Understanding the Dynamics of Well-Being

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Abstract

This paper discusses a few competing theories of well-being put forward in Psychology, and proposes a simple model that nests their main features. Some observational implications of each model are discussed and tested empirically using the German Socio-Economic Panel (GSOEP).

1 Introduction

In this paper, I propose to analyse the formation of individual well-being, in light of the main well-being models that have stemmed from the Psychology literature.

The individual will not be taken as a decision-maker or an optimising agent, but instead his well-being changes as a response to the events he experiences[1]. The question I propose to answer is to what extent does he react to events.

[1] One can think of these events as a step after the choice problem takes place and an outcome is realised.

The adaptation-level (AL) theory, proposed by Helson (1948, 1964) was the first attempt to formalise the basic idea that one objective stimulus can be perceived and yield different subjective well-being reactions, according to the history and characteristics of the individuals. Even though his theory was developed while analysing psychophysiological phenomena (such as the adaptation of individuals to different brightness, colour scales or weights), and maybe for this reason ignored by social scientists for so long, this concept was readily apt to be used more broadly[2].

Brickman and Campbell (1971) introduce this idea in Economics, further arguing that AL theory would predict that internal forces interact as to offset any potential permanent impact of an event. They define this extreme adaptation behaviour as a hedonic treadmill to illustrate the fact that individual long-run well-being is solely determined by their intrinsic level of happiness and does not structurally change with the individual event history.

Kahneman and Tversky (1979) develop an axiomatic theory, which they call Prospect Theory, that better fits paradoxical experimental results that have been amounting evidence against the expected utility theory. In their model, utility or well-being does not depend on objective stimulus, but instead on the deviation from a subjective norm or reference point or, actually, from an AL.

These theories will be discussed in more detail and their main empirical predictions will be tested using self-reported Subjective Well-Being (SWB) data[3].

Most empirical studies of happiness, have only looked at income-based variables as the relevant events. However, evidence seems to suggest that income advantages are not clearly correlated with higher happiness (see Frey and Stutzer, 2002 for a summary of cross-country comparisons[4] and e.g. Blanchflower and Os-

[2]Helson (1971) himself wrote: "The presence of extreme contrasts has accentuated the dissatisfactions and disequilibria that are found in our society today. Contrast the superabundance of wealth with extreme poverty almost side by side; [...] billions poured into a far-off war with the curtailments of funds for education, [...] affects every individual who watches television [...]. The facts learned about the role of [...] norms carry directly over to our perception of social, political and economic conditions."

[3]The relative merits and demerits of these self-reported measures have been greatly discussed, within Economics, ever since the seminal papers of van Praag (1971). van Praag and Frijters (1999) and, more recently, van Praag and Ferrer-i-Carbonell (2004) provide more extensive discussions of the theoretical and empirical strengths of relying on these measures as the main tool for well-being analysis. This paper will provide some considerations later, when the actual data are presented.

[4]Evidence seems to suggest that income is welfare enhancing for low income countries but,

wald, 2000, for a time series analysis of happiness in three different countries[5]). Longitudinal studies are scarce mainly due to the difficulty in constructing the relevant individual AL to compare income against[6]. Other studies, even though they have broadened the determinants of happiness beyond income and welfare, have so far sought support for one of these theories alone. The existence of adaptation to events such as marriage, unemployment or disability has widely been tested for and has received some empirical support (see e.g. Argyle, 1999, for a good review of this empirical literature). Alternatively, implications of the prospect theory have also received support, mainly from Experimental and Behavioural Economics.

This paper's main contributions are to provide a unifying framework that nests these models of well-being, so that they can be tested against each other, and to abstract from a choice of the relevant AL in a longitudinal individual study.

Section 2 presents a more detailed description of these theories of well-being and discusses some of their main predictions. Section 3 describes the data used and a preliminary analysis of the happiness behaviour. Section 4 explains the empirical model chosen, together with the estimation procedure. Section 5 presents the results and section 6 summarises and concludes.

2 The well-being competing theories

2.1 The AL Theory

Is 12°C cold? Are 5 Kg heavy? Is a bonus of £1000 high? Immediately one realises that the answer to these and to so many other questions is "Depends". The main contribution of the AL theory of Helson (1948, 1964) is not so much having emphasized the relative judgement and perception of stimuli but, more importantly, to have dared to answer the questions of *how* it depends and on *what* it depends.

once some income threshold has been reached, income is no longer correlated with happiness.

[5]Even though their empirical results seem to suggest a weak relationship between income and happiness, the author are very conservative in their conclusions and do not emphasize this enough.

