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Personality Traits Across the Life Cycle: Disentangling Age, Period, and Cohort Effects*

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Abstract

Despite the importance for socio-economic outcomes, there is an ongoing debate about the stability of personality traits over the life cycle. By disentangling age, period and cohort influences on personality traits, this paper adds to the existing empirical contributions, which often focus on age patterns and disregard cohort and period influences. We present the results from systematic specification tests that provide novel evidence for the separability of age, period, and cohort effects in almost all personality traits. Our estimates also document that for different cohorts, the evolution of personality traits across the life-cycle follows a stable, though non-constant, age-profile, while there are sizeable differences across time periods.

Keywords: Big Five personality traits, Locus of Control, Risk attitudes, age-period-cohort decomposition, life cycle.

JEL codes: D8, J1

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1 Introduction

Over the past years, the role of heterogeneity in preferences and personality traits for important economic life-time outcomes, such as wages and careers, has shifted into the focus of economic research. Traditionally, economists had been interested primarily in the measurement of economic preferences, e.g., regarding risk taking, and their implications for outcomes. Mounting empirical findings about the central importance of psychological personality traits, such as the Big-5 personality traits or locus of control, whose predictive power for wages and behavioral outcomes has been shown to even exceed the importance of cognitive ability, has broadened the interest to personality traits in general (Heckman et al., 2006, 2019). By now, the results of this research program suggest that measures of economic preferences and psychological personality traits are distinct and complement each other in determining outcomes (Borghans et al., 2008; Becker et al., 2012; Heckman et al., 2019).

While there is an emerging consensus about the importance of personality traits for socio-economic outcomes, there is an ongoing debate whether preferences and personality traits follow a stable pattern over the life cycle. The stability of personality traits is a highly relevant question, from the perspectives of measurement as well as of policy. Despite considerable evidence in psychology and economics that suggests that personality traits vary systematically by age, a growing literature has documented the influence of environmental factors, such as lifetime experiences or aggregate shocks. These factors are inherently linked to cohorts and periods and might therefore influence the estimates of the age profile and life cycle patterns.

This paper contributes new evidence on the age-profiles of personality traits and explicitly estimates the interplay between age, cohort and period effects. In particular, we estimate a non-linear age-period-cohort model that allows us to test for the additive separability of age, cohort and time effects while imposing only mild identifying assumptions on the empirical model. We do so by estimating nested non-linear models that allow for flexible non-linear effects of age, period and cohort, as well as their interactions. The only identifying assumption is that one dimension of linear effects must be normalized, so we normalize the linear cohort effects related to year of birth to zero. This allows us then to use formal hypothesis tests to examine whether the variation in personality traits or preferences over time is additively separable into pure (and potentially non-linear) age effects, time effects, and cohort effects. This separability is a prerequisite to identify a common (uniform) age-profile of personality traits or preferences across cohorts. Building on the implications of the estimates of this age-period-cohort model, we then investigate the evolution of personality traits across the life cycle for different cohorts.

The empirical analysis is based on data from the German Socio-Economic Panel (SOEP). The SOEP contains longitudinal information on a variety of measures of personality traits and economic preferences that have been used extensively in the existing literature. In particular, we use information on personality traits such as risk attitudes, the conventional five-factor model of personality "Big-5" (Openness to experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism), and locus of control.

Our analysis establishes several novel findings. First, our results document the linear separability of age, period and cohort effects for all personality traits (except for Neuroticism). This implies that the age-profile is stable across cohorts. We show that a restricted model that omits interactions between age and time in the changes of personality traits for a given cohort fits the observed data well. This finding sheds new light on the interpretation of existing evidence regarding life cycle profiles of personality traits.

Second, empirical results based on estimates of the restricted model provide new evidence on the age profiles for a broad variety of personality traits. The largest variation over the life course is found for risk attitudes and conscientiousness, which both increase with age. Openness to experience decreases up until age 35 and then remains stable. Extraversion and internal locus of control are found to decrease with age. Finally, agreeableness and neuroticism remain fairly stable throughout most of the life-cycle. These results regarding the age profiles are robust to variation in the sampling period and in the functional form of the non-linear age-period-cohort model.

Third, our results document sizeable period effects, which are common across cohorts. This sheds new light on the existing literature regarding the compatibility of a stable life cycle profile of preferences and traits with instability in the context of external shocks.

Fourth, we investigate whether the period effects can be proxied using non-linear variation in macro indicators such as GDP growth or unemployment. This identification approach to overcome the perfect collinearity problem between age, period, and cohort, follows Heckman and Robb (1985) and has been used previously by Dohmen et al. (2017) in the context of risk attitudes. The results reveal substantial variation in the correlation between period effects and macro-economic indicators across different time periods, and correspondingly considerable variation in the life cycle profile of personality estimated using this approach, while the results obtained with the flexible approach suggested in our paper appear more stable.

The results contribute to the existing literature in several ways. The analysis is motivated by a considerable body of evidence in psychology and economics that suggests that personality traits vary systematically by age. In particular, numerous studies in psychology and economics have documented an age profile in the Big-5 personality traits (Roberts et al., 2006; Borghans et al., 2008; Noftle and Fleeson, 2010; Lucas and Donnellan, 2011; Cobb-Clark and Schurer, 2012; Mye et al., 2016). Likewise, locus of control has been reported to exhibit variation with age, although the evidence is mixed regarding the extent and behavioral relevance of this variability (Specht et al., 2013; Cobb-Clark and Schurer, 2013). Among economic preferences, there is mounting evidence for systematic variation in risk preferences with age within countries (Dohmen et al., 2011; Sahm, 2015; Schurer, 2015; Josef et al., 2016; Dohmen et al., 2017) and across countries (Rieger et al., 2015; Mata et al., 2016; Chopik and Kitayama, 2018; Falk et al., 2018).

Existing evidence also suggests, however, that personality traits are malleable over the life cycle, potentially more so than cognitive factors (Almlund et al., 2011). Evidence from intervention studies suggests that policies might have long-run implications through their effects on personality, as is suggested, e.g., by the evidence for causal effects on outcomes during adulthood from school interventions in the context of the Perry program (Heckman et al., 2013). There is also evidence that economic preferences, e.g., regarding risk taking, are fairly stable but not fully persistent (Schildberg-Hörisch, 2018) and influenced by individual shocks, e.g., to health (Decker and Schmitz, 2016) or aggregate economic shocks such as the Great Recession (Guiso, 2012; Dohmen et al., 2015). Evidence by Malmendier and Nagel (2011) suggests that pronounced aggregate economic shocks that individuals experience during childhood, such as the Great Depression, affect attitudes of entire cohorts throughout their lives. Moreover, existing evidence also suggests that preferences and traits are formed early in life and influenced by parents and the immediate environment during childhood (Dohmen et al., 2012).

Taken together, these findings suggest that factors related to birth cohort and period might seriously affect estimates of life cycle profiles if age patterns are not disentangled from period and cohort effects. Intuitively, if, for example, older cohorts are permanently less open to experience compared to younger cohorts because they were socialized in a different historical setting (e.g., the Great Depression), then a decreasing age-profile of openness to experience might reflect this cohort-specific effect and thereby exaggerate the effect of aging. Similarly, period-specific events such as the experience of the Great Recession might temporarily shift the willingness to take risk of all cohorts, which would affect the age-profile of risk risk attitudes in a longitudinal study that does not account for these period effects.

In contrast to most of the existing literature, which considers cross-sectional or longitudinal variation to identify the "typical" age-profile of personality traits or preferences, our approach accounts for systematic variation across cohorts and time. The key problem in this context is that even the use of longitudinal variation does not allow disentangling in a straightforward way the separate impact of these three regressors due to the linear relationship between age, period, and cohort. In personality psychology, cohort differences were long considered as nuisances, and only few notable exceptions including studies by Roberts et al. (2006) and Hülür (2017) address the role of systematic cohort variation in personality. In economics, a recent study by Dohmen et al. (2017) documents that the willingness to take risks exhibits a decreasing age-profile even when accounting for variation across cohorts and time. Their approach resolves the linear identification problem by either setting the period effects to zero or by applying a non-linear proxy variable approach to account for period and cohort effects while assuming separability of age, period, and cohort effects. This implies, however, that the empirical strategy rules out any potential interactions between age and time effects for given cohorts by assumption. In fact, the entire literature on life-cycle profiles of personality traits and economic preferences seems to have assumed, implicitly or explicitly, that age, period, and cohort effects are separable. Our analysis provides the first formal test of this assumption in the context of personality traits and economic preferences building on work by MaCurdy and Mroz (1995). Using longitudinal data from a nationally representative household survey, the main finding is that personality traits and preferences evolve along a stable age-profile during adulthood, which is unaffected by period and cohort effects.

Moreover, the few studies that account for period and cohort effects typically apply a proxy approach to address the identification problem. For instance, the main specification estimated by Dohmen et al. (2017) hinges on the assumption that macroeconomic fluctuations in terms of the growth rate of Gross Domestic Product represent a good proxy for period effects. Our results show that this approach is valid only as long as the proxy is sufficiently strong. We demonstrate the need for caution when using proxy variables to resolve the linear identification problem and limitations in the applicability of such an approach by documenting that the estimated life cycle pattern in risk attitudes depends on the particular sample period where this approach is applicable. Dohmen et al. (2017) exploit non-linear variation during a particular sample period (the context of the Great Recession). Whereas our estimation approach delivers qualitatively similar findings regarding the life cycle pattern of risk attitudes, we show that our approach also provides similar estimates consistently for different sample periods where the proxy approach is not applicable, suggesting that the quality of the proxy is not robust to changing the sample period or context.

In summary, the results of this paper provide novel evidence on life-cycle profiles of personality traits and preferences, which is crucial for the discussion of stability of preferences and personality. The findings are also relevant in the context of policy analysis and evaluation, because the knowledge of the life cycle patterns influences the design of policies through, e.g., better targeting. Finally, our findings have important implications for the stability of age patterns in personality and preferences and their interpretation, for instance in the context of cognitive aging and Flynn effect, which is related to cohort or period effects (Bonsang and Dohmen, 2015; Bratsberg and Rogeberg, 2018).

The remainder of the paper is organized as follows. Section 2 discusses the data sources, the variable construction and provides descriptive statistics for the estimation sample. Section 3 provides stylized facts regarding the age-profile of personality traits. Section 4 describes the empirical approach and the econometric specification tests. Section 5 presents the results of the specification tests and the estimated life-cycle profiles of the nine personality trait measures. Section 6 assesses the robustness of the estimated age-profile in the context of risk attitudes, and Section 7 concludes.

2 Data

We use data from the German Socio-Economic Panel Data (SOEP), a longitudinal survey conducted since 1984 that is representative of the population living in Germany. Each year, the SOEP collects demographic indicators, labor market outcomes and many other variables for individuals that are at least 17 years old. The raw sample size exceeds 20,000 individuals each year. For general details about the survey see Goebel et al. (2019). We extract data on nine personality trait measures from the SOEP.

Risk Attitudes. Our measure of general risk attitudes is based on a single item that reads "How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?", and is measured on a scale from 0 to 10, where 0 means "not at all willing to take risks" and 10 means "very willing to take risks". We standardize this measure to have a mean of zero and a standard deviation of one using the overall mean and standard deviation across all available waves of the survey. This allows us to construct a measure of risk attitudes for the years 2004, 2006, and 2008-2016. The validity of this measure of risk attitudes has been documented by Dohmen et al. (2011).

Locus of Control. The SOEP contains information to construct comparable locus of control measures for the years 2005, 2010, and 2015.[1] The questionnaire contains ten items measured on a scale from 1 to 7 that were initially conceived to cover four dimensions: i) internal locus of control, ii) external locus of control, iii) attitudes about fairness, and iv) individual versus collective orientation (Nolte et al., 1997).[2] Based on these ten items, we construct locus of control measures using principal component factor analysis.[3] First, we use principal component factor analysis to identify the underlying factors using the three available waves of the survey. The results show that nine out of the ten items load on two factors that can be identified as internal and external locus of control. We then isolate the items that correspond to internal and external locus of control and conduct a second factor analysis to get the loadings (weights) for a single factor. In the final step the items are aggregated using the loadings as weights and a standardized version of the items. Therefore, the measures of locus of control are standardized with mean zero and standard deviation one. For completeness, we additionally construct an overall measure of locus of control by reversing the scale of those items that load on the external locus of

[1]Although there is information in 1999 about locus of control, the scale is different. To avoid comparability issues we do not consider the information for 1999 in the analysis.

