24***	335.92***	102.22***	5.11***	500.36***
	(336.43)	(43.50)	(17.02)	(81.85)	(22.80)	(2.23)	(126.18)
P	0.22	0.045	0.027	0.017	0.018	0.0028	0.015

Panel (b): Norway

	Paid work	Education	Childcare	Household	Othercaring	Voluntary	Leisure
Fixed Effects							
Intercept	211.47***	18.27***	28.91***	168.03***	28.46***	6.00***	299.62***
Age	18.07***	-7.17***	-0.81**	3.30***	0.38	0.26**	-8.41***
Age^2	-0.23***	0.06***	0.006	-0.01	-0.002	-0.003**	0.10***
Female	-132.71***	0.71	21.00***	135.17***	-22.62***	-2.10***	-19.18***
Married	0.13	-7.54***	3.89***	19.92***	5.28***	0.49	-29.37***
Child04	-39.25***	-13.71***	76.03***	7.10**	-1.05	-1.68**	-20.19***
NoChild	33.12***	4.61**	-23.42***	-25.32***	-0.73	-0.44	10.09**
Weekend	-200.50***	-15.47***	0.55	-9.24***	3.63**	-2.14***	149.22***
Random Effects							
Intercept	39.10***	-28.79***	11.66***	-2.80***	13.57***	0.36***	-45.97***
Cohort							
1895-1899	-55.82***	34.73***	-18.75***	9.72***	1.94***	-1.57***	57.49***
1900-1904	-66.03***	26.35***	-19.76***	10.89***	4.25***	-0.33***	50.14***
1905-1909	-62.34***	26.05***	-18.18***	7.68***	-1.15***	-0.70***	46.44***
1910-1914	-46.95***	27.42***	-17.00***	9.31***	-7.00***	-0.24***	26.76***
1915-1919	-25.15***	24.46***	-13.15***	-7.65***	-7.68***	-0.80***	19.53***
1920-1924	-48.07***	25.61***	-12.81***	5.69***	-8.36***	-0.46***	26.97***
1925-1929	-23.85***	24.51***	-11.61***	0.63	-7.23***	-1.01***	14.39***
1930-1934	-30.25***	25.58***	-14.77***	3.81***	-5.12***	-0.94***	15.79***
1935-1939	-18.37***	27.71***	-15.11***	-5.78***	-9.26***	-0.46***	12.49***
1940-1944	-35.66***	29.75***	-13.35***	-4.26***	-5.99***	-0.93***	22.87***
1945-1949	-44.49***	32.71***	-11.42***	0.65	-5.66***	-1.08***	18.88***
1950-1954	-45.50***	23.03***	-14.05***	11.74***	-6.22***	-0.89***	25.14***
1955-1959	-44.98***	30.05***	-18.03***	-0.12	-3.76***	-0.87***	32.21***
1960-1964	-35.05***	26.09***	-16.77***	1.54*	-4.84***	-1.29***	28.17***
1965-1969	-56.41***	36.88***	-19.32***	4.35***	-5.22***	-0.05	36.78***
1970-1974	-39.11***	19.14***	-16.62***	3.16***	-3.66***	-0.39***	32.44***
1975-1979	-33.39***	32.13***	-11.14***	-7.46***	1.38***	-0.64***	28.78***
1980-1984	0	0	0	0	0	0	0
Period							
1970-1974	-7.30***	2.96***	5.77	-21.90***	-0.32***	0.68***	58.47***
1980-1984	4.71***	2.39***	5.88	3.55***	-6.68***	0.53***	16.04***
1990-1994	2.87***	0.68***	0.85	22.34***	-26.25***	0.49***	8.86***
2000-2004	0	0	0	0	0	0	0
AIC	342280	290865	268179	313395	282846	250569	326073
Covariance parameters							
Residual	47954.91***	6190.37***	2511.52***	15173.74***	4495.01***	1250.04***	25115.85***
	(428.29)	(55.29)	(22.42)	(135.52)	(40.14)	(11.16)	(224.31)
Intercept	766.61***	159.55***	39.12***	432.72***	188.09***	1.32***	1054.65***
	(183.99)	(38.14)	(9.18)	(97.44)	(40.81)	(0.79)	(232.80)
P	0.016	0.025	0.015	0.028	0.040	0.0011	0.040