[6]One exception is Clark and Oswald (1996), which attempts to define the AL as the expected income of a homogeneous sample in terms of personal and demographic characteristics, which can be questioned.

The starting point of AL theory is to specify and acknowledge the existence of different points of indifference, which depend on the individual i, the current event of interest (or focal stimulus) X_t, the context and on the event history. This is what Helson calls the AL's and he defines each as a geometric weighted average of mean past focal stimuli $X_\tau, \tau = 1, \ldots, t$ and context factors. The latter are composed by a background stimulus B (representing the anchor or immediate standard of comparison to evaluate the current stimulus against) and by residual stimuli R_{it}, which include previous experience, individual judgemental differences, together with every piece of information brought forward by the particular event and it is, by its own nature, unknown to the observer. Formally,

$$AL_{it} = k \left(\left(\prod_{\tau=1}^{t} X_\tau \right)^{1/t} \right)^p B^q R_{it}^r, \tag{1}$$

where k is a constant, $p + q + r = 1$ are the weighting coefficients and can further be interpreted as the probability with which each component will be used in constructing the AL.

Events are then to be subjectively evaluated in light of the relevant AL. A recurrent specification (see Corso, 1971 for a critical appraisal of different specification proposals) describes the subjective perception of the event t, h_{it}, as the objective event adequately translated into psychological units and weighted by the AL, such as:

$$h_{it} = AL_{it} x_{it} \tag{2}$$

where x_{it} is recurrently defined as the deviation of X_t from a threshold. The nature of this threshold has been debated. Some argue it is the AL itself, others that it is just an exogenous anchor or standard of comparison. Given that Eq. 2 can be linearisable, and an exogenous threshold would be absorbed by the first term, more generally Eq. 2 can be written as

$$h_{it} = AL_{it} + v\left(X_t - f\left(AL_{it}\right)\right), \tag{3}$$

where $v(0) = 0$ and $v' \geq 0$[7]. A final remark on the stimuli used to construct the AL in Eq. 1. Even though one is lead to think these are solely previous

[7] To go from Eq. 2 to Eq. 3, clearly logs were applied. Given that one has abstracted from the physical units in this analysis, I dropped the logs from the latter equation to avoid heavy notation.

individual stimuli, this need not be so. In fact, interpersonal comparisons have also been proved to be important in well-being evaluations, so that X_j could represent a stimulus experienced by another individual to whom one evaluates himself against in any period. This concept, which was pioneered by Veblen (1899) in *The Theory of the Leisure Class: An Economic Study of Institutions*, and formalised by Duesenberry (1952), is also easily accommodated within the AL framework.

2.2 Implications for Well-Being - The Hedonic Treadmill Model

In most of the empirical applications testing for the validity of AL-theory, it has been found that, for a given anchor B and a repeated stimulus $X_t = X_{t+1} = X_{t+2} = \ldots$, h_{it} diminishes in magnitude. The fact that individuals adapt to a permanent or repeated stimulus is the only unambiguous prediction of the AL-theory.

Taking adaptation to its extreme, it implies that well-being does not respond at all to outcomes and that the AL shifts as to offset the impact of any change. This troubling idea was proposed by Brickman and Campbell (1971), where it establishes the existence of a set-point or treadmill of happiness, to which individuals tend to revert, after some temporary or transitory departure. This simply defines well-being as a function of two independent elements, an individual specific component R_i and a transient shock x_{it}, which represents the subjective evaluation of the stimulus. In their own words, the "nature of AL phenomena condemns men to live on a hedonic treadmill, to seek new levels of stimulation merely to maintain old levels of subjective pleasure, to never achieve any kind of permanent happiness or satisfaction. [...] subjective pleasure is [...] an ever-receding illusion".

Formally, this implies

$$h_{it} = x_{it} + R_i \tag{4}$$

The authors take it for granted that adaptation is complete. However, it is worth pointing out that the original theory does not imply this extreme behaviour, for a repeated stimulus. Further, even though individuals adapt to past stimuli, this by no means implies that their reaction to future disparities is small in magnitude. Even though it is more likely that the anchor shifts as to mitigate the impact of stimuli, empirical evidence has also witnessed an increased sensitisation towards a particular stimulus[8]. While these results might weaken the hedonic treadmill hypothesis, they are still compatible with the AL theory.