[2]The specific wording of the questions can be found in the appendix.

[3]The construction follows the approaches pursued by Piatek and Pinger (2016) and Caliendo et al. (2016). Both studies use the same data source.

control construct and then conduct the factor analysis on all of the nine items to get the loadings and aggregate the nine items. This overall measure is increasing in internal locus of control (Caliendo et al., 2016).

Big Five Personality Traits. The construction of the Big Five personality trait measures is based on a short version of the Big Five Inventory that consists of three items for each construct and that was developed by Gerlitz and Schupp (2005), who also examine the validity of this inventory to identify the Big Five traits.[4] The inventory contains self-assessment questions where respondents indicate their agreement to each of the 15 statements on a scale from 1 (does not apply at all) to 7 (applies perfectly). Such information is available for the years 2005, 2009, and 2013. Given that the items are already known to belong to a specific construct, we use the factor analysis only to get the weights necessary to aggregate the items. Table A1 in the Appendix provides further details.

Sample Construction. Before the construction of the variables, we exclude the observations that have missing values for year of birth, sex, and in any of the items necessary to construct the personality trait measures. We further restrict the sample to individuals aged 25 to 60 years old in order to focus on an age range in which personality traits do not change rapidly for reasons that are related to adolescence, education, or vocational training. We exclude first-time surveyed individuals to mitigate problems due to first-time non response. This procedure leads to a final sample of 167,573 observations which we use for the empirical analysis. Importantly, although we focus on individuals aged 25 to 60 in the analysis, the construction of the indicators is based on the larger sample of people aged 17 to 80 years old.

Table 1 presents the means and standard deviations of the nine standardized personality trait measures by year. The first row show a considerable decrease in the willingness to take risks in 2009 compared to all of the other years in the series, and a slight increase of willingness to take risks in recent years. The lower panel of the table shows that the age structure of the sample has remained relatively stable throughout the period of analysis. Altogether, these findings suggest that personality traits may change over time or across birth cohorts, which is what we aim to disentangle in this paper.

3 Stylized Facts on Age-Profiles

This section provides graphical evidence regarding the age-profiles of personality measures. We first analyze the means of the nine personality trait measures by age using three

[4] As stated in Lang et al. (2011), three items per construct represent a minimum for latent factor modelling and identification of the Big Five traits.

Table 1: Means of Personality Traits by Year

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Risk Attitudes (standardized index: mean zero, standard deviation one)													
Risk aversion	−0.022	*n.a.*	0.100	*n.a.*	−0.054	−0.321	−0.106	−0.020	0.113	−0.041	0.063	0.110	0.124
	(0.969)	*n.a.*	(0.937)	*n.a.*	(0.957)	(0.904)	(0.955)	(0.920)	(0.942)	(1.002)	(1.017)	(1.013)	(1.032)
Big Five Traits (standardized index: mean zero, standard deviation one)													
Openness	*n.a.*	0.030	*n.a.*	*n.a.*	*n.a.*	−0.071	*n.a.*	*n.a.*	*n.a.*	0.066	*n.a.*	*n.a.*	*n.a.*
	n.a.	(0.976)	*n.a.*	*n.a.*	*n.a.*	(0.990)	*n.a.*	*n.a.*	*n.a.*	(0.979)	*n.a.*	*n.a.*	*n.a.*
Conscientiousness	*n.a.*	0.148	*n.a.*	*n.a.*	*n.a.*	0.038	*n.a.*	*n.a.*	*n.a.*	0.048	*n.a.*	*n.a.*	*n.a.*
	n.a.	(0.926)	*n.a.*	*n.a.*	*n.a.*	(0.961)	*n.a.*	*n.a.*	*n.a.*	(0.930)	*n.a.*	*n.a.*	*n.a.*
Extraversion	*n.a.*	0.034	*n.a.*	*n.a.*	*n.a.*	−0.040	*n.a.*	*n.a.*	*n.a.*	0.058	*n.a.*	*n.a.*	*n.a.*
	n.a.	(0.991)	*n.a.*	*n.a.*	*n.a.*	(1.019)	*n.a.*	*n.a.*	*n.a.*	(1.009)	*n.a.*	*n.a.*	*n.a.*
Agreeableness	*n.a.*	0.038	*n.a.*	*n.a.*	*n.a.*	−0.103	*n.a.*	*n.a.*	*n.a.*	−0.011	*n.a.*	*n.a.*	*n.a.*
	n.a.	(0.998)	*n.a.*	*n.a.*	*n.a.*	(1.014)	*n.a.*	*n.a.*	*n.a.*	(0.978)	*n.a.*	*n.a.*	*n.a.*
Neuroticism	*n.a.*	0.065	*n.a.*	*n.a.*	*n.a.*	−0.023	*n.a.*	*n.a.*	*n.a.*	−0.085	*n.a.*	*n.a.*	*n.a.*
	n.a.	(1.000)	*n.a.*	*n.a.*	*n.a.*	(0.996)	*n.a.*	*n.a.*	*n.a.*	(1.006)	*n.a.*	*n.a.*	*n.a.*
Locus of Control (standardized index: mean zero, standard deviation one)													
Locus of Control	*n.a.*	−0.011	*n.a.*	*n.a.*	*n.a.*	*n.a.*	0.023	*n.a.*	*n.a.*	*n.a.*	*n.a.*	0.046	*n.a.*
	n.a.	(1.014)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	(0.998)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	(0.982)	*n.a.*
Internal LoC	*n.a.*	0.004	*n.a.*	*n.a.*	*n.a.*	*n.a.*	−0.141	*n.a.*	*n.a.*	*n.a.*	*n.a.*	−0.027	*n.a.*
	n.a.	(0.989)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	(0.976)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	(1.003)	*n.a.*
External LoC	*n.a.*	0.005	*n.a.*	*n.a.*	*n.a.*	*n.a.*	−0.034	*n.a.*	*n.a.*	*n.a.*	*n.a.*	−0.036	*n.a.*
	n.a.	(1.010)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	(0.989)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	(0.987)	*n.a.*
Age Structure (as proportions)													
Age $\in$ [25,35)	0.227	0.225	0.218	0.211	0.209	0.210	0.208	0.206	0.218	0.208	0.220	0.204	0.208
Age $\in$ [35,50)	0.493	0.490	0.482	0.474	0.468	0.461	0.449	0.435	0.520	0.418	0.497	0.496	0.485
Age $\in$ [50,60)	0.255	0.265	0.281	0.291	0.295	0.301	0.314	0.327	0.243	0.342	0.262	0.277	0.286
No. of observations	13426	12261	12009	12684	11781	10567	9669	9199	16768	10501	17615	15565	15528

Source: Own calculations based on SOEP v33.1 long format.
Notes: Personality traits are standardized to have mean zero and standard deviation 1 for the entire panel data set. Mean and variance for standardization estimated using the sample of people aged 17 to 80 years old. We report the year specific means (year specific standard deviations in parenthesis). "n.a." is shorthand for non-available.

different years of cross-section data. Then, we change the perspective to cohort age-profiles for synthetic cohorts in order to track how personality traits change with age (and time) for given cohorts.

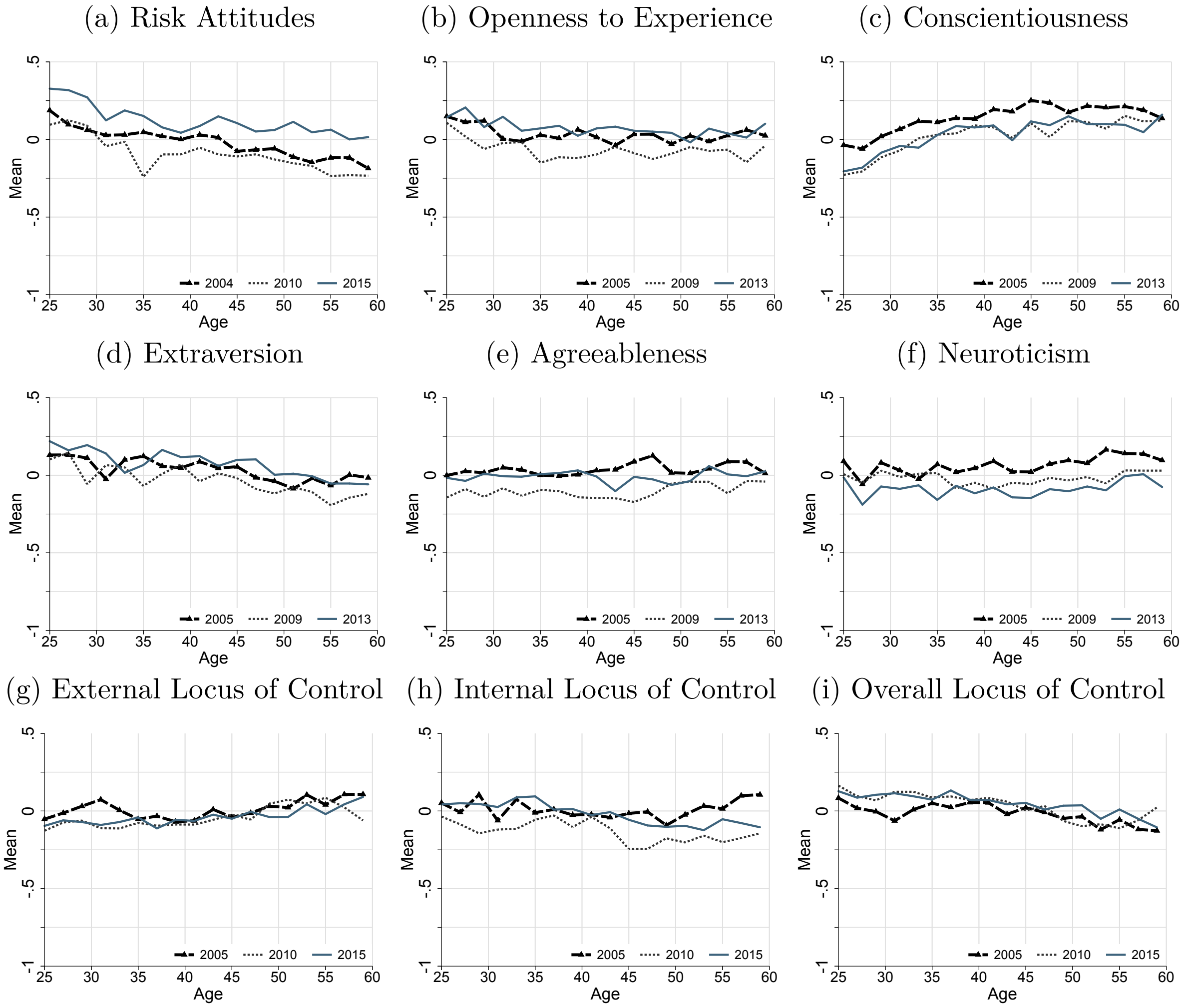
3.1 Cross-Sectional Age-Profiles

Figure 1 presents the means of the nine personality traits by age for three different survey years.[5] If the shape of the cross-sectional age-profile variesacross years in a non-uniform way, this suggests interaction effects between age and period, i.e. the presence of cohort effects.

Panel (a) shows a substantial increase in the measure of risk attitudes, in terms of a greater unwillingness to take risks or greater risk aversion, in the cross-sectional data. The difference in risk aversion between the ages of 25 and 60 is close to half a standard deviation. To a smaller extent, openness to experience, extraversion, and overall locus of control decrease with age (Panels (b), (d), and (i)). The latter means that in the cross-section data on average their overall external locus of control increases as individuals age. The decline in the extraversion measure between the ages of 25 and 60 is close to a quarter of a standard deviation and is much less substantial in the cases of openness to experience and overall locus of control. In the case of openness to experience, Panel (b) shows that its mean is stable over the age range 35 to 60 years. The patterns observed in

[5] To reduce the noise of the estimates we use two-year age intervals based on adjacent years. For example, ages 17 and 18 are grouped as 17, 19 and 20 as 19, and so on.