Panel (c): the Netherlands

	Paid work	Education	Childcare	Household	Othercaring	Voluntary	Leisure
Fixed Effects							
Intercept	169.49***	26.46***	19.99***	164.02***	33.37***	11.92***	320.02***
Age	8.42***	-9.20***	0.13	4.04***	1.48***	1.05***	-2.01*
Age^2	-0.13***	0.082***	-0.002	0.004***	-0.01***	-0.01***	0.04***
Female	-155.53***	-1.79	17.75	126.28***	-0.66	-3.21***	-13.52***
Educ2	28.59***	14.41***	2.78***	-24.96***	-1.81	2.32**	-10.11***
Educ3	17.37***	34.89***	3.82***	-33.93***	-5.03***	4.42**	-11.16***
Married	-5.80***	-11.56***	10.64***	20.09***	5.12***	-2.38***	-30.47***
Child04	-24.48***	-10.00*	75.70***	5.38***	-5.40	-2.44*	-26.17**
Childno	6.25***	-3.24**	-23.85***	-12.30***	-1.88*	-1.45	31.33***
Random Effects							
Intercept	-1.72	12.578***	5.02***	-0.309	-4.59***	1.36***	27.19***
Cohort							
1895-1899	-113.06***	37.48***	-13.40***	-2.78	8.63***	1.01	18.81***
1900-1904	-72.11***	18.98***	-20.70***	3.01**	9.59***	3.05***	13.49***
1905-1909	-66.32***	16.23***	-21.14***	4.92**	6.63***	2.55***	9.94***
1910-1914	-47.67***	10.32**	-20.34***	1.46	5.16***	3.84***	3.57*
1915-1919	-40.43***	1.45	-21.37***	0.85	10.77***	1.58***	3.27
1920-1924	-21.46***	0.076	-18.15***	-0.24	6.98***	-1.17***	-5.51**
1925-1929	-2.29	-5.02	-16.44***	-0.16	5.45***	-1.23***	-12.25***
1930-1934	0.29	-6.72**	-16.61***	-1.44	3.57***	0.84**	-8.38***
1935-1939	-19.90***	-6.67**	-13.63***	1.07	5.52***	0.44	-0.87
1940-1944	-33.58***	-5.38	-11.43***	3.68***	8.10***	-1.51***	-0.62
1945-1949	-40.56***	-0.65	-11.21***	7.19***	5.92***	0.73**	-5.32**
1950-1954	-30.64***	2.13	-16.66***	-1.38	6.07***	0.52	-2.42
1955-1959	-32.54***	6.70**	-20.69***	-1.31	5.49***	-0.25	-5.25**
1960-1964	-33.81***	8.81**	-26.36***	-1.15	6.35***	1.21***	1.86
1965-1969	-27.46***	5.92*	-20.79***	-2.01	6.86***	1.28***	2.71
1970-1974	-22.96***	-12.20***	-12.41***	8.31***	8.13***	0.76**	0.74
1975-1979	-0.45	-26.22***	-4.85***	7.45***	9.64***	1.94***	-7.38***
1980-1984	0	0	0	0	0	0	0
Period							
1975-1979	40.50***	-18.04***	15.15***	2.16***	-1.59***	-1.82***	-29.00***
1980-1984	34.87***	-19.89***	17.72***	1.94***	-2.61***	-2.09***	-19.04***
1985-1989	45.90***	-17.24***	13.94***	-2.34***	-2.75***	-2.49***	-38.67***
1990-1994	31.46***	-15.48***	13.44***	0.24	-0.97***	-1.73***	-27.82***
1995-1999	18.94***	-6.50***	10.96***	-3.53***	-1.96***	-2.06***	-24.46***
2000-2004	0	0	0	0	0	0	0
AIC	170955	144834	133109	154694	137529	129780	162111
Covariance parameters							
Residual	21823.90***	3043.07***	1266.10***	6471.77***	1783.42***	996.82***	11263.00***
	(268.37)	(37.43)	(15.57)	(79.56)	(21.93)	(12.26)	(138.52)
Intercept	1373.47***	576.78***	135.90***	95.84***	19.02***	8.48***	368.72***
	(258.68)	(102.87)	(23.94)	(22.80)	(5.17)	(2.51)	(76.99)
P	0.059	0.16	0.097	0.015	0.011	0.0084	0.032

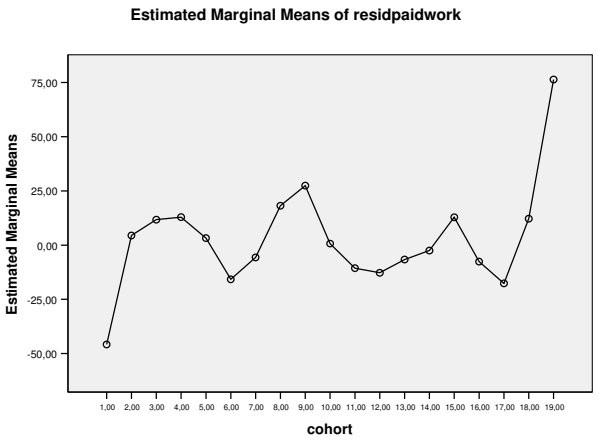
[a] *The parameter estimates of the random effects are estimated using the GLM procedure in SPSS (with period and cohort as factors) on the differences between the residuals of the mixed models and the fixed effects model.*

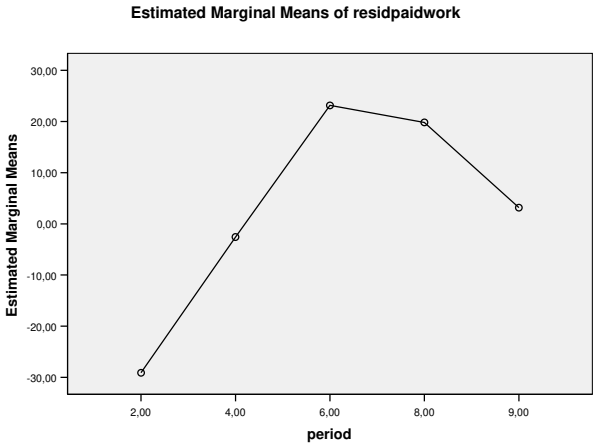
** indicates p < 0.05; **indicates p < 0.01; ***indicates p < 0.001, two-tailed test.*

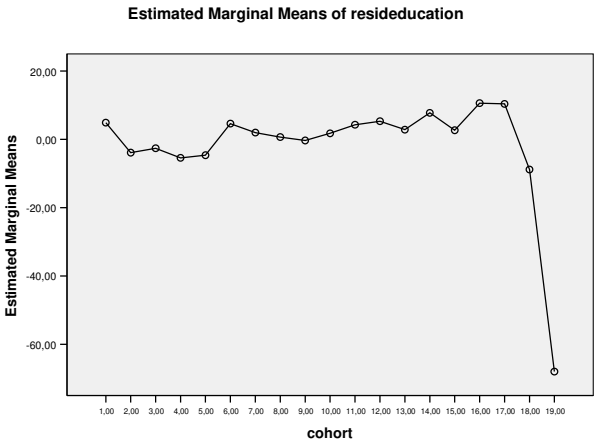
Source: own estimations based on MTUS selection

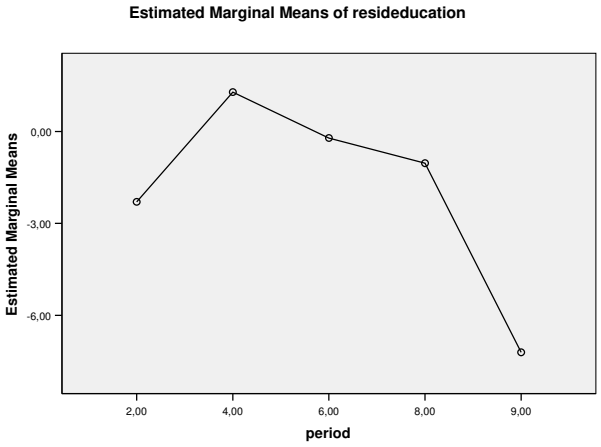
Appendix II Estimated marginal means for time use in the USA, Norway, and the Netherlands