2.3 The Prospect Theory Model

Kahneman and Tversky (1979) develop a decision theory based on basic postulates on individual behaviour, in light of experimental results that have been refuting expected utility theory as an adequate approximation of individual choice behaviour. This theory was developed primarily for monetary decisions, but it can easily be extended to non-monetary outcomes. The hedonic value of a prospect $h(x, p; y, q)$ that yields outcome x with probability p and outcome y with probability q is a linear average of the subjective value of the relevant outcomes, so that

$$h(x, p; y, q) = \pi(p)\, v(x) + \pi(q)\, v(y), \tag{5}$$

where π is what the authors call a decision weight function and should not be interpreted as a proper probability[9].

For realised outcomes (wlg say x was realised), Eq. 5 boils down to $h(x, p; y, q) = v(x)$, which parallels the subjective outcome evaluation function already seen in Eq. 3. Indeed, the authors assume v to be a function of the magnitude of the outcome deviation from the AL (which they call Reference Point but it is to be interpreted similarly), that is concave for gains and convex for losses, even though being steeper for losses. This is already a simplification over the AL theory, where the sign of the second derivative of v is not well-established. In fact, most authors believe this sign can go both ways, depending on the magnitude of the deviation.

They further simplify the analysis in two ways. Firstly, they assume that the pre-event status is a sufficient statistic for the AL, so that $f(AL_{it}) = X_{t-1}$. Further, even though they acknowledge that the latter should enter as a term in h, leave it out in their formulation, arguing that "preference order [...] is not greatly

[8] Argyle (1999) also reviews that individuals do not adapt to a constant noise or to sexual stimuli.

[9] Actually, π is assumed to verify 3 assumptions:

$\pi(rp) < r\pi(p), \forall r \in]0, 1[$, for low p

$\pi(p) > p$, for low p

$\pi(p) + \pi(1-p) < 1, \forall p \in]0, 1[$

.

altered by small or even moderate variations in asset position. Moreover, this order seems to be similar for individuals within a large range of asset positions.". As such,

$$h_{it} = v\left(X_t - X_{t-1}\right) \tag{6}$$

3 Data Description

Before presenting the empirical model which will be used to test the competing theories discussed in the previous section, this section presents a description of the data set used to accommodate the data features into the model. A preliminary descriptive analysis will then be followed by a discussion of the autocovariance structure of happiness following Cappellari (2004). This section concludes with a suggestion of the lag structure of happiness.

3.1 Variable and Validity Discussion

The data used is the German Socio-Economic Panel (GSOEP), from 1984 up to 2002, hence comprising 19 waves. This panel was primarily founded to gather information on West German private households but was soon extended to include East Germany and an over-represented sample of immigrants. Among others, it provides data on household composition, biographical and background information, employment history and characteristics, earnings, time allocation and satisfaction indicators. Therefore, it is a very comprehensive study that focuses on a wide range of individual dimensions[10].

The main variable of this paper is the self-reported general satisfaction index, a discrete variable which can take 11 equidistant values, from 0 to 10. Table 1 presents some descriptive statistics that summarise the main features of this variable. Overall, the youngest group reports the higher satisfaction, but the decrease in satisfaction is not monotonic over the lifecycle. Men do seem to be happier, but gender differences ended up not being significant. Satisfaction does seem to be decreasing over time whereas tendentiously, it is the higher educational groups

[10] For more information, visit http://www.diw-berlin.de/english/sop. In this study, attention was restricted to the West German native sample, firstly because its time span is larger and, mainly, to keep a relatively homogeneous sample.

which report higher satisfaction (nevertheless, these differences could party be explained by income differences, which has not been controlled for here). Further, it is worth pointing out that a very small fraction of the respondents reports a satisfaction below 5, so that the average answer ends up over 7. Figures 1, 2 and 3 complement this analysis by decomposing the time evolution of satisfaction into different cohorts, controlling for region, educational level and gender respectively. Then it becomes clear that the older male cohorts was happier than the female one, which is driving male happiness upwards. The second youngest male cohort is the unhappiest among men while it is the youngest female cohort relatively worse off among women. Nevertheless, the overall decreasing pattern overtime subsides within cohorts also and are much more pronounced than in the pooled sample.

Broadly, interviewees were asked *at the end* of the questionnaire (at least for the west German sample), about their satisfaction with life in general, according to the following phrasing[11]:

> And finally, we would like to ask you about your satisfaction with your life in general. Please answer by using the following scale, in which 0 means totally unhappy, and 10 means totally happy.
>
> How happy are you at present with your life as a whole?