Figure 1: Cross-Sectional Age-Profiles of Personality Traits for Selected Years



Source: Own calculations based on SOEP v33.1 long format.
Notes: To reduce noise, age is grouped into use two-year age intervals based on adjacent years. The figures display means by age-year cells.

Panels (g), and (h) show that the means of external and internal locus of control tend to increase after a certain age. Specifically, the rise in the mean value of external and internal locus of control starts (approximately) at ages 40 and 50, respectively. Panel (c) shows that the mean value of conscientiousness by age increases about 0.25 standard deviations from 25 to 35 years, then is stable until 55 years, and afterwards decreases slightly. Finally, there is no evidence for a pronounced age pattern in the mean values of agreeableness and neuroticism (Panels (e) and (f)).

At this point it has to be emphasized that these cross-sectional means do not necessarily reflect the actual life-cycle age-profiles of the personality traits for a given cohort. The reason is that, on the one hand, cross-sectional profiles may be confounded by differences across cohorts and, on the other hand, by time evolving as a given cohort ages. In fact, taking into account the presence of cohort effects has a substantial effect on the estimated life-cycle age-profile of neuroticism and other personality traits as we will show below.

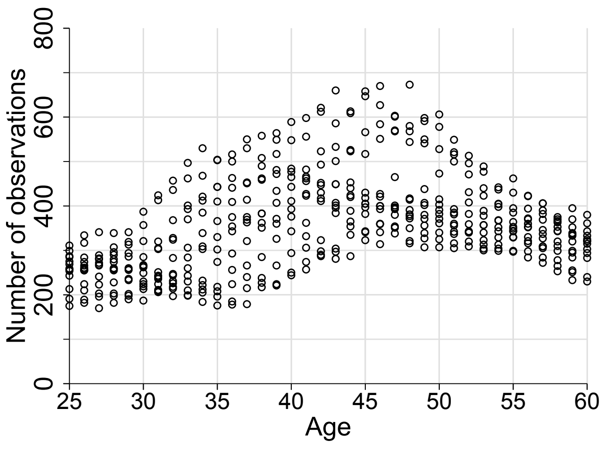
While the cross-sectional profiles of most indicators resemble each other at first sight for different survey years, below we provide formal tests in order to be able to discard the possibility of interactions between age and period in the changes of personality traits for a given cohort.

3.2 Synthetic Cohorts

The previous analysis provided a first impression of possible age patterns in personality traits. However, the analysis remains silent about the differences between cohorts that might be related to these age patterns. In the following, we track birth cohorts over time to shed some light on the possible cohort effects present in the data. We do this using synthetic cohorts in terms of considering thze average value of outcome for each cohort-year cell and using the number of observations in each cell as weights in the regressions. Following synthetic cohorts allows us to compare the average life cycle profile of measures of personality traits for individuals with similar life experiences. It further helps to mitigate the possible non-random attrition in the data when analyzing the evolution of mean personality traits across the life cycle.

Synthetic cohorts in this study are defined based on individuals' year of birth.[6] Figure 2 shows the number of observations in each cohort-year cell by age. In total, there are 465 cohort-year cells. Note that the number of observations in each cohort-year cell decreases at old ages.

Figure 2: Number of Observations for Each Cohort-Age Cell



Source: Own calculations based on SOEP v33.1 long format.
Notes: Each point represents the number of observations in each cohort-age cell, where cohort is defined using a one-year birth interval and age is measured in years.

We calculate the mean of the personality trait measures for each cohort-year cell and plot these means against the age of the individuals for a given cohort. Figure 3 depicts the evolution of the mean of the nine personality trait measures over the life course by cohort

[6] The choice of the interval that defines a cohort implies a trade-off between a narrow definition that reduces the heterogeneity within each cohort-year cell and the variation that can be used for estimation. The richness of the data allow us to use a one-year birth intervals to define cohorts.

for the cohorts born 1950, 1960, 1970, 1980, and 1990. Each point corresponds to the same cohort and is drawn using the same marker. Different cohorts are left unconnected. This implies that all age-cohort cells exhibit substantial variation that can be used for estimation. According to the estimates in Panel (a), younger cohorts tend to be less risk averse compared to older cohorts at any given age. For example, at the age of 35 the 1980 cohort is almost 0.20 standard deviations more willing to take risks than the 1970 cohort at the same age. Also, the age profile is not monotonic within cohorts, but typically exhibits a v-shape pattern. This is suggestive of period effects that affect risk attitudes of different cohorts at different ages, but in qualitatively similar ways. This feature provides scope for the use of non-linear proxies for identifying period effects, as will be discussed in more detail below.

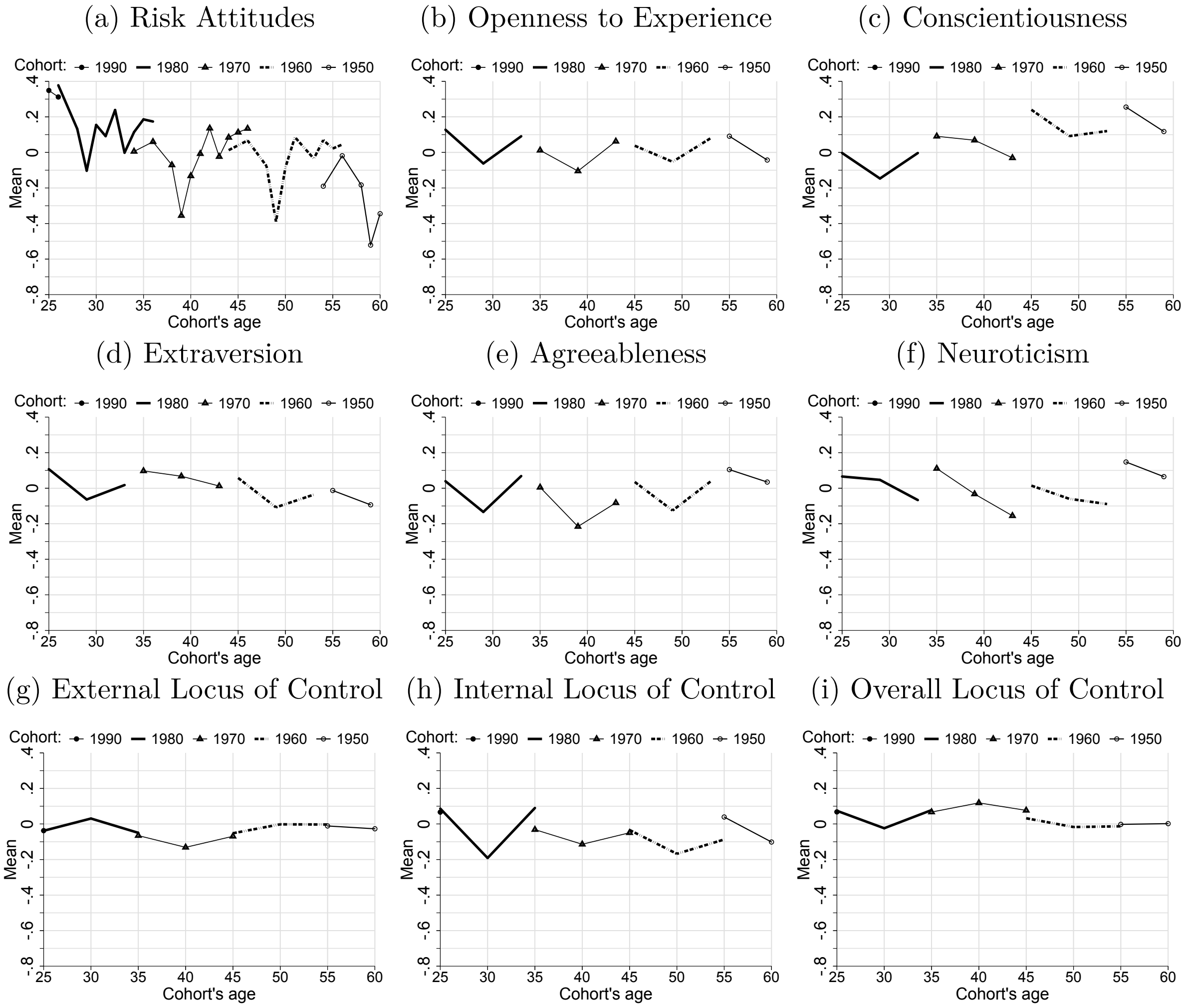
For openness to experience (Panel (b)) there are no substantial jumps between the estimates for different cohorts before the age of 60. For conscientiousness (Panel (c)), age patterns are more heterogeneous for younger cohorts than for older ones. Panels (d) and (e) for extraversion and aggreeableness suggest that cohort effects are negligible and the patterns resemble the one observed in the estimates of Figure 1. Panel (f) reveals an important pattern in mean values of neuroticism by cohort: the estimates for all of the shown cohorts are negatively sloped and indicate pronounced differences across cohorts. In particular, at any given age younger cohorts show lower mean values of neuroticism than older cohorts. It is the combination of these two features in the estimates for neuroticism that imply the smooth evolution in age in Figure A1. Finally, note that the estimates for internal and, in particular external locus of control show no substantial jumps for the estimates between cohorts; all of the estimates before the age of 60 for different cohorts seem to be connected.

The key insight of this analysis is that cross-sectional estimates of the mean value of personality traits by age for different years are likely confounded with cohort effects. Moreover, these cohort effects seem to be stronger for some personality traits than for others. However, the graphical evidence presented in this subsection is not sufficient to determine the importance of cohort effects and the evolution of personality traits over the life course, especially in light of the low number of years available for measures other than willingness to take risks. This implies the need for a formal analysis based on econometric techniques in order to identify the age-profile of personality traits over the life cycle.

4 Empirical Approach

The main goal of our paper is to uncover the systematic variation of personality traits over the life cycle. Due to the linear relationship between age, period, and cohort it is not possible to identify separate effects of age, period, and cohort without further assumptions. In order to examine whether we can identify a universal profile of personality traits over

Figure 3: Cohort Age-Profiles of Personality Traits



Source: Own calculations based on SOEP v33.1 long format.
Notes: Cohorts are defined using a one-year birth interval. The figures show from left to right how the mean value of the respective personality trait evolves as the cohort becomes older. Points for the same cohort are connected, and points that belong to different cohorts are left unconnected.

the life-cycle that is independent from the cohort under consideration, we follow a strategy developed by MaCurdy and Mroz (1995) and applied recently by Antonczyk et al. (2018).[7] In particular, we specify an age-period-cohort model of personality traits that has testable implications regarding the uniformity of trends for different cohorts across time (see also Fitzenberger, 1999).

4.1 Empirical Framework

The linear relationship between age (a), period (t), and cohort (c) given by $t = c + a$ does not allow for point identification of the effect of each of these dimensions in a linear regression model without further assumptions. To illustrate this, denote the age-profile of outcome y as $f(t, a)$, and the "cohort profile" as $g(c, a)$. Then, for a given year t the

[7]This framework has also been applied in other contexts, see, e.g., Fitzenberger et al. (2001), and Fitzenberger and Wunderlich (2002). Gosling et al. (2000) apply a similar framework.

function f yields the cross-section age-profile, while holding the cohort constant in g yields the "life cycle" profile, which reflects movements over the life cycle for a given cohort. Note that by using the linear relationship between age, period, and cohort the functions f and g are equivalent representations since $g(c, a) \equiv g(t - a, a) \equiv f(t, a)$. Thus, it is possible to write the outcome y as follows:

$$y = g(c, a) + u = f(t, a) + u \tag{1}$$

where u is an error term reflecting transitory deviations from the deterministic functions f or g.