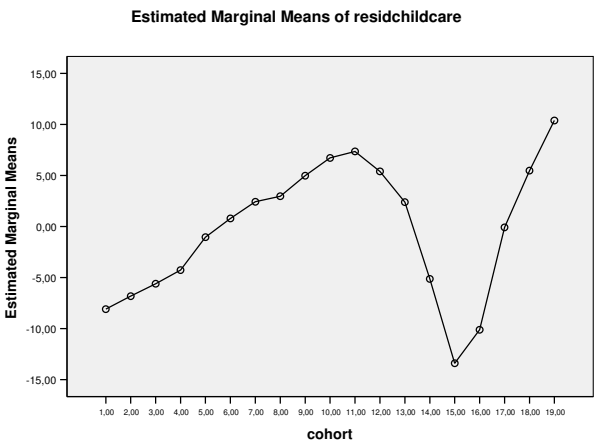
Panel (a) the USA

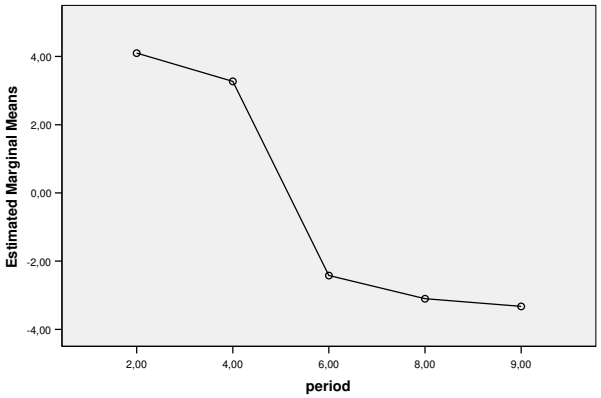


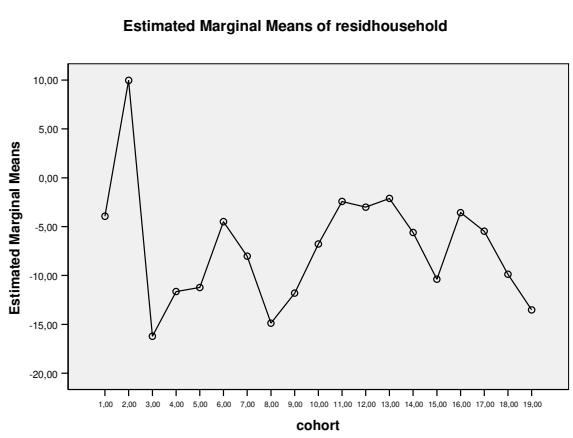








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Estimated Marginal Means
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-15,00
-20,00
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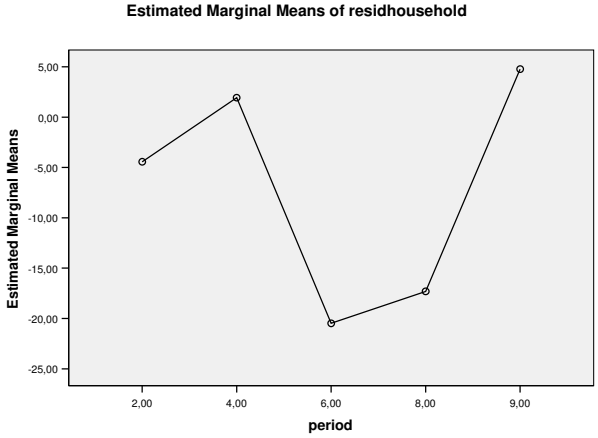
cohort


Estimated Marginal Means of residhousehold
Estimated Marginal Means
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-15,00
-20,00
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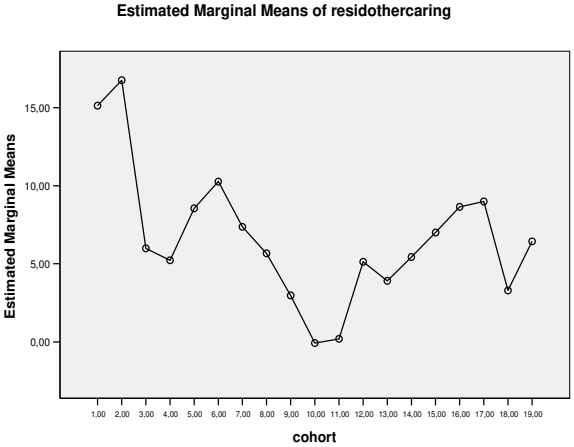
2,00 4,00 6,00 8,00 9,00
period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Estimated Marginal Means
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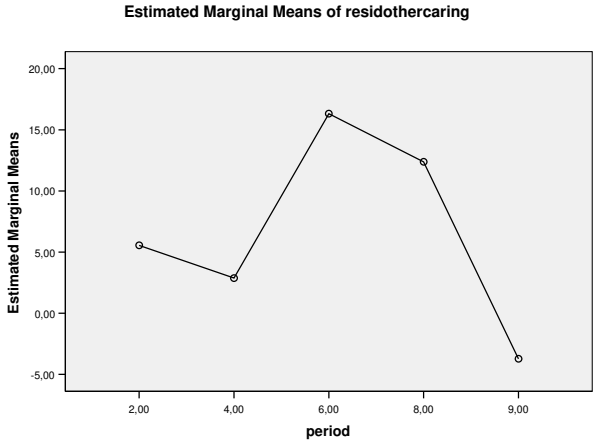
5,00
0,00
1,00 2,00 3,00 4,00 5,00 6,00 7,00 8,00 9,00 10,00 11,00 12,00 13,00 14,00 15,00 16,00 17,00 18,00 19,00
cohort