Relative benefits and caveats of self-reported, single-item measures of well-being have long been discussed in the literature (see e.g. Schwarz and Strack, 1999). Indeed, single item questions on satisfaction are simple, easy to understand and cost effective. On the other hand, they have long been considered as thin in content, not only when we compare these measures across different individuals or across time, but even as a reflection of individual true present state[12]. To make it explicit, the assumptions made in this paper to validate this measure as representative of individual happiness are[13]:

[11]Slight variations on the phrasing, visual aspect of the question or event the adjacent questions occur across waves. Tests and a more detailed discussion of these variations is discussed in appendix. All in all, these tests do suggest that these variations do not have a systematic impact on the individual responses.

[12]Nevertheless, these problems would be exacerbated with multiple-item measures. Current alternative proposals, reviewed in Larsen and Fredrickson (1999), are relatively costly to obtain or too cumbersome for the individuals.

[13]There are methodologies that only require assumptions A.1 and A.2 (see Ferrer-i-Carbonell

A.1 The happiness variable is increasing with true unobserved well-being

A.2 The happiness variable is temporally comparable within the individual sphere

A.3 The happiness variable is interpersonally comparable

A.4 Happiness and unhappiness are described by the same unobserved variable at 2 opposite poles

The fact that this question has been posed at the end of the questionnaire does uniformise the information used across individuals, because they have to recall information on areas such as health, pay, leisure, dwelling, politics, etc. before judging their subjective well-being. This might mitigate the impact of current individual concerns on the final response, as well as the on-the-spot randomness of an answer with such a broad scope such as this one. Further, the panel structure does allow for some correction of random moods. However, there is a further aspect that could mitigate the comparability of responses both across time and across people. What is 10? Is it the highest possible state one could ever feel himself in or the highest he has ever experienced? Is average happiness in the middle of the scale? Clearly there is room for different interpretations of the scale given[14].

Assumption 4 stems from the fact that the bipolar measure of well-being, rather than two different scales for unpleasant and pleasant components, might be a too oversimplified view of individual evaluation. Nevertheless, Kahneman (1999) discusses evidence supporting this bipolar or continuum index of happiness, further arguing that one can use a go-on or stop rule to evaluate the overall individual state.

3.2 The Autocovariance Structure

To model the lag structure of the happiness variable, I computed the sample covariance structure within cohort groups[15], controlling for calendar time. Then these covariances $\operatorname{cov}(h_{at}, h_{at-s})$ were regressed on cohort a, year t and size of

and Frijters, 2004). However, as analysed by those authors, the underlying methodology does not change the results significantly, as long as individual heterogeneity is dealt with.

[14]This is one of the main reasons why I chose a relatively culturally homogeneous sample, leaving out the immigrants and East-Germans.

[15]The cohort groups are the ones already defined in Table 1.

the covariance lag s dummies, following Cappellari (2004). Column (1) of table 2 presents the estimation results. Estimated coefficients on interval width are all negative and decline over lags. This decrease is sharper in the first lags and then decays slowly, which could be consistent both with an autoregressive process with a fixed component or with an ARMA process. To try and disentangle these two scenarios, the same procedure was undertaken, but now using the covariances of the residuals of a within-groups regression of happiness on individual dummies, so that these covariances are free of the fixed component. Column (2) of table 2 shows that the pattern repeats itself, which does suggest that an ARMA specification is more adequate. For parsimony reasons, I opted for an ARMA $(1, 1)$, so that the happiness variable would be adequately modelled as $h_{it} = \gamma h_{it-1} + \varepsilon_{it} + \theta\varepsilon_{it-1}$. The next section discusses the empirical model in more detail and the adjustments that were carried out to nest and test the competing theories.

4 Empirical Strategy

4.1 Empirical Model

In light of the discussion of the competing theories of well-being discussed in Section 2, an important term of the happiness function h_{it} is an individual intrinsic component μ_{i0}, which directly parallels the happiness treadmill or the average value to which individuals revert to after having adapted to transitory shocks (it represents R_i in Eq. 4). Another important ingredient is the happiness direct response to these transitory shocks ν_{it} and finally, there should be a "permanent" or structural component μ_{it} representing the mapping of the current AL onto the happiness domain. μ is allowed to be updated to reflect the fact that individual AL depends on the event history. Further taking into account the results of Section 3.2, which suggest happiness is well-represented by an ARMA $(1, 1)$, the empirical model chosen is described in Eq. 7.