Despite the identification problem, it is possible to use the model to investigate whether every cohort experiences the same time trend (i.e., a uniform time trend). Consider the change for a given cohort c over time which is described by the partial derivative of function g with respect to t or equivalently a,

$$\left.\frac{\partial g}{\partial t}\right|_c = \left.\frac{\partial g}{\partial a}\right|_c \equiv g_a(c, a) \equiv g_a. \tag{2}$$

This derivative is a function of unknown form of time t and age a. The crucial question is whether this derivative is separable into a pure aging effect ($A_a(a)$) and a pure time effect ($B_a(t)$) or whether there are interactions between time and age that indicate differential profiles for different cohorts. We therefore formulate the separability assumption

$$g_a = A_a(a) + B_a(t) = A_a(a) + B_a(c + a), \tag{3}$$

where $A_a(a)$ reflects the change over the life cycle, and $B_a(t)$ is the time-related variation of the outcome. If this characterization holds, then the change in an outcome over the life cycle is independent of the calendar year t and implies that each cohort faces the same change over the life cycle due to aging. The key point to notice is that condition (3) is violated if interaction terms of a and t enter into the specification of g_a. As noted by Fitzenberger (1999), this condition does not rely on arbitrary identification conditions. However, a caveat is that the level of the outcome is left unspecified.

Integrating back condition (3) with respect to a under our separability assumption yields the following additive specification for g:

$$g(c, a) = G + K(c) + A(a) + B(c + a) \tag{4}$$

where $G + K(c)$ is the cohort-specific constant of integration.

In the following, we parameterize Equation (4) and test the separability assumption by additionally including integrals of interaction terms between age and time. In particular, we test the hypothesis that the interaction terms are equal to zero. Only if this hypothesis cannot be rejected is the separable formulation in Equation (4) justified.

4.2 Empirical Specification

First, we normalize age as $a = (age - 25)/10$ and period as $t = (year - 2004)/10$, where age and $year$ are measured in years. This way $a = 0$ for the youngest age considered. Analogously, we define cohort as $c = t - a$ such that the cohorts born after 1979 have nonnegative values. For example, the cohort of individuals born in 1979 was 25 years old in 2004 and has a cohort value of $c = 0$, while the 1980 cohort is assigned a value of $c = 0.1$.

Second, in the main specifications used for hypothesis testing we parameterize the terms A and B using a third degree polynomial in age and a set of binary year indicators, respectively. We define K as a polynomial in the cohort dimension, with

$$K(c) = \gamma_2 c^2 + \gamma_3 c^3 + \gamma_4 c^4 + \gamma_5 c^5 \tag{5}$$

where γ_2, γ_3, γ_4, and γ_5) are coefficients.

Third, let R denote the set of integrals of a set of potential interaction terms $\{at, at^2, a^2t, a^2t^2\}$. Assuming that these terms are sufficient to capture the potential interactions between age and time,[8] the implied integrals are:

$$\begin{aligned}
R_1 &= \int a(c+a)da = ca^2/2 + a^3/3 \\
R_2 &= \int a(c+a)^2 da = c^2a^2/2 + 2ca^3/3 + a^4/4 \\
R_3 &= \int a^2(c+a)da = ca^3/3 + a^4/4 \\
R_4 &= \int a^2(c+a)^2 da = c^2a^3/3 + 2ca^4/4 + a^5/5 \,.
\end{aligned} \tag{6}$$

Consequently, the most general specification of equation (4) that accounts for all interaction terms R is given by:

Model 1.

$$y = G + \alpha_1 a^1 + \alpha_2 a^2 + \alpha_3 a^3 + D^t\beta + \gamma_2 c^2 + \gamma_3 c^3 + \gamma_4 c^4 + \gamma_5 c^5 + \sum_{i=1}^{4} \rho_i R_i + u,$$

where a, and c are the age, and cohort variables respectively; D^t contains binary indicators for each survey year; α, β, γ, and ρ are vectors of coefficients to be estimated;

[8]The decision of considering only up to second order interaction terms is arbitrary, but interaction terms of higher order did not change the results in the case of risk risk attitudes, and higher order terms cannot be estimated in the case of other personality traits due to the small number of periods in the sample.

G is the constant term; and u is the error term. Note that to avoid the multicollinearity problem the linear term of the cohort polynomial is excluded.

Based on this empirical model, we can develop formal hypothesis tests of the implicit assumption in the literature about the separability of age and and time effects and obtain guidance about which model suits the data best. In particular, a formal test of the separability assumption implies testing whether all the coefficients of the interaction terms are jointly zero:

Test 1.

$$H_{UI} : \rho_1 = \rho_2 = \rho_3 = \rho_4 = 0.$$

If this condition holds, then the age-profile is given either by the polynomial in age or the coefficients of the dummy variables in the time dimension.

A second test refers to the question whether an even more parsimonious specification describes well the patterns of the data. To this end, consider a restricted version of Model 1, which omits the interaction terms,

Model 2.

$$y = G + \alpha_1 a^1 + \alpha_2 a^2 + \alpha_3 a^3 + D^t\beta + \gamma_2 c^2 + \gamma_3 c^3 + \gamma_4 c^4 + \gamma_5 c^5 + u$$

Finally, consider a third specification that also omits the cohort effects,

Model 3.

$$y = G + \alpha_1 a^1 + \alpha_2 a^2 + \alpha_3 a^3 + D^t\beta + u.$$

Specification Tests. To determine the most parsimonious specification from the three proposed models we use a procedure that is based on formal hypothesis testing. **Test 1** described above assesses whether the separability condition holds in Model 1 by testing whether the coefficients of the interaction terms ρ are jointly significantly different from zero. **Test 2** tests whether in Model 1 the coefficients of interaction terms ρ *and* the coefficients of cohorts effects γ are statistically different from zero. Finally, **Test 3** tests whether the coefficients of the cohort effects γ are jointly different from zero in Model 2, implying that estimating Model 3 is equivalent to estimating Model 2.

4.3 Empirical Implementation

In the following, we present results from estimating the empirical models for data for individuals in the age interval from 25 to 60 years. For those personality traits for which we have only few survey years available we only estimate third degree polynomials in the cohort dimension in Model 2 and Model 3 and include only the R_1 interaction term in Model 1. Also notice that we work with the sample of synthetic cohorts (average value of outcome for each cohort-year cell) using the number of observations in each cell as weights in the regressions.

A key requirement for our hypothesis tests is to obtain standard errors that are robust to heteroskedasticity and autocorrelation of the error term. We check robustness to a variety of error specifications. First, we show estimates based on clustered standard errors at the cohort level. Then, we cluster standard errors by five-year intervals in the age dimension for each survey year. Finally, we implement Conley (1999) standard errors using a Bartlett kernel in the estimation and vary the assumed distance of correlations in the cohort and time dimensions.

5 Empirical Results

5.1 Results of Specification Tests and Model Fit

In this section, we present the results of formal hypotheses tests, which provide guidance about which model best suits the data. Additionally, we analyze the goodness of fit of in-sample predictions using the three models both graphically and using chi-square tests.

Table 2 shows the results of our hypothesis tests. The first column indicates that the null hypothesis that the coefficients ρ of the interactions terms are jointly zero cannot be rejected at conventional significance levels for eight out of nine of the personality trait measures. This implies that the separability condition (3) holds for these eight personality traits. The only exception is neuroticism, for which the test results indicate that the null of no interaction effects in the changes of personality traits for a given cohort can be rejected. In addition, the results of Tests 2 and 3 imply that cohort effects are important in the domains risk attitudes and internal locus of control. For all other traits, the null that cohort effects are zero cannot be rejected.

To further explore the differences between the models and to assess how substantial these differences are, Figure 4 plots the fitted values for each personality trait for each selected cohort over time. The graphs document that the differences in the fitted values between the estimated models are negligible.

For some personality traits the difference between fitted values and observed data seems relatively large, however. To explore the model performance, we conduct two different specification checks. Table 3 shows the results of chi-square goodness of fit tests to assess whether the fitted values generated from the estimated models fit the observed cohort data. The test results indicate that the restricted models without interaction terms provide a good model fit. The results also corroborate the previous finding that cohort effects are important when modeling risk attitudes and internal locus of control, but not so much for

Table 2: Hypothesis Tests (p-values)

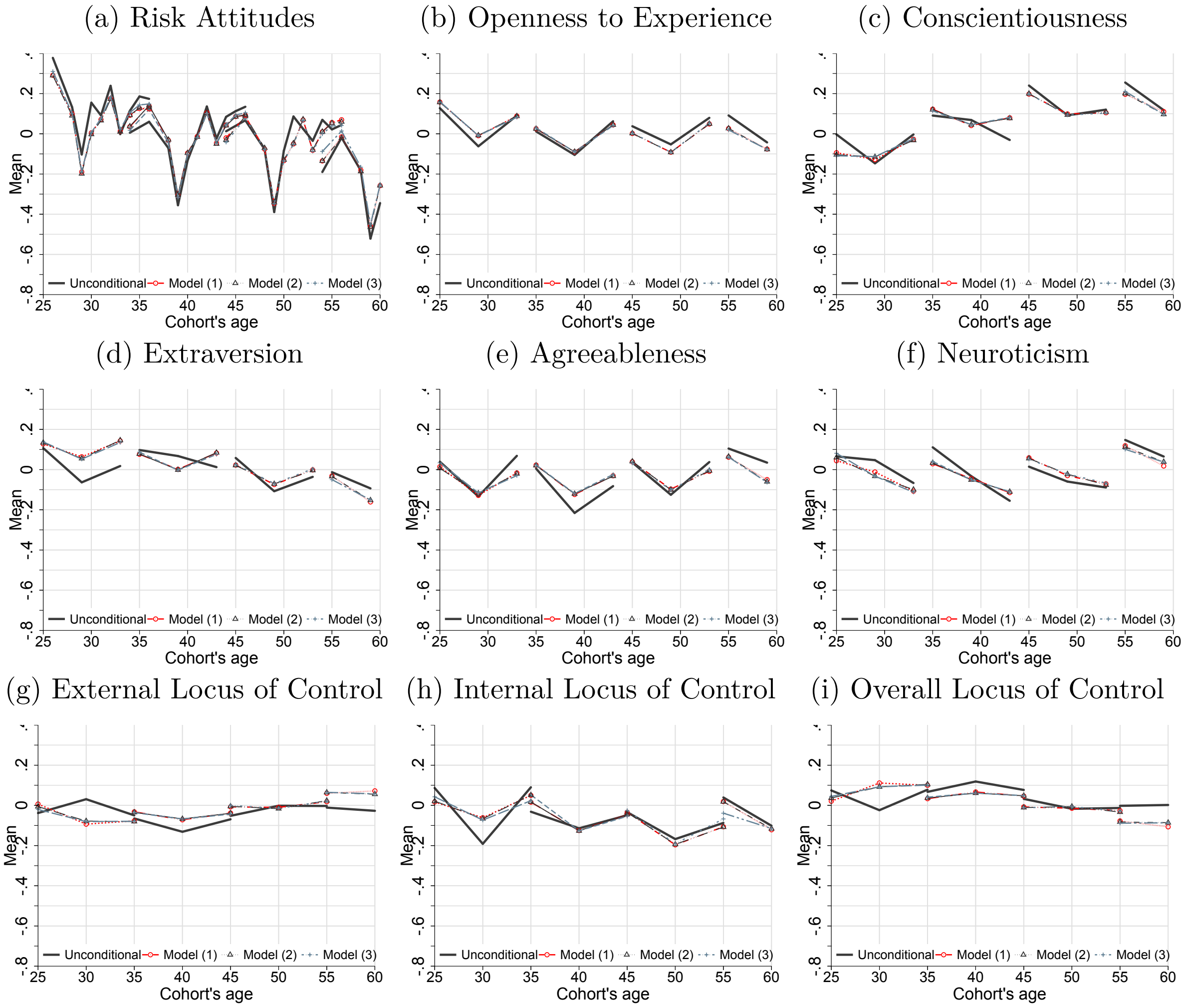
	Standard Error Estimator	Model (1) Test 1 $Null: \rho_i = 0$	Model (1) Test 2 $Null: \rho_i = \gamma_i = 0$	Model (2) Test 3 $Null: \gamma_i = 0$
Risk Attitudes				
Risk aversion	Cluster: year of birth	0.135	0.002***	0.009***
	Cluster: t and a = 1x5	0.248	0.000***	0.000***
	Conley: t and c=3x5	0.311	0.000***	0.000***
	Conley: t and c=7x7	0.314	0.000***	0.000***
Big Five Factors				
Openness	Cluster: year of birth	0.865	0.805	0.613
	Cluster: t and a = 1x5	0.852	0.592	0.444
	Conley: t and c=7x7	0.868	0.679	0.474
Conscientiousness	Cluster: year of birth	0.102	0.259	0.521
	Cluster: t and a = 1x5	0.122	0.325	0.423
	Conley: t and c=7x7	0.104	0.228	0.467
Extraversion	Cluster: year of birth	0.322	0.335	0.251
	Cluster: t and a = 1x5	0.419	0.484	0.417
	Conley: t and c=7x7	0.477	0.354	0.244
Agreeableness	Cluster: year of birth	0.282	0.283	0.209
	Cluster: t and a = 1x5	0.150	0.079*	0.042**
	Conley: t and c=7x7	0.244	0.126	0.097*
Neuroticism	Cluster: year of birth	0.086*	0.077*	0.345
	Cluster: t and a = 1x5	0.013**	0.037**	0.321
	Conley: t and c=7x7	0.031**	0.038**	0.328
Locus of Control				
External LoC	Cluster: year of birth	0.259	0.472	0.612
	Cluster: t and a = 1x5	0.411	0.607	0.592
	Conley: t and c=7x7	0.282	0.517	0.546
Internal LoC	Cluster: year of birth	0.699	0.000***	0.000***
	Cluster: t and a = 1x5	0.668	0.000***	0.000***
	Conley: t and c=7x7	0.642	0.000***	0.000***
Locus of Control	Cluster: year of birth	0.158	0.423	0.743
	Cluster: t and a = 1x5	0.301	0.644	0.710
	Conley: t and c=7x7	0.173	0.475	0.667