Estimated Marginal Means of residothercaring
Estimated Marginal Means
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5,00
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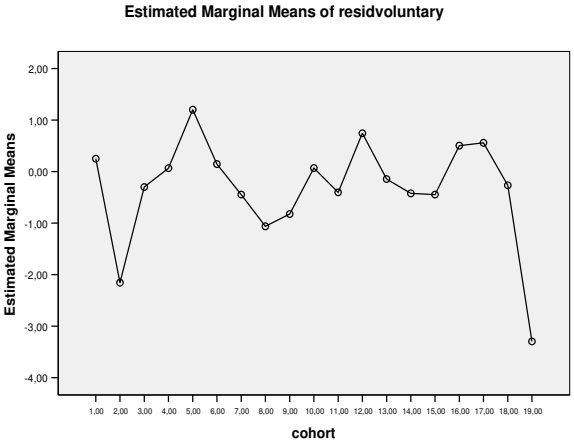
period


Estimated Marginal Means of residvoluntary
Estimated Marginal Means
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-1,00
-2,00
-3,00
-4,00
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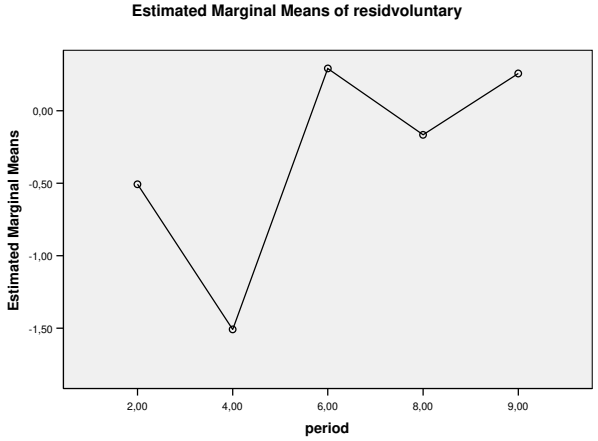
cohort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Estimated Marginal Means
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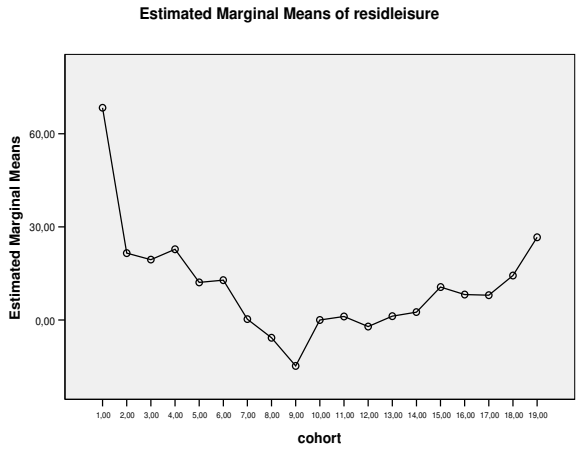
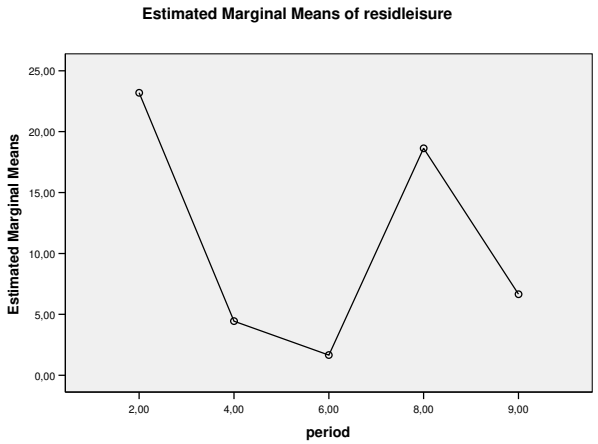
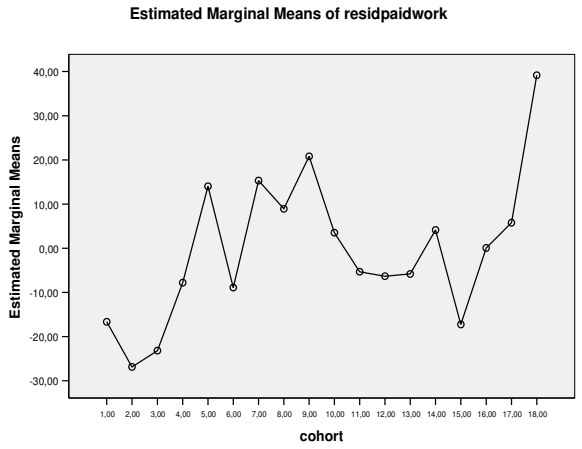
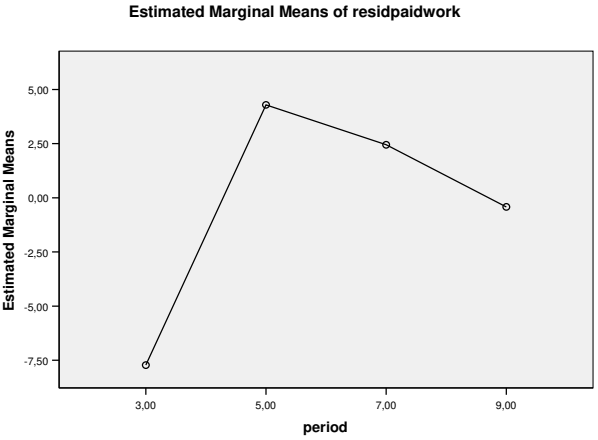
-1,00
-1,50
2,00 4,00 6,00 8,00 9,00
period