Note that the transitory and systematic components are allowed to be correlated, if $\rho \neq 0$[16]. This is, as far as I know, the first paper that attempts to tackle

[16] This is actually why denoting the systematic part as the permanent component would be misleading. In the literature (see e.g. Gottschalk and Moffitt, 1993, or Meghir and Pistaferri, 2004), mainly analysing the variance structure of earnings, the permanent component is independent of the transitory component.

correlated structural and transitory components.

$$
\begin{aligned}
h_{i1} &= \mu_{i0} \\
h_{i2} &= \gamma\mu_{i0} + \varepsilon_{i2} \\
h_{it} &= \mu_{it} + \nu_{it}, \forall t \geq 2 \\
\mu_{it} &= \gamma\mu_{i,t-1} + \rho\epsilon_{i,t-1}, \forall t \geq 1 \\
\nu_{it} &= \theta\nu_{i,t-1} + \epsilon_{it}, \forall t \geq 2
\end{aligned} \tag{7}
$$

A further remark emphasizing the nature of this model needs to be made. Eq. 7 is already the happiness translation of events, so that no assumptions on the relevant events need to be made. Despite the caveats, this will allow one to abstract from a particular specification of the events and standards of comparison.

4.2 Restrictions on the Empirical Model

Given the empirical model in Eq. 7, each of the theories of well-being discussed imply a set of restrictions in the parameters γ, ρ and θ. A summary of these restrictions are presented in the first column of Table 3.

The Hedonic treadmill model assumes happiness fluctuates around a mean value and all shocks are transitory. Given the empirical model chosen, this is achieved by setting $\gamma = 1$ and $\rho = \theta = 0$, so that $h_{it} = \mu_{i0} + \varepsilon_{it}$.

On the other hand, if only deviations from the AL determine well-being, prospect theory implies $h_{it} = \varepsilon_{it}$ where, as mentioned before, ε is already the mapping of the subjective shock onto happiness. If the current state is however relevant, a milder version of this theory would imply $h_{it} = \mu_{it} + \varepsilon_{it}$, so that $\theta = 0$. Further, to account for decreasing marginal utilities (disutilities) of a positive (negative) event, ρ should be negative.

This last assumption, contrary to some misconceptions of the AL theory, is not required to support it. All one can say is that for a constant or repeated stimulus, the hedonic reaction to it decreases in magnitude over time. Eq. 8 shows the impact of an event occurred at time s.

$$
\begin{cases}
\frac{\partial h_{is}}{\partial \varepsilon_{is}} = 1 \\
\frac{\partial h_{is+k}}{\partial \varepsilon_{is}} = \gamma^{k-1}\rho + \theta^k, 1 \leq k \leq t-s
\end{cases} \tag{8}
$$

Hence, AL theory implies $\left|\gamma^{k-1}\rho + \theta^k\right| < \left|\gamma^{k-2}\rho + \theta^{k-1}\right| < 1, \forall 2 \leq k \leq t-s$.

4.3 Identification issues

When the model in Eq. 7 is estimated in its first moments, the systematic component cannot be disentangled from the transitory component and no parameter can be identified without further assumptions. The strategy adopted in this paper is to estimate the model in its corresponding second moments, i.e. variances of happiness and covariances of happiness within agegroups, controlling for calendar time. Full details will be explained in the next section. The crucial assumption to carry out the estimation is $\text{var}(\varepsilon_{at}) = \sigma^2_{\varepsilon a}, \forall t$, i.e, stationary event variances within each agegroup. This allows parameters to be locally identified.

5 Estimation Results

As mentioned in Section 4.3, the model in Eq. 7 is estimated in its second moments, using an Equally Weighted Minimum Distance (EWMD) estimator, following the work by Gottschalk and Moffitt (1993, 2002)[17]. Details on the estimation method and the data generating process assumed are presented in Appendix B.

The data consists of 754 observations, from which 76 are the variances of happiness averaged over each agegroup, for all years, $\text{var}(h_{at}), a = 1, \ldots, 4 \; t = 1, \ldots, 19$, and the remaining observations are all the possible within-individual covariances $\text{cov}(h_{at}, h_{at-s})$, again averaged over each agegroup a and for all time periods t , $a = 1, \ldots, 4$ and $t > s = 1, \ldots, 18$.

The model has 11 parameters (γ, ρ, θ, and the initial conditions $\sigma^2_{\epsilon a}$, $\text{var}(\mu_{0a})$, $\forall a = 1, \ldots, 4$). Over and above the restrictions summarised in Table 3, stationarity of γ and θ were imposed, as well as the nonnegativity of the variances[18]. Model restrictions are tested using the χ^2-test described in Chamberlain (1984). Results are presented in Table 4. Column (1) presents the unrestricted estimates whereas all the other columns present the restricted models already discussed and summarised in Table 3. $\hat{\rho}$ is significantly negative, which does suggest that the structural happiness component "gets used" to good or to bad shocks. In fact, the models where it was restricted to be zero end up being rejected by the data.