Source: Own calculations based on SOEP v33.1 long format.
Notes: The number in parentheses refers to the model in which the test was done. Model (1) is the baseline specification using year dummies. In Model (2) the coefficients for the interaction effects ρ_i are set to zero. Clustered standard errors calculated at i) cohort level (year of birth), and ii) interval of a years in the age dimension for each year. Conley standard errors using a Bartlett Kernel, where t indicates the number of years included in the time dimension and c the number of cohorts included in the cohort dimension. Stars indicate the following significance levels: * means the test is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level; no asterisk means the test is not different from zero at conventional levels of significance.

the other personality traits.

As a final check, we conduct chi-square tests to assess whether the predictions obtained with estimates of Model 3 and Model 2 are significantly different from the predictions obtained with estimates of Model 1. The respective results are shown in Table 4. The null of no differences between predictions of Model 2 and Model 1 cannot be rejected at conventional levels. Only for conscientiousness and neuroticism, the null is rejected at the 10% significance level. This provides further evidence that the model with interaction terms does not perform significantly better than the model without interaction terms. Finally, the null of no differences between predictions of Model 3 and Model 1 is only rejected for risk attitudes and internal locus of control. This corroborates the previous findings that cohort effects are important factors shaping these personality traits.

Figure 4: Actual and Fitted Cohort-Age Profiles (Selected Cohorts)



Source: Own calculations based on SOEP v33.1 long format.
Notes: Cohorts are defined using a one-year birth interval. The figures show from left to right how the mean value of the respective personality trait evolves as the cohort becomes older. Points for the same cohort are connected, and points that belong to different cohorts are left unconnected. Unconditional refers to the mean of the respective personality trait for each cohort-year cell. Fitted values based on estimates of models (1), (2), and (3). The plotted cohorts are: 1950, 1960, 1970, and 1980.

5.2 Life Cycle Profiles of Personality Traits

In this section, we present the estimated life-cycle profile obtained with the the model that provides the best fit for each of the nine personality traits. Based on the test results presented in the previous subsection, the preferred model for most personality traits is Model 3, while the preferred model for risk attitudes and internal locus of control is Model 2. The estimated age-profiles are obtained under the assumption that the coefficient on the linear cohort term is zero (Fitzenberger, 1999). This assumption is motivated by condition (3), which allows us to decompose the change over time of an outcome into a pure age and a pure time effect, both common to all cohorts. As noted by Deaton (1997) and Heckman and Robb (1985), other normalization assumptions can be used to "identify"

Table 3: Chi-Square Goodness-of-Fit Test Statistics

	Model (1) Unconstrained	**Model (2)** $\rho_i = 0$	**Model (3)** $\rho_i = \gamma_i = 0$
Risk Attitudes			
Degrees of freedom	374	378	382
Risk aversion	382.07	387.29	427.06
(p-value)	(0.38)	(0.36)	(0.06)*
Big Five Factors			
Degrees of freedom	99	100	102
Openness	73.16	73.17	73.75
(p-value)	(0.98)	(0.98)	(0.98)
Conscientiousness	74.31	75.41	76.17
(p-value)	(0.97)	(0.97)	(0.97)
Extraversion	96.52	97.04	100.65
(p-value)	(0.55)	(0.57)	(0.52)
Agreeableness	90.87	91.59	94.23
(p-value)	(0.71)	(0.71)	(0.70)
Neuroticism	102.31	105.70	108.24
(p-value)	(0.39)	(0.33)	(0.32)
Locus of Control			
Degrees of freedom	99	100	102
External LoC	100.97	102.64	103.46
(p-value)	(0.43)	(0.41)	(0.44)
Internal LoC	107.09	107.21	140.35
(p-value)	(0.27)	(0.29)	(0.01)***
Locus of Control	98.77	101.45	102.06
(p-value)	(0.49)	(0.44)	(0.48)

Source: Own calculations based on SOEP v33.1 long format.
Notes: Model (1) is the baseline specification (equation (1)) using year dummies. In Model (2) the coefficients for the interaction effects ρ_i are set to zero and in Model (3) the coefficients ρ_i and γ_i are set to zero. The test statistics calculated as $res'S^{-1}res$, where res is the estimated residual vector (mean personality trait for each cohort-year cell minus the fitted value). The matrix S^{-1} is the inverse of the robust (White) variance-covariance matrix of coefficients of a regression of the dependent variable on dummies for each cohort-year cell excluding the constant term. P-values in parentheses, where the degrees of freedom equals the number of cohort-year cells minus the number of parameters estimated in the corresponding model. Stars indicate the following significance levels: */**/*** means the test is statistically significant at the 10/5/1 percent level.

the age-profile.[9] We assess the robustness of the results to alternative choices in Section 6.

Figure 5 presents the estimated age-profile for each personality trait. The solid red line indicates the estimated polynomial in age. We further plot an alternative specification where we model $A(a)$ using a set of age dummies, represented by the dashed black line. Confidence intervals are plotted for the age dummies based on Conley standard errors. For neuroticism, our tests rejected the Null of no interaction effects. A common life-cycle profile for all cohorts is therefore not supported by the data for this trait. Figure A4 further investigates the role of interaction effects for personality traits and compares age profiles that include interaction terms for selected cohorts to the restricted Model 2. For Neuroticism there are clear differences between the two variants indicating variation in the slope of the profile for different cohorts. In contrast, interaction terms seem indeed negligible for the other personality traits.

[9] See, e.g., Mason and Fienberg (2012) for an overview of approaches in other fields.

Table 4: Chi-Square Test Statistics for Comparison to Baseline Model (1)

	Model (2) vs. Model (1) $\rho_i = 0$	Model (3) vs. Model (1) $\rho_i = \gamma_i = 0$
Risk Attitudes		
Degrees of freedom	4	8
Risk aversion	4.82	48.45
(p-value)	(0.31)	(0.00)***
Big Five Factors		
Degrees of freedom	1	3
Openness	0.03	1.02
(p-value)	(0.87)	(0.80)
Conscientiousness	3.38	5.45
(p-value)	(0.07)*	(0.14)
Extraversion	0.52	3.19
(p-value)	(0.47)	(0.36)
Agreeableness	1.19	3.96
(p-value)	(0.27)	(0.27)
Neuroticism	3.80	6.68
(p-value)	(0.05)*	(0.08)*
Locus of Control		
Degrees of freedom	1	3
External LoC	1.59	2.74
(p-value)	(0.21)	(0.43)
Internal LoC	0.22	33.73
(p-value)	(0.64)	(0.00)***
Locus of Control	2.35	3.02
(p-value)	(0.13)	(0.39)

Source: Own calculations based on SOEP v33.1 long format.
Notes: The test statistics are calculated as $(X_1\hat{\beta}_1 - X_m\hat{\beta}_m)'Var^{-1}(X_1\hat{\beta}_1 - X_m\hat{\beta}_m)$ where X is the matrix of regressors for all cohort-year cells (dimension: number of cells times number of coefficients in the respective model) and $\hat{\beta}_1$ and $\hat{\beta}_m$ are the coefficient estimates for Model (1) and (m) [m$\neq$ 1], respectively. Var^{-1} is the inverse of the estimated variance-covariance matrix of $X_1\hat{\beta}_1$ based on the Huber-White variance-covariance matrix of $\hat{\beta}_1$. The degrees of freedom are the differences in the number of coefficients between the models. Stars indicate the following significance levels: */**/*** means the test is statistically significant at the 10/5/1 percent level.

6 Identification Under Alternative Assumptions

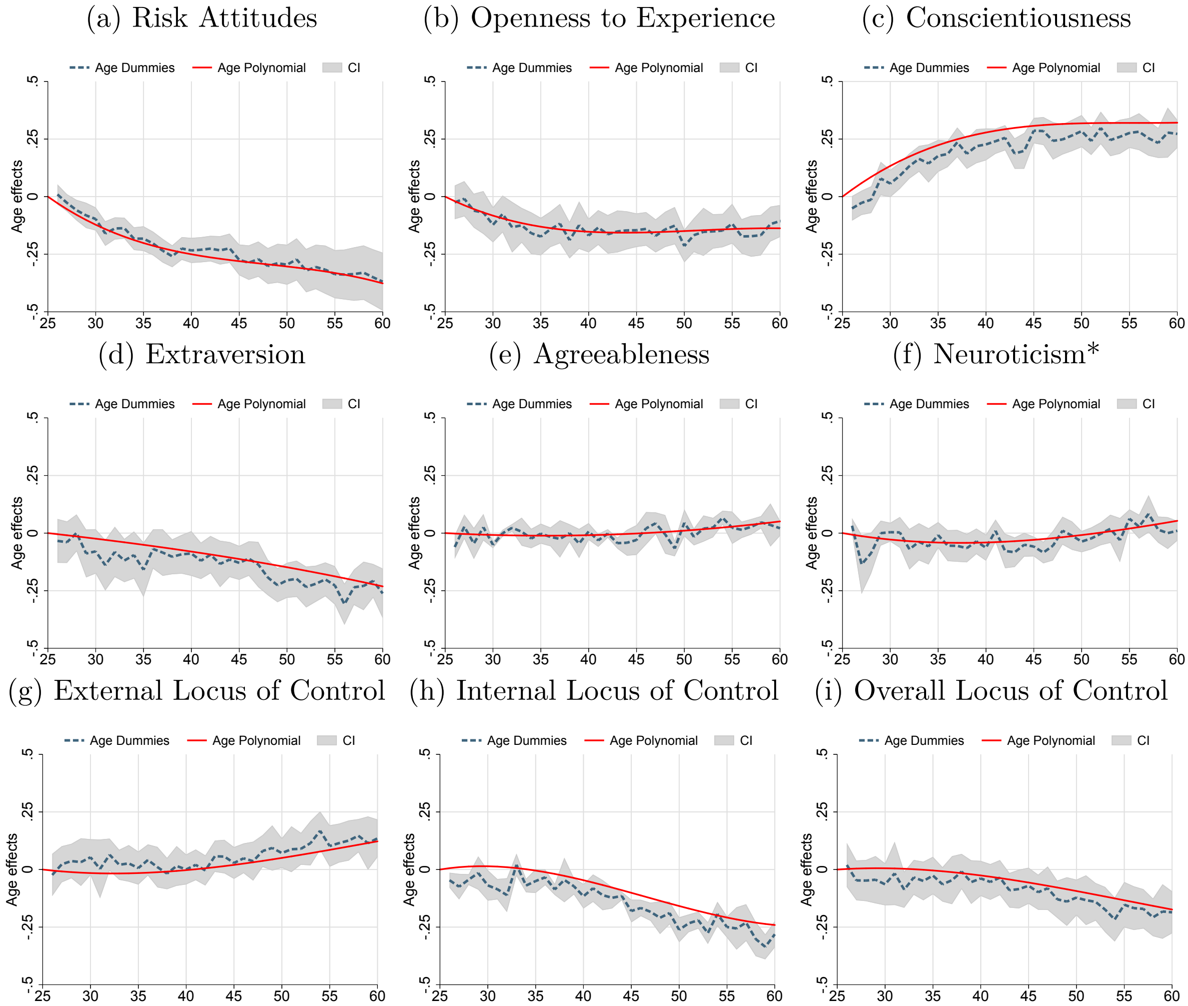
The results presented in the previous section were based on the assumption that the linear term of the cohort effects can be omitted and thus excluded in the specifications.[10] An alternative assumption to identify the age-period-cohort decomposition is to impose restrictions in the period dimension. This could potentially result in different age-profiles. In this section we assess the consequences of alternative identification assumptions for estimated life-cycle profiles of personality traits. To focus the discussion, we conduct this analysis for the measure of risk attitudes only.