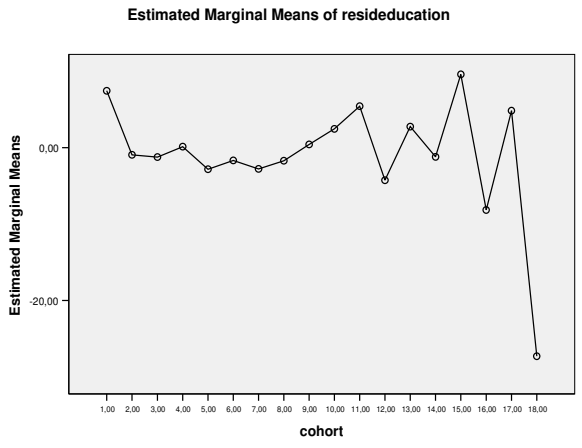


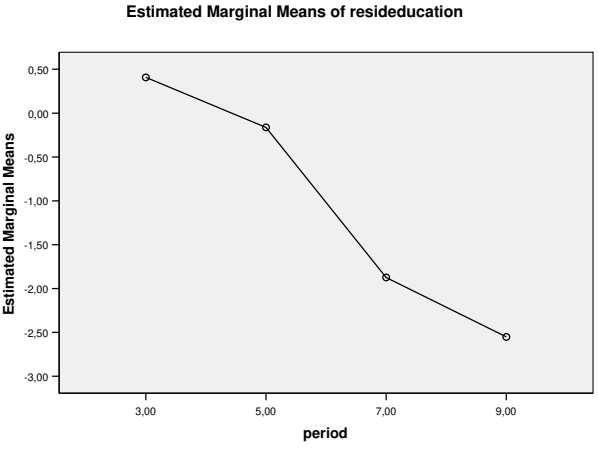


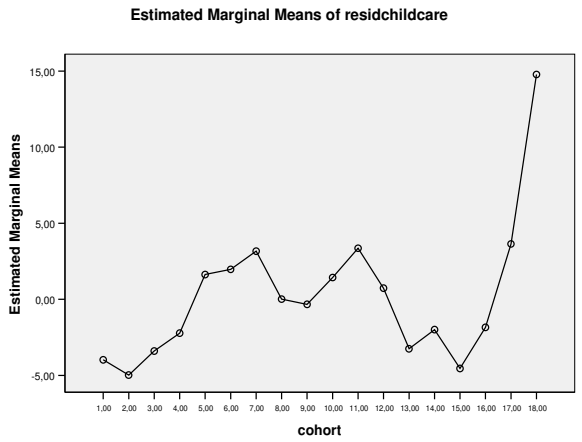
Panel (b) Norway










Estimated Marginal Means of residchildcare
Estimated Marginal Means
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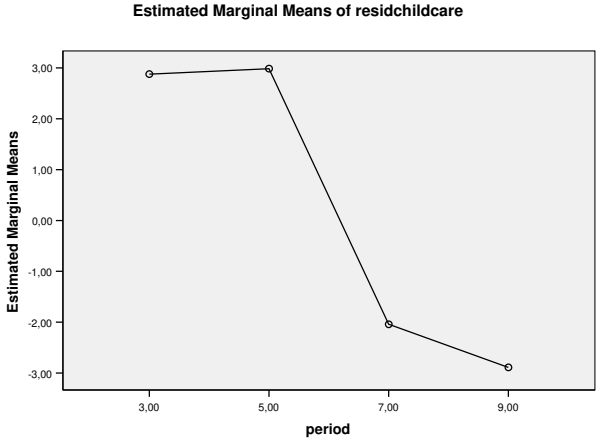
-5,00
1,00 2,00 3,00 4,00 5,00 6,00 7,00 8,00 9,00 10,00 11,00 12,00 13,00 14,00 15,00 16,00 17,00 18,00
cohort


Estimated Marginal Means of residchildcare
Estimated Marginal Means
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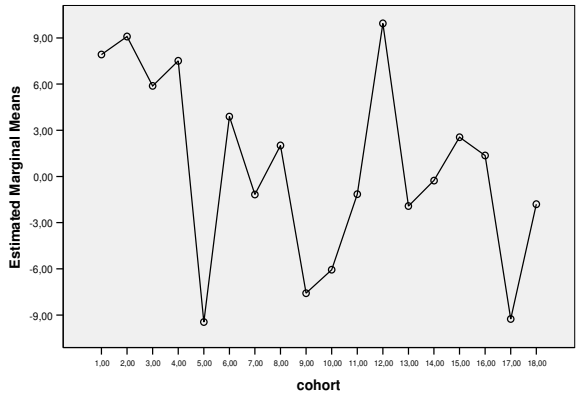
2,00
1,00
0,00
-1,00
-2,00
-3,00
3,00 5,00 7,00 9,00
period


Estimated Marginal Means of residhousehold
Estimated Marginal Means
9,00
6,00
3,00
0,00
-3,00
-6,00
-9,00
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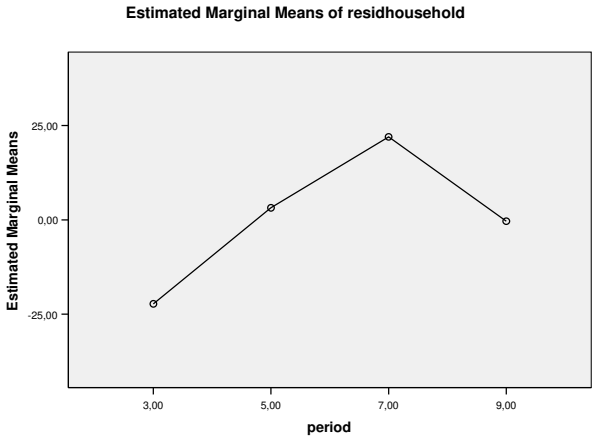
cohort