[17] Given the discussion in Abowd and Card (1989) over the relative benefits of using the Optimal Minimum Distance Estimator (OMD), I chose not to use the inverse of the covariance matrix of the first stage residuals.

[18] To limit the parameter space, variances were also constrained to be smaller than 4.

The structural component does play a role, given that $\hat{\gamma}$ is statistically relevant and high. Furthermore, there seems to be a positive correlation between events, as given by $\hat{\theta}$, event though Column (4) estimates suggest this might in fact be zero. Even though this result might seem surprising, it can however indicate that individuals do a pretty good job in absorbing information so that events do not seem to have a systematic impact on happiness. Finally, it is worth pointing out that the systematic component is being updated so that it would be insufficient to have modelled it as a pure permanent component, orthogonal to the transitory component. All in all, both the mild version of the prospect theory and the hedonic adaptation models are supported by the data, even though the latter has a marginally better fit. Nevertheless, this suggest that the oversimplification of Kahnemann and Tversky (1979), in excluding the AL as a relevant argument from the happiness function, is not supported by these data.

5.1 Including Covariates

In the previous section, I only condition the variance and covariance behaviour of happiness on calendar time and agegroup. This section provides a way to conditioning on more “mean-shifters”. It basically follows the approach suggested in Abowd and Card (1989), where OLS residuals will be used to represent the individual specific happiness and the happiness-relevant events, which are net of mean-shifters that could be blurring inter-individual comparisons.

The main issues here are to choose those covariates that cannot be considered “events” and to keep individual effects. The first issue is solved by considering only time-invariant covariates. The second issue is more problematic because, by not controlling for individual specific effects, these might bias the results, mainly given the potential correlation with the initial conditions (see Meghir and Pistaferri, 2004, for a discussion). Still, Table 5 presents the OLS results of a regression of the happiness variable on gender, time, year of birth, education and regional dummies. These results are merely illustrative given that there are important factors that have not been included in the regression for varying over time. As already seen in Section 3.1, happiness differs across time, cohort, regional and educational groups, but it does not differ significantly across gender. There is a decreasing satisfaction trend over time, even though younger cohorts seem relatively happier. Contrary to most empirical studies (e.g. Clark and Oswald, 1996), education ends up having a positive impact on happiness, even though here income is again not controlled for.

Table 6 has the EWMD estimates of this exercise. Surprisingly, the parameter values do not change considerably, which is an indication that the model specification is adequate. Same conclusions as discussed in Section 5 apply, so that the hedonic adaptation model is still marginally superior to the prospect theory estimates of the milder model.

5.2 Conditioning on Individual Effects

5.2.1 Eliminating Fixed-Effects

To provide more empirical support to the structure assumed throughout this paper, within-groups residuals were used to replicate the happiness second moments. The motivation for this exercise is that by eliminating the individual specific component, the parameter γ associated with it should become smaller (actually, it should be statistically insignificant if unobserved heterogeneity is all that is being captured by it). Further, it provides a way to check what the impact of the potential correlation between the initial conditions and these fixed-effects is. Table 7 shows the results obtained. To put it shortly, every sign of the main 3 parameters changes but in essence, the estimates still support and rationalise the same cognitive processes. Indeed, $\hat{\gamma}$ does change considerably, becoming much smaller in magnitude, albeit negative. The fact that $\hat{\rho}$ becomes positive still suggests the same adaptation process, where the structural component is downgraded by a negative γ and information piles up by a positive ρ. Now all models apart from the hedonic treadmill model receive some empirical support, but the hedonic adaptation model now clearly outperforms all others. In fact, the unrestricted estimates end up satisfying the conditions imposed by it. The fact that the prospect theory model, where the only relevant factor are deviations from the AL, is supported by these data does suggest that the intrinsic individual happiness component is crucial in determining one's AL. This has already been found in the literature (e.g. Ferrer-i-Carbonell and Frijters, 2004) and explains why models that do not account for these yield so different estimates.

5.2.2 Eliminating Gaussian Random-Effects

One additional problem of this approach is that by allowing the structural and the transitory components to be correlated, one cannot disentangle the latter from measurement error. Assuming that measurement error is white noise and normally distributed, performing individual random-effects and using the residuals of this regression would control for this measurement error. Results are in Table 8, and they parallel the ones obtained in Section 5.2.1. In conclusion, even though the point estimates do vary considerably whether one controls for individual effects, the hedonic adaptation model seems superior to all others.