One alternative to avoid the linear identification problem (perfect collinearity between age, period, and cohort) is to omit one of three dimensions entirely in the estimation. For instance, one could omit all of the period dummies, which implies imposing as many constraints as period effects on the data.[11] Heckman and Robb (1985), on the other hand,

[10]Note that this does not mean that cohort effects are not taken into account since the models include higher order polynomial terms in the cohort dimension.

[11]An alternative approach, not analyzed here but often used in the study of consumption and saving, is to normalize the set of year dummies and make them orthogonal to a time trend and sum up to zero

Figure 5: Fitted Age-Profiles Based on Preferred Models with Separability



Source: Own calculations based on SOEP v33.1 long format.
Notes: Age profiles show fitted changes in personality traits due to aging relative to a person aged 25. Solid lines [Age Polynomials] depict the fitted profiles based on Model (3) [no cohort and interaction terms] except for panels (a) and (h) which are based on model (2) including cohort effects but no interaction terms. Dashed lines [Age Dummies] depict the estimated age dummies by year replacing the age polynomial in these models. Confidence Interval (CI) for age dummies based on Conley standard errors. * = Tests do not support the identification of a unique age-profile.

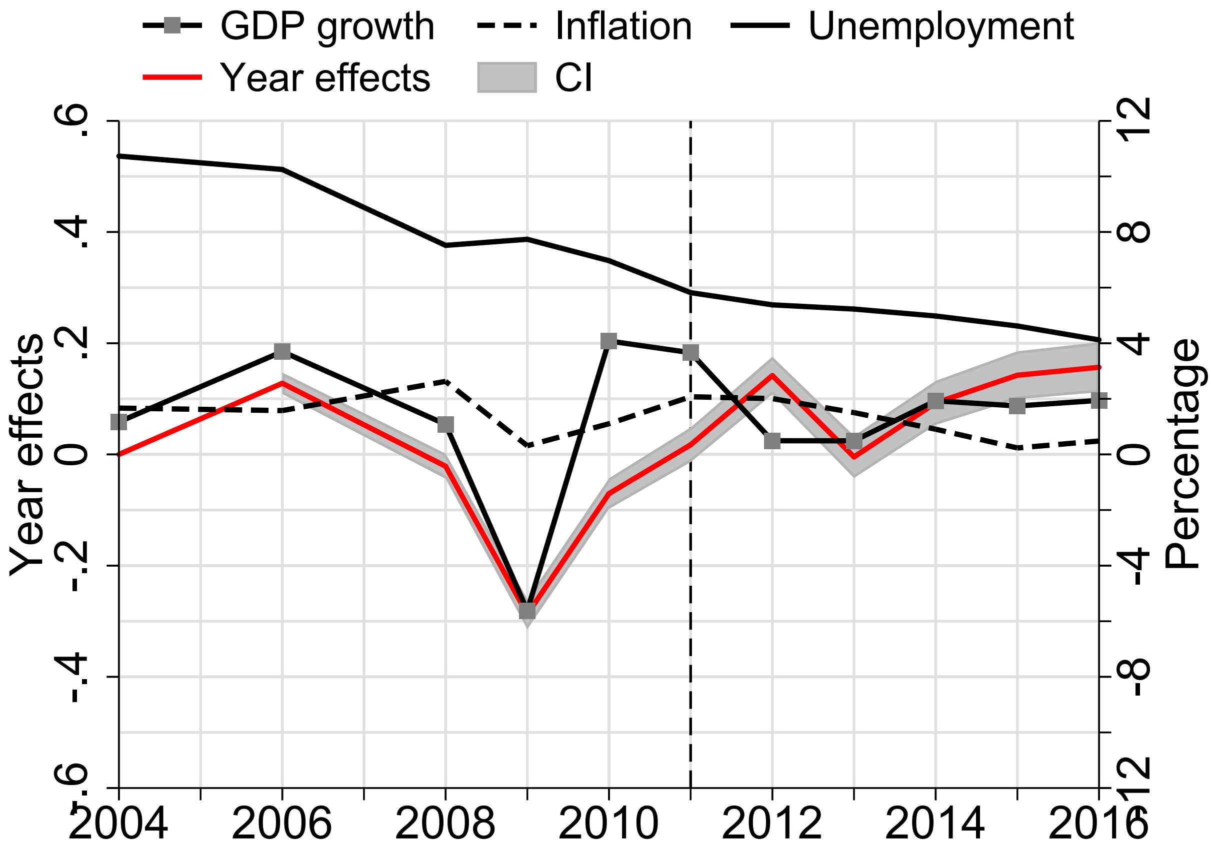
suggest that the identification problem in the age-period-cohort model arises because age, period, and cohort are only proxies of underlying variables which are themselves not linearly dependent. Consequently, with better proxies the linear dependency would not emerge and the identification problem would not arise in the first place.

Dohmen et al. (2017) implement both of the aforementioned approaches to estimate the age-profile of risk attitudes using the SOEP data for the period 2004-2011.[12] Concretely,

(Deaton, 1997). This is equivalent to assuming that all the linear time trends observed in the data can be attributed to age and cohort effects (Deaton and Paxson, 1994; Attanasio, 1998), and implies imposing fewer constraints compared to the first approach. In the context of consumption this procedure is justified by noting that "a steady growth in year effects simply means that consumption is growing with age and declining with cohort, and it is appropriate to attribute the effects to age and cohort, not time" (Deaton and Paxson, 1994). This approach appears less appropriate in the context of personality traits, however.

[12]There are a few differences in terms of sample compared to this study that, however, do not affect the

Figure 6: Fitted Year Effects for Risk Attitudes and Macro Indicators



Source: Own calculations based on SOEP v33.1 long format.
Notes: Plot shows the coefficients of the year dummies and their confidence interval based on Conley standard errors based on our preferred model. Gross Domestic Product growth, Inflation, and Unemployment (International Labor Office definition) measures are obtained from the World Bank Open Data Base. The macro indicators are measured as percentages.

they use the growth rate of Gross Domestic Product as a proxy for year effects and a full set of dummies for age and cohort effects in their main specification. Thus, their study provides a natural benchmark against which to compare our results. Since we have a longer time period available, we can replicate their results not only for the period they consider (2004-2011), but also for our longer sample (2004-2016).

We first explore the correspondence between the estimated year effects in our preferred model 2 for risk attitudes and different macroeconomic indicators. Figure 6 plots the respective time series. The graph reveals a close correspondence between the pattern of the estimated year effects and GDP growth during the initial time periods, until the onset of the great recession in 2009. For subsequent time periods, however, the relation between GDP growth and estimated period effects becomes visibly weaker. Table 5 reports the respective correlation coefficients. While GDP growth and the estimated period effects exhibited a

substance of the results below. Specifically, we use the subsample for people who reached 17 and entered to the sample (jugendl file in the SOEP long format) since the measure of risk preferences is also available for these individuals, while Dohmen et al. (2017) do not consider this subsample.

correlation of 0.85 in the sample until 2011, the sign flips and the correlation is -0.18 for the time period from 2011 onwards. Overall, the inflation rate and the unemployment rate both exhibit a much smoother development in comparison to the estimated year effects. Correspondingly, their correlation with the estimated period effects is also considerably lower than for GDP growth. Also here we find large disparities in correlation patterns when estimation is based on different time periods (Table 5). Moreover, the overall correlation for the entire sample is very low, even when compared to GDP growth.

Figure 7 presents the estimated age-profile for risk attitudes obtained with the three different approaches, and for four different time and age intervals. The first approach (depicted as solid red line) estimates the age-profile based on our preferred specification (baseline), which imposes the restriction that the linear term of the cohort effects is zero. The second approach (depicted as solid black line) ignores time effects altogether in the empirical specification and uses only a complete set of age and cohort dummies. Finally, the third approach (depicted as dashed black line) is based on an empirical specification that includes a full set of age and cohort dummies, and that includes the growth rate of Gross Domestic Product as a proxy for period effects, as in Dohmen et al. (2017).[13] We model the age effects using age dummies to make the results comparable to the estimates reported in Dohmen et al. (2017).

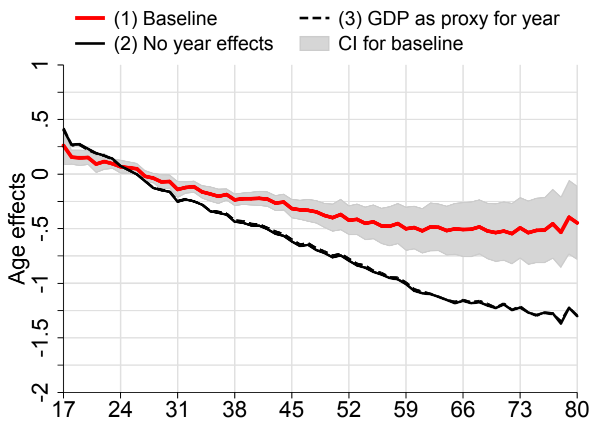
Panel (a) of Figure 7 presents the results for the time and age interval studied in Dohmen et al. (2017). The figure reveals two important facts. First, the profiles identified by not taking into account period effects or using the growth rate of GDP as a proxy for period effects are very similar to each other when estimating the model for the sample period 2004-2011 as in Dohmen et al. (2017). The second feature of the figure is that the age profile estimated using the preferred specification according to the approach in this paper (baseline) is qualitatively very similar to the age profile obtained with the approach used in Dohmen et al. (2017), although the age profile obtained with our preferred specification is less pronounced than the one obtained under the two alternative approaches. Panel (b) presents the corresponding results for the entire sample period 2004-2016. Here, the results reveal important qualitative differences in the estimated profiles. Specifically, the estimates from our preferred model using the extended sample resemble the ones estimated using the sample for the 2004-2011. However, the other two approaches deliver qualitatively different estimated age-profiles compared to those in Panel (a). In particular, the estimates suggests that the willingness to take risks increases rather than decreases with age, especially after age 30. The results from panels (c) and (d) show the corresponding results when restricting attention to a more narrow age range of 25-60 years. The findings are similar. In particular, while the baseline approach of this study delivers qualitatively and quantitatively very similar results regarding the life cycle profile

[13] The GDP growth rate was obtained from the World Bank Open Databases through the wbopendata command in Stata. We omit the dummy for the youngest age (17), and the oldest cohort (1924).

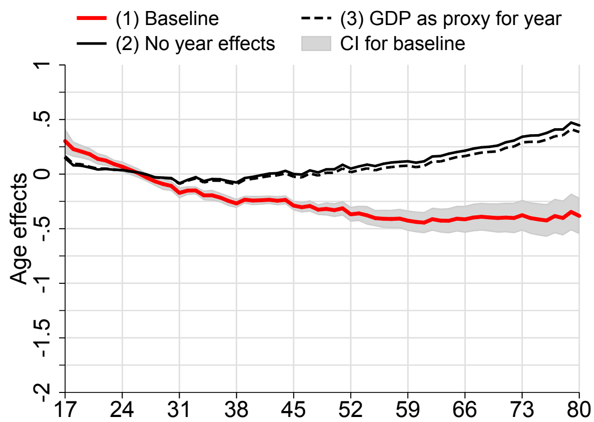
of risk attitudes, the alternative identification approaches of using a proxy for period effects or not controlling for period effects at all deliver very different results depending on the years covered by the estimation sample. Taken together, this suggests that these alternative approaches are more sensitive to period fluctuations and the variation that is contained in the respective non-linear proxy, whereas the approach used in the analysis of the previous section delivers similar estimates of the age-profile independently of the period or age interval used for the analysis.