Estimated Marginal Means of residhousehold
Estimated Marginal Means
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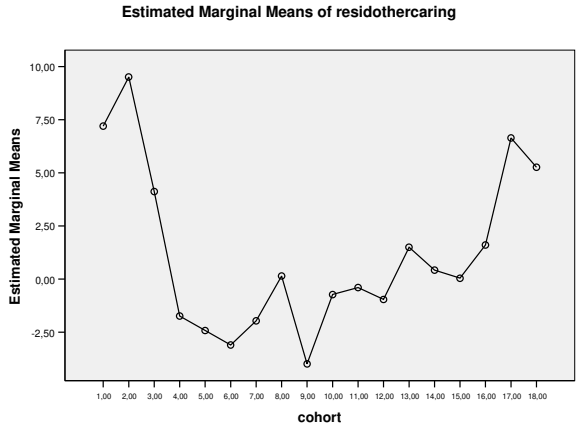
3,00 5,00 7,00 9,00
period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Estimated Marginal Means
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5,00
2,50
0,00
-2,50
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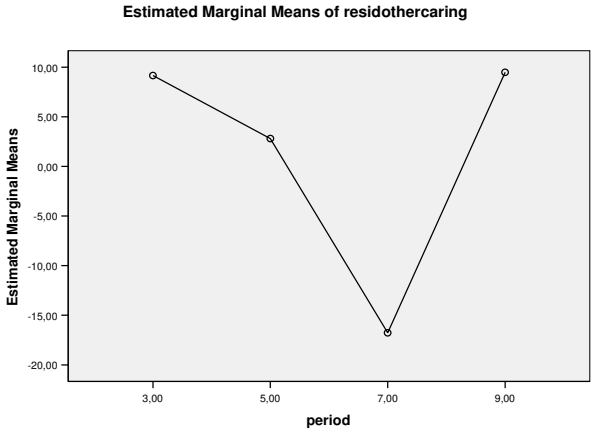
cohort


Estimated Marginal Means of residothercaring
Estimated Marginal Means
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-10,00
-15,00
-20,00
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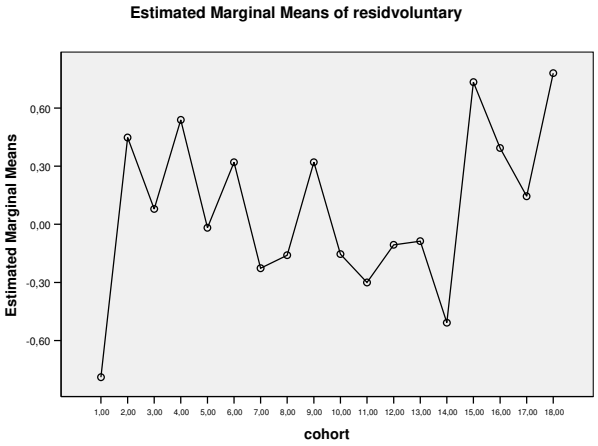
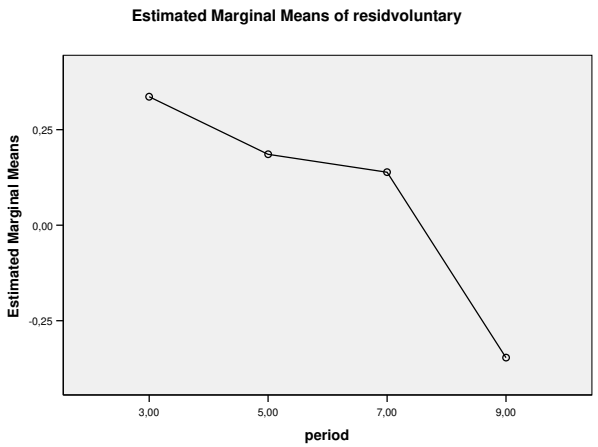
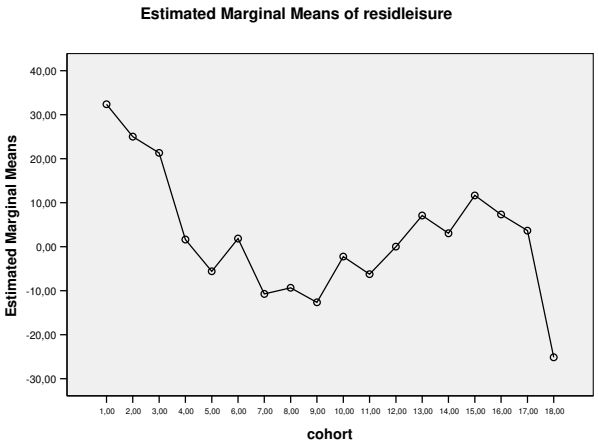
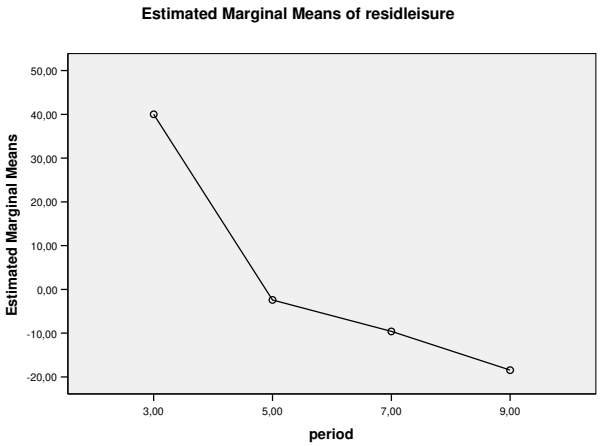
period