6 Summary and Conclusions

This paper attempts to compare and test prominent well-being theories put forward in the Psychology literature. It does so by proposing an empirical model that nests their main features and estimating it. Results suggest that the hedonic adaptation model is superior to all of its other simplifications, even though a prospect theory model, which takes into account the current or structural component of happiness, was proved to be a good alternative. To abstract from the choice of a relevant event or the relevant factors in determining individual AL, this paper has hinged on a few stringent untestable assumptions. Future research should nevertheless try to relax these by estimating, not just *how* people build happiness, which was the goal of this paper, but *what* makes people happy.

Table 1: The general satisfaction variable across age, gender, time, region and education groups.

agegroup$^{(*)}$ +	Obs	Mean	Standard Deviation	1st Decile	Median	9th Decile
1	23018	7.270354	1.742424	5	8	9
2	25704	7.189737	1.720903	5	8	9
3	21463	7.102502	1.799814	5	7	9
4	28749	7.142475	1.879570	5	8	9
$^{(*)}$Agegroup 1 age in [20,29[; agegroup 2 in [30,39[; agegroup 3 in [40,49[; agegroup 4 in [50,65] respectively						
sex +						
Male	59150	7.185833	1.806575	5	8	9
Female	64455	7.169389	1.876516	5	8	9
region +						
Berlin	2932	6.903820	1.931873	5	7	9
Schleswig-Holstein	3571	7.327919	1.944828	5	8	10
Hamburg	1846	7.001625	2.048331	4	7	9
Lower Saxony	11330	7.070697	1.929977	5	7	9
Bremen	1182	7.266497	2.267663	5	8	10
North Rhine-Westphalia	25602	7.195024	1.818352	5	8	9
Hesse	8467	7.296445	1.915099	5	8	10
Rhinel.-Palatinate, Saarl.	7790	7.255456	1.864509	5	8	9
Baden-Wuerttemberg	14189	7.091479	1.815753	5	7	9
Bavaria	17359	7.107207	1.856617	5	7	9
year +						
1984	8557	7.448639	2.088468	5	8	10
1988	7062	7.048287	1.953377	5	7	9
1992	6393	7.301580	1.704305	5	8	9
1996	6073	7.124815	1.759193	5	7	9
2000	5536	7.047688	1.736031	5	7	9
2002	5561	6.937242	1.761759	5	7	9
education +						
Secondary School	66617	7.078058	1.931517	5	7	9
Intermediate School	28512	7.319725	1.712771	5	8	9
Technical School	5574	7.217797	1.754111	5	8	9
Upper Secondary	16533	7.341801	1.635143	5	8	9
Other	1051	6.896289	2.010850	5	7	9
No Degree, Dropout	3410	7.132258	2.016459	5	8	9
In School	703	7.650071	1.557043	5	8	9
Total	123605	7.177258	1.843388	5	8	9

+ Kruskal-Wallis rank sum tests indicate that only gender differences in satisfaction are negligible. Results available upon request.

Table 2: Autocovariance structure

	OLS (1)		Within-Group (2)	
cohort2	0.177	(0.046)	0.041	(0.016)
cohort3	0.341	(0.045)	0.054	(0.017)
cohort4	0.479	(0.053)	0.043	(0.018)
year2	0.665	(0.099)	-0.013	(0.032)
year3	0.630	(0.089)	-0.015	(0.029)
year4	0.764	(0.089)	-0.012	(0.031)
year5	0.822	(0.090)	-0.016	(0.030)
year6	0.863	(0.092)	-0.003	(0.030)
year7	0.699	(0.074)	0.004	(0.029)
year8	0.724	(0.072)	-0.001	(0.030)
year9	0.740	(0.070)	0.000	(0.034)
year10	0.885	(0.082)	0.051	(0.032)
year11	0.923	(0.085)	0.016	(0.034)
year12	0.951	(0.085)	0.025	(0.037)
year13	0.986	(0.088)	0.056	(0.040)
year14	1.031	(0.090)	0.044	(0.041)
year15	0.997	(0.093)	0.064	(0.062)
year16	0.999	(0.120)	-0.020	(0.065)
year17	1.169	(0.127)	-0.003	(0.075)
year18	1.269	(0.195)	-0.126	(0.102)
year19	1.897	(0.469)	-0.326	(0.144)
lag1	-0.688	(0.085)	-1.425	(0.044)
lag2	-0.858	(0.082)	-1.578	(0.043)
lag3	-0.931	(0.080)	-1.657	(0.043)
lag4	-0.991	(0.080)	-1.714	(0.047)
lag5	-1.040	(0.081)	-1.782	(0.045)
lag6	-1.073	(0.084)	-1.802	(0.046)
lag7	-1.106	(0.082)	-1.844	(0.047)
lag8	-1.129	(0.086)	-1.866	(0.047)
lag9	-1.134	(0.083)	-1.887	(0.048)
lag10	-1.137	(0.085)	-1.915	(0.050)
lag11	-1.149	(0.093)	-1.933	(0.051)
lag12	-1.134	(0.097)	-1.941	(0.051)
lag13	-1.133	(0.105)	-1.956	(0.050)
lag14	-1.115	(0.109)	-1.980	(0.063)
lag15	-0.994	(0.133)	-1.924	(0.063)
lag16	-0.850	(0.150)	-1.980	(0.053)
lag17	-0.702	(0.205)	-2.057	(0.080)
lag18	0.075	(0.475)	-2.006	(0.074)
cons	1.283	(0.050)	1.585	(0.057)