Figure 7: Fitted Age-Profiles for Risk Attitudes Under Different Constraints

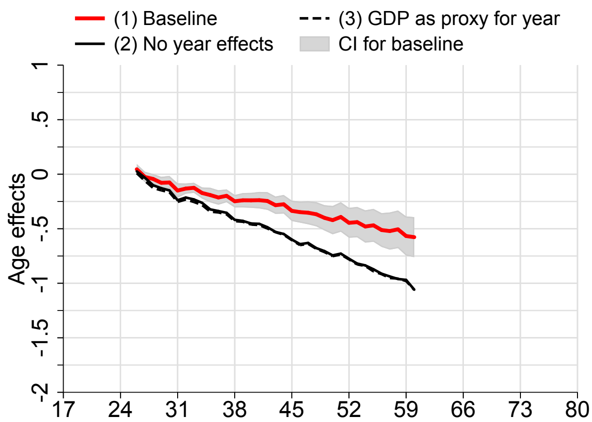
(a) Sample: years 2004-2011, age 17-80



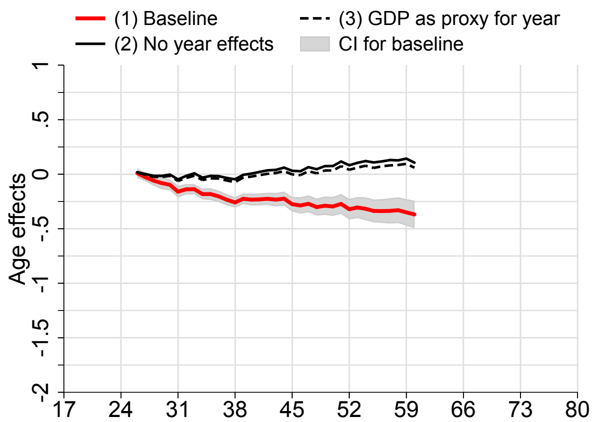
(b) Sample: years 2004-2016, age 17-80



(c) Sample: years 2004-2011, age 25-60



(d) Sample: years 2004-2016, age 25-60



Source: Own calculations based on SOEP v33.1 long format.
Notes: All estimates shown are based on model (2) with age dummies (dummies for each year of age). Baseline specification refers to model (2) with the age-profile identified by restricting the linear term in the cohort dimension to zero and using year dummies to model the period dimension. Approach (2) [No year effects] refers to the age-profile estimated by using dummies for each cohort and not taking into account the time dimension. For approach (3) [GDP as proxy] the period dimension is proxied using the growth rate of GDP. Note that the estimates for approaches (2) and (3) are almost indistinguishable for panels (a) and (c).

Table 5: Correlation Between Estimated Year Effect and Macro Indicators for Various Periods

	2004–2016	**2004–2011**	**2011–2016**
GDP growth	0.65	0.85	−0.18
Unemployment rate	−0.32	0.34	−0.68
Inflation rate	0.09	0.69	−0.55

Source: Own calculations based on SOEP v33.1 long format and World Bank open data indicators.
Notes: Year effect for 2004 (base year) is set to zero. Correlation estimated based on all the available years for risk attitudes.

7 Concluding Remarks

This paper provided a first systematic analysis of life-cycle patterns of various personality traits by performing formal specification tests of a flexible model of age-period-cohort effects. Based on a rich specification that included potential interactions between age and time effects, we conducted various specification and goodness of fit tests. In particular, this allowed us to test the assumption of no interactions between age and period effects, which is a prerequisite for uniform age profiles of personality traits across cohorts. For most personality traits, we find that interactions between age and time effects can be excluded and, consequently, that life-cycle profiles can be identified with additively separable models. For some traits, the findings additionally indicate that a restricted model without interaction terms and cohort effects provides a good fit of the observed data. Based on the estimates of the most appropriate model for nine personality trait measures, we report the estimated life cycle profiles these personality traits.

The empirical findings reveal that the willingness to take risks, openness to experience, extraversion, and a perception of an internal locus of control decline with age. In contrast, conscientiousness, and a perception of an external locus of control increase with age. For agreeableness and neuroticism appear to be fairly unaffected by age.

From a methodological perspective, our findings show that alternative approaches to identify age-period-cohort effects that rely on proxy variables for the period effects hinge on the correlation between proxy indicators and the development of period effects. Our findings show that this correlation might be subject to substantial variation, depending on the sample period. This finding calls for caution in the use of proxy-approaches whose applicability might be restricted to particular contexts.

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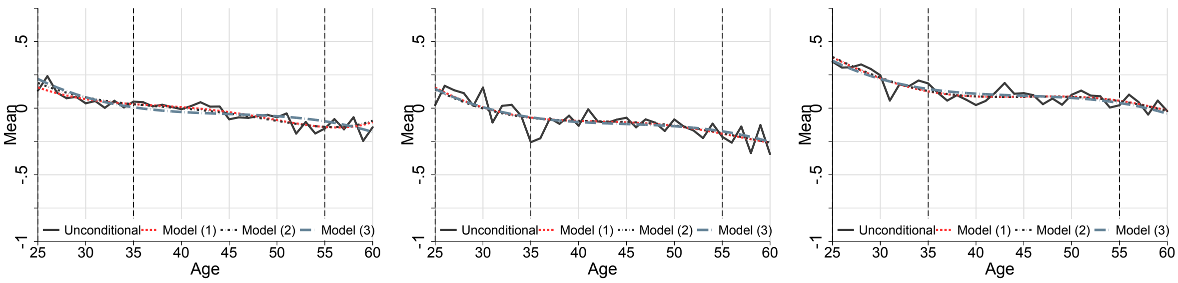
Appendix

Figure A1: Means of Personality Traits by Age and Year: Risk Aversion

(a) 2004 (b) 2010 (c) 2015



Source: Own calculations based on SOEP v33.1 long format.
Notes: Plot shows the unconditional mean of the personality trait by age for each year and the fitted values based on estimates of models (1), (2), and (3). Vertical dashed lines are included for ages 35, and 55

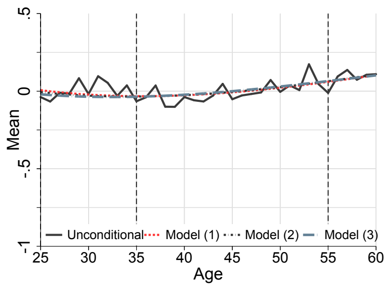
Table A1: Specific Items Used to Construct Personality Trait Measures

	Mean	S.D.	Weight
Risk Attitudes. Scale: 1-point 0 (risk averse) to 10 (fully prepared)			
How do you see yourself:			
Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?	4.670	2.344	1.000
Big Five. Scale: 1-point 1 (does not apply) to 7 (Applies perfectly)			
I see myself as someone who:			
Openness to experience:			
is original, comes up with new ideas.	4.622	1.396	0.453
values artistic, aesthetic experiences.	4.115	1.823	0.409
has an active imagination.	4.804	1.511	0.459
Conscientiousness:			
does a thorough job.	6.149	1.021	0.471
tends to be lazy. (Original scale reversed)	5.575	1.587	0.378
does things effectively and efficiently.	5.781	1.097	0.449
Extraversion:			
is communicative, talkative.	5.494	1.330	0.456
is outgoing, sociable.	5.090	1.427	0.457
is reserved. (Original scale reversed)	3.909	1.606	0.360
Agreeableness:			
is sometimes somewhat rude to others. (Original scale reversed)	4.961	1.652	0.438
has a forgiving nature.	5.435	1.324	0.428
is considerate and kind to others.	5.758	1.089	0.523
Neuroticism:			
worries a lot.	4.436	1.679	0.416
gets nervous easily.	3.668	1.688	0.478
is relaxed, handles stress well. (Original scale reversed)	3.460	1.485	0.433
Locus of control. Scale: 1-point 1 (does not apply) to 7 (Applies perfectly)			
The following statements apply to different attitudes towards life and the future.			
To what degree to you personally agree with the following statements:			
External locus of control			
Compared to other people, I have not achieved what I deserve.	3.252	1.774	0.266
	(4.748)	(1.774)	(0.243)
What a person achieves in life is above all a question of fate or luck.	3.592	1.675	0.245
	(4.408)	(1.675)	(0.225)
I frequently have the experience that other people have a controlling influence over my life.	3.102	1.698	0.286
	(4.898)	(1.698)	(0.269)
If I run up against difficulties in life, I often doubt my own abilities.	3.281	1.662	0.267
	(4.719)	(1.662)	(0.243)
The opportunities that I have in life are determined by the social conditions.	4.485	1.486	0.218
	(3.515)	(1.486)	(0.201)
I have little control over the things that happen in my life.	2.704	1.509	0.304
	(5.296)	(1.509)	(0.290)
Internal locus of control			
How my life goes depends on me.	5.514	1.309	0.483
	(5.514)	(1.309)	(0.175)
One has to work hard in order to succeed.	5.964	1.128	0.518
	(5.964)	(1.128)	(0.013)
Innate abilities are more important than any efforts one can make.	4.871	1.337	0.473
	(4.871)	(1.337)	(−0.056)

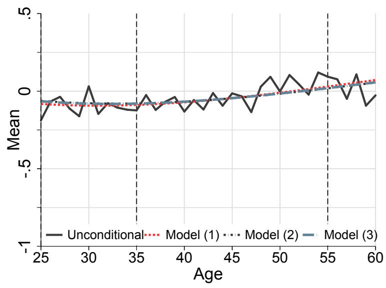
Source: Own calculations based on SOEP v33.1 long format.
Notes: Table presents the mean and standard deviation of the original items used to construct the variables. Values in parentheses represent the values used for the overall locus of control variable. Weights are the scoring coefficients from the principal component factor analysis estimation using orthogonal rotation.