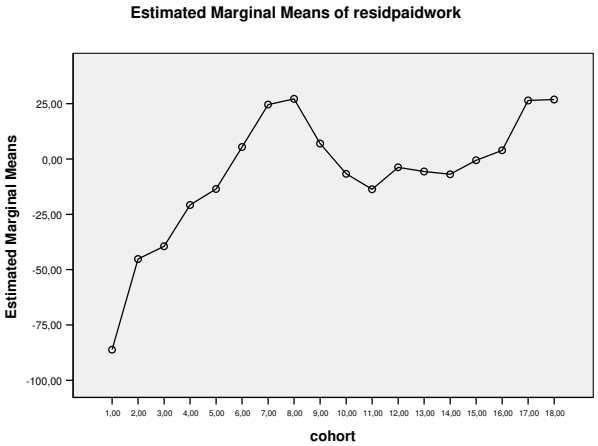


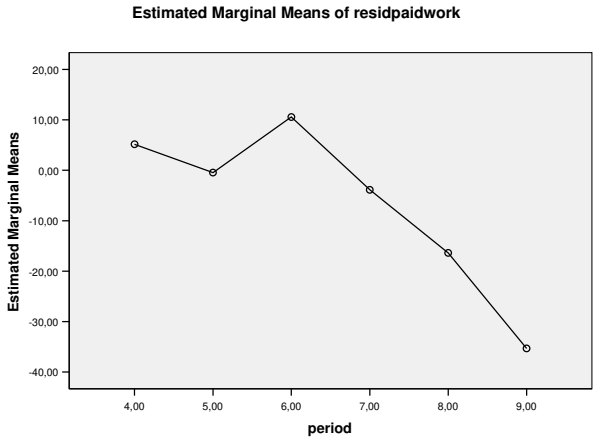


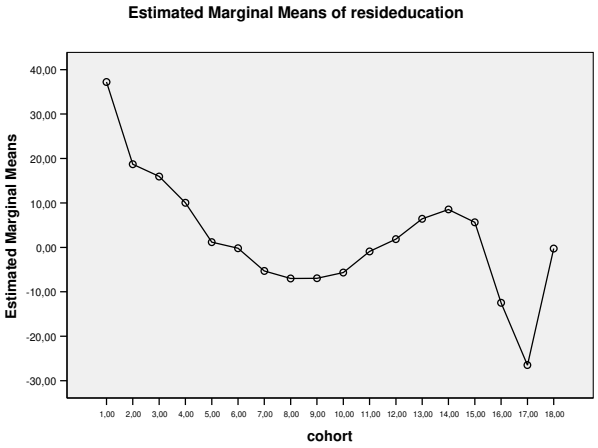




Panel (c) the Netherlands



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Estimated Marginal Means
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20,00
10,00
0,00
-10,00
-20,00
-30,00
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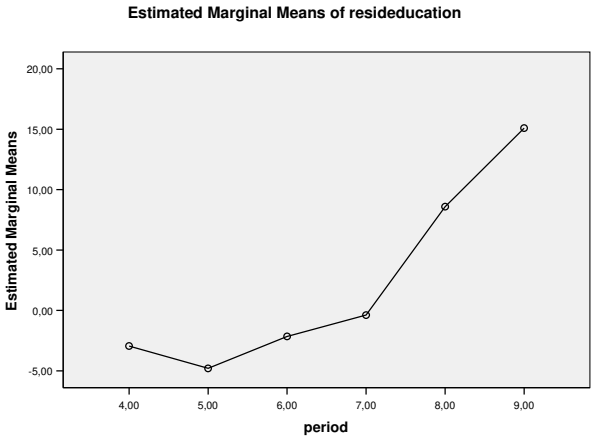
cohort


Estimated Marginal Means of resideducation
Estimated Marginal Means
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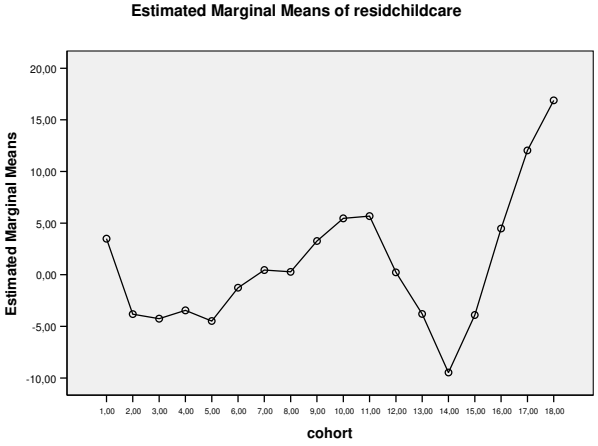
10,00
5,00
0,00
-5,00
4,00 5,00 6,00 7,00 8,00 9,00
period


Estimated Marginal Means of residchildcare
Estimated Marginal Means
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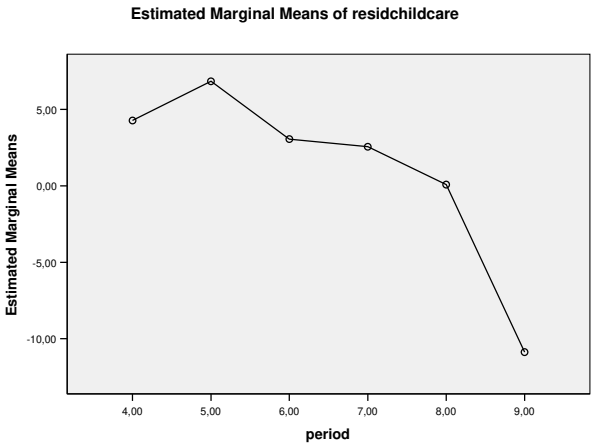
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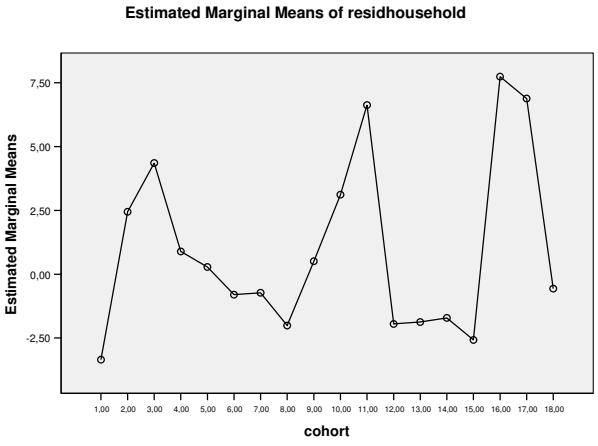
period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Estimated Marginal Means
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0,00
-2,50
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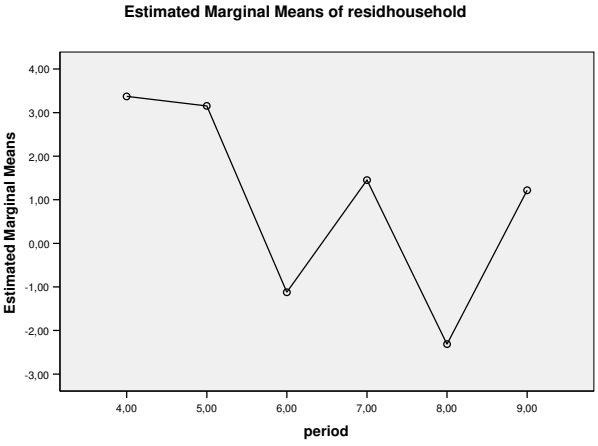
cohort


Estimated Marginal Means of residhousehold
Estimated Marginal Means
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0,00
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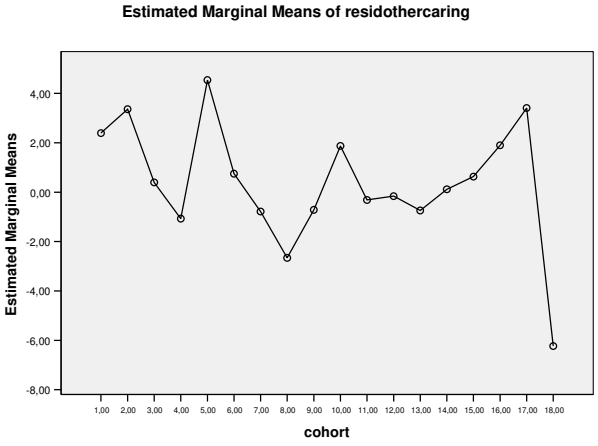
period


Estimated Marginal Means of residothercaring
Estimated Marginal Means
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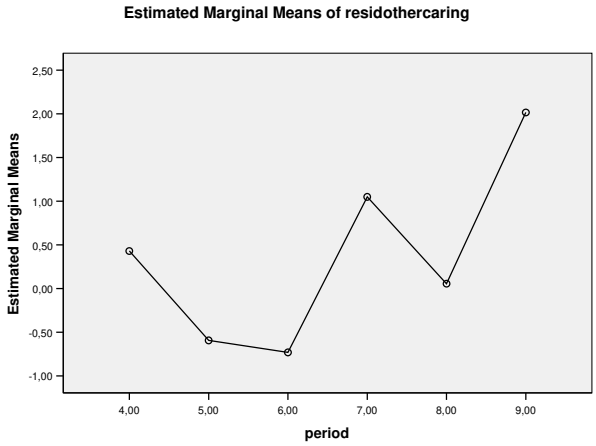
cohort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Estimated Marginal Means
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-1,00
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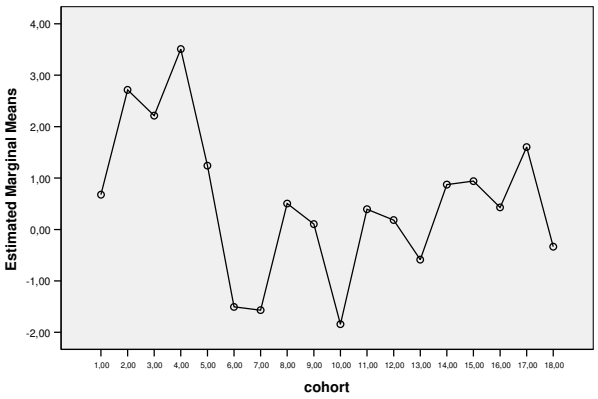
period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Estimated Marginal Means
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1,00
0,00
-1,00
-2,00
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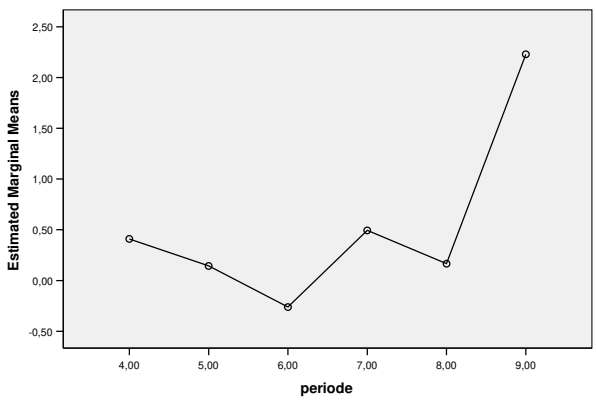
cohort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Estimated Marginal Means
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-0,50
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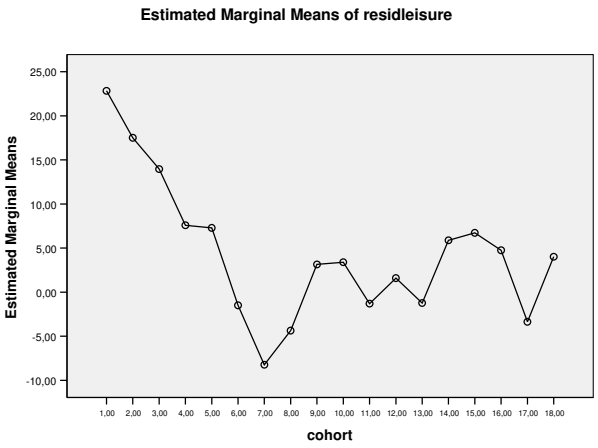
periode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Estimated Marginal Means
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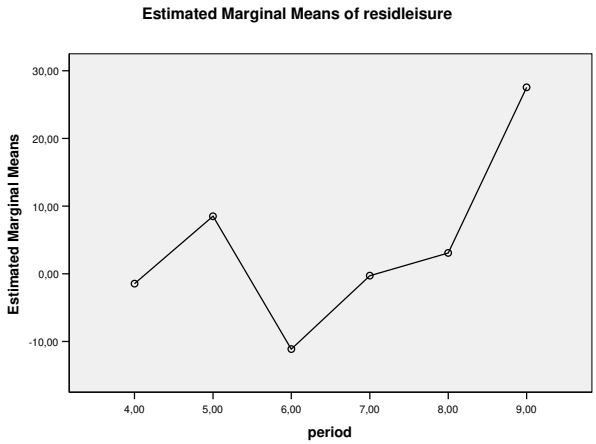
cohort


Estimated Marginal Means of residleisure
Estimated Marginal Means
30,00
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10,00
0,00
-10,00
4,00 5,00 6,00 7,00 8,00 9,00
period

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