Figure A2: Means of Personality Traits by Age and Year: Locus of Control

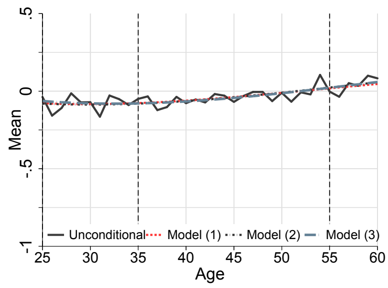
(a) External Locus of Control: 2005



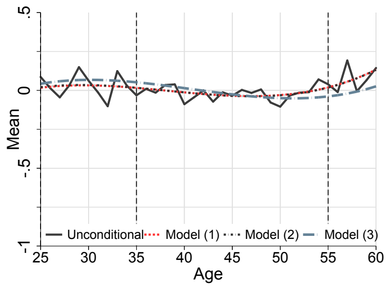
(b) External Locus of Control: 2010



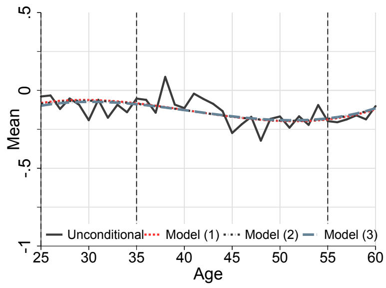
(c) External Locus of Control: 2015



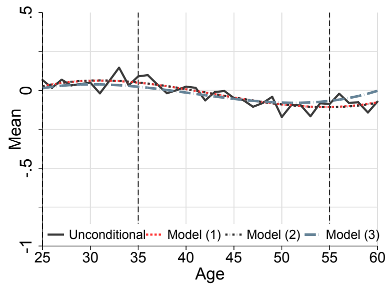
(d) Internal Locus of Control: 2005



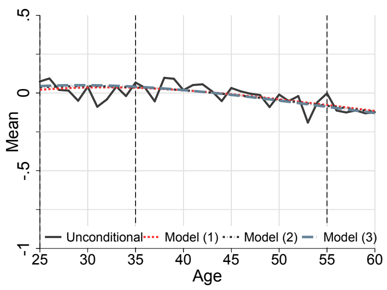
(e) Internal Locus of Control: 2010



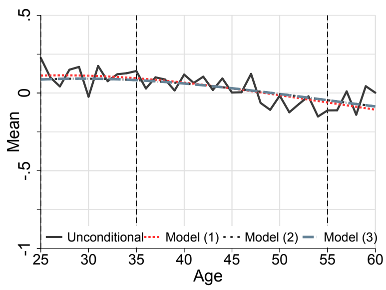
(f) Internal Locus of Control: 2015



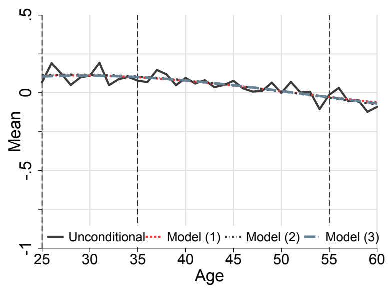
(g) Locus of Control: 2005



(h) Locus of Control: 2010



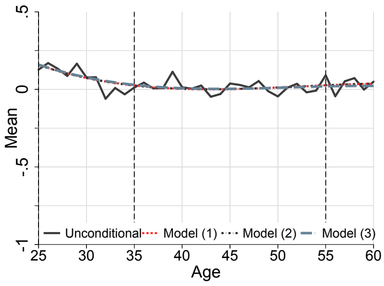
(i) Locus of Control: 2015



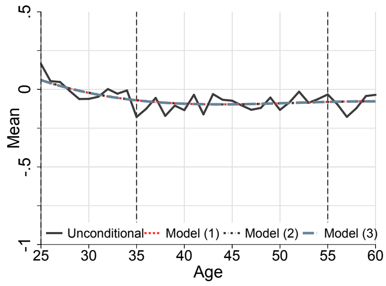
Source: Own calculations based on SOEP v33.1 long format.
Notes: Plot shows the unconditional mean of the personality trait by age for each year and the fitted values based on estimates of models (1), (2), and (3). Vertical dashed lines are included for ages 35, and 55

Figure A3: Means of Personality Traits by Age and Year: Big 5

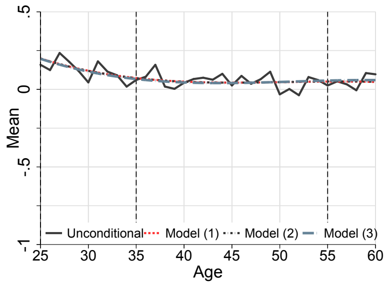
(a) Openness: 2005



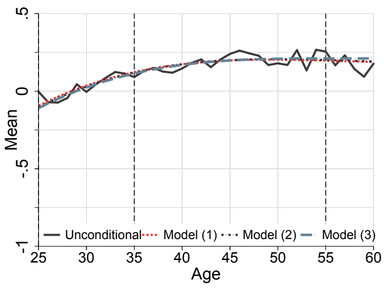
(b) Openness: 2009



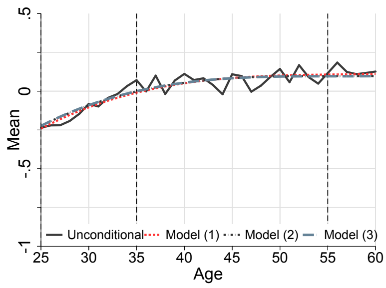
(c) Openness: 2013



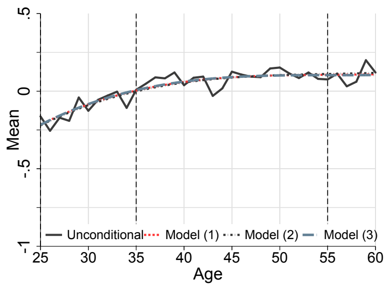
(d) Conscientiousness: 2005



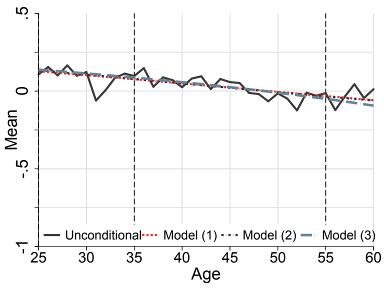
(e) Conscientiousness: 2009



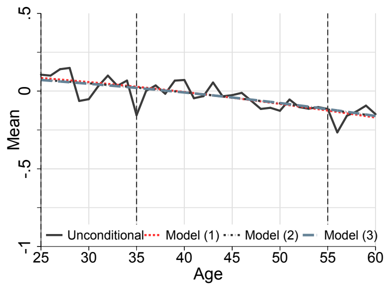
(f) Conscientiousness: 2013



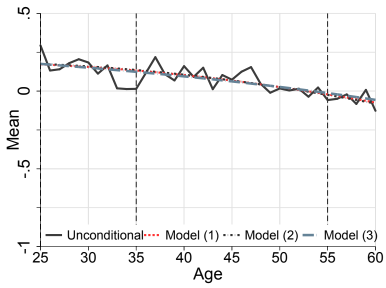
(g) Extraversion: 2005



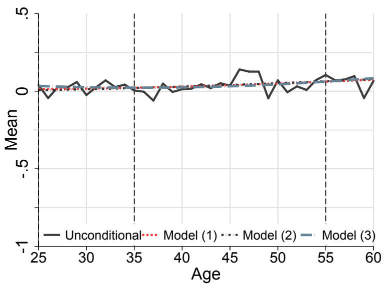
(h) Extraversion: 2009



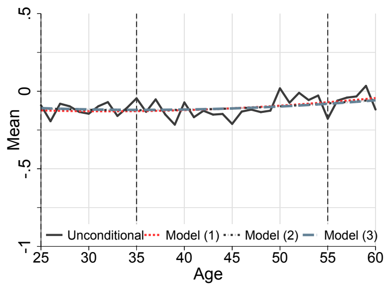
(i) Extraversion: 2013



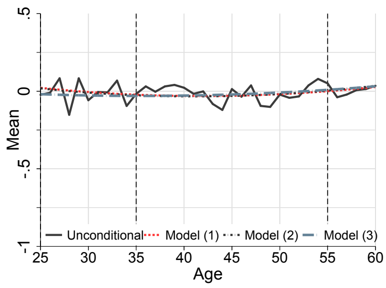
(j) Agreeableness: 2005



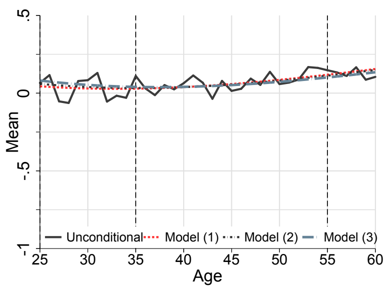
(k) Agreeableness: 2009



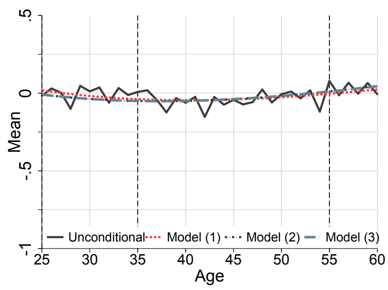
(l) Agreeableness: 2013



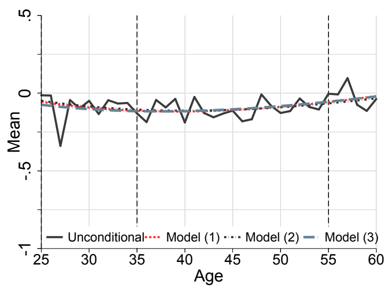
(m) Neuroticism: 2005



(n) Neuroticism: 2009

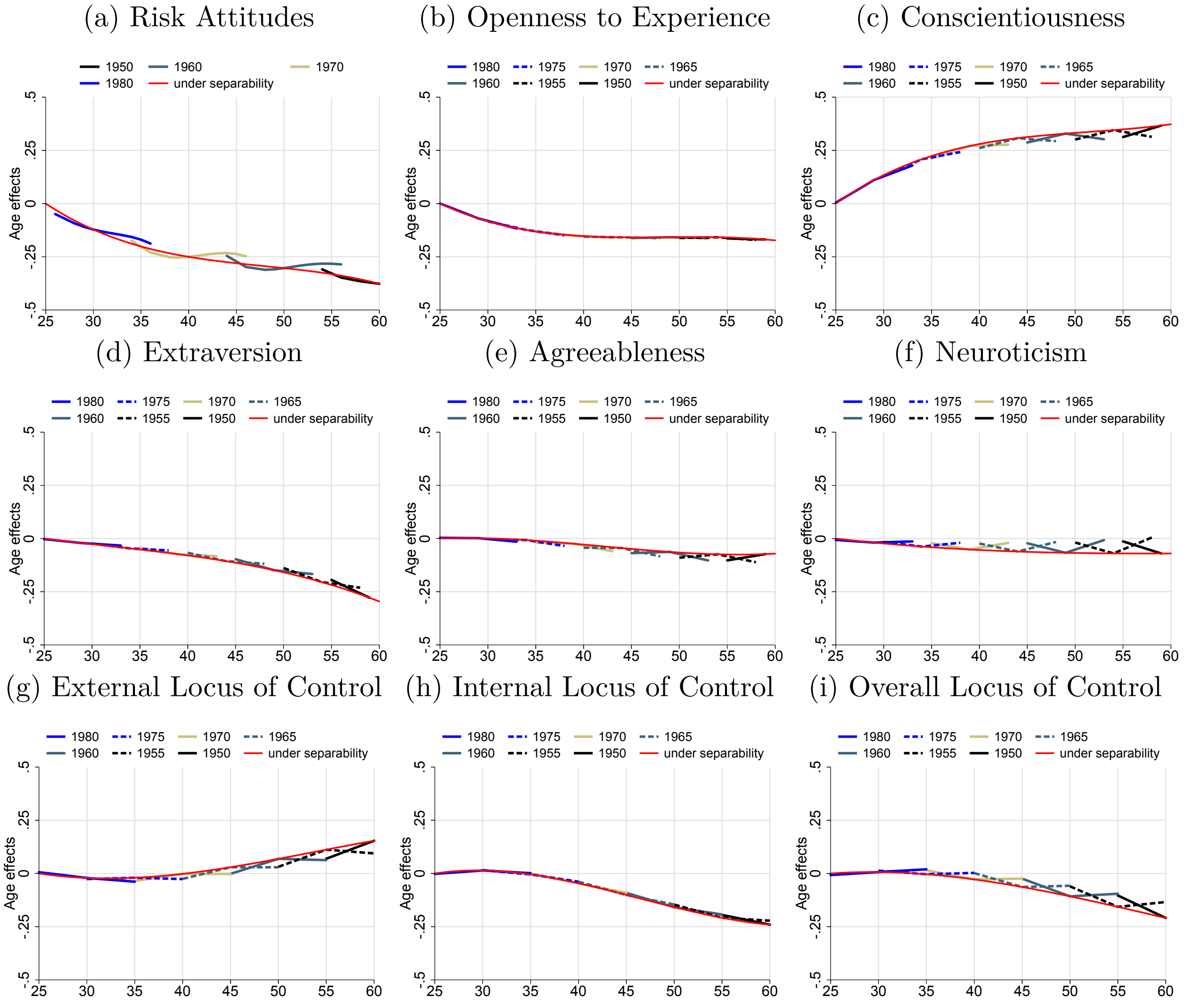


(o) Neuroticism: 2013



Source: Own calculations based on SOEP v33.1 long format.
Notes: Plot shows the unconditional mean of the personality trait by age for each year and the fitted values based on estimates of models (1), (2), and (3). Vertical dashed lines are included for ages 35, and 55

Figure A4: Age Effects Based on Model 2 (Under Separability) and Model 1 for Selected Cohorts



(a) Risk Attitudes (b) Openness to Experience (c) Conscientiousness (d) Extraversion (e) Agreeableness (f) Neuroticism (g) External Locus of Control (h) Internal Locus of Control (i) Overall Locus of Control

Source: Own calculations based on SOEP v33.1 long format.
Notes: The 'under separability' curve plots the age effects based on the age polynomial from model (2). The other curves correspond to the age effects for different selected cohorts based on the age polynomial, cohort polynomial and interactions from model (1). For each cohort the distance between the middle point of the cohort's ordinate and the model under separability at the corresponding age is subtracted.