Robust standard errors in parentheses

Table 3: Predictions of the Competing Theories of Well-Being

	Restrictions on parameters
Hedonic Treadmill Model	$\rho = \theta = 0$ and $\gamma = 1$ (2*)
Prospect Theory	$(\rho = \theta = \gamma = 0)$ (3*) or $(\theta = 0$ and $\rho < 0)$ (4*)
AL Model	$\lvert\gamma^k \rho + \theta^{k+1}\rvert < \lvert\gamma^{k-1}\rho + \theta^k\rvert < \lvert\rho + \theta\rvert < 1$ (5*)

* these will be the column numbers in Tables 4, 6, 7 and 8, where the corresponding models will be tested for.

Table 4: MDE Results controlling for age and calendar year

	Unrestricted Model	Hedonic Treadmill Model	Prospect Theory		AL Theory
	(1)	(2)	(3)	(4)	(5)
ρ	-0.255417	0	0	-0.265962	-0.263230
	(0.000001)	(—)	(—)	(0.000001)	(0.006512)
θ	0.042728	0	0	0	0.012139
	(0.000004)	(—)	(—)	(—)	(0.028907)
γ	0.955925	1	0	0.953989	0.954446
	(0.000000)	(—)	(—)	(0.000003)	(0.001181)
$\sigma^2_{\epsilon 1}$	1.508971	1.902883	2.878268	1.444888	1.462709
	(0.000019)	(0.000000)	(0.000003)	(0.000056)	(0.040015)
$\sigma^2_{\epsilon 2}$	1.415033	1.665667	2.867337	1.360240	1.375740
	(0.000007)	(0.000000)	(0.000000)	(0.000039)	(0.036234)
$\sigma^2_{\epsilon 3}$	1.585886	1.741305	3.113677	1.527878	1.544430
	(0.000013)	(0.000000)	(0.000004)	(0.000029)	(0.040700)
$\sigma^2_{\epsilon 4}$	1.616635	1.883664	3.383036	1.551736	1.570007
	(0.000018)	(0.000000)	(0.000006)	(0.000026)	(0.040369)
V (μ_{01})	1.682171	0.975381	3.854129	1.699390	1.695850
	(0.000001)	(0.000000)	(0.000013)	(0.000001)	(0.009151)
V (μ_{02})	2.048869	1.201671	4	2.073488	2.068173
	(0.000003)	(0.000000)	(0.301489)	(0.000016)	(0.014730)
V (μ_{03})	2.295466	1.372376	3.765784	2.321133	2.315606
	(0.000010)	(0.000000)	(0.000005)	(0.000081)	(0.016460)
V (μ_{04})	2.561622	1.499366	4	2.595352	2.587947
	(0.000005)	(0.000001)	(0.718720)	(0.000007)	(0.019116)
Obj. function	49.7998	92.8182	1132.80	49.9912	49.8978
χ^2	—	43.0184	1083.00	0.1914	0.0980
5% cv	—	7.8147	7.81	5.9915	7.8147*

Note: asymptotic standard errors in parentheses.
* The matrix of restrictions is full rank as long as $\rho \neq 0$, and θ and γ not simultaneously equal to 1.

Table 5: OLS Results

covariate	coef.	covariate	coef.	covariate	coef.
sex	-0.007	ybirth1915	0.152*	ybirth1958	0.272***
year1985	-0.201***	ybirth1916	0.282***	ybirth1959	0.382***
year1986	-0.135***	ybirth1917	0.401***	ybirth1960	0.386***
year1987	-0.334***	ybirth1918	0.136	ybirth1961	0.346***
year1988	-0.412***	ybirth1919	0.700***	ybirth1962	0.541***
year1989	-0.398***	ybirth1920	0.189**	ybirth1963	0.422***
year1990	-0.176***	ybirth1921	0.627***	ybirth1964	0.367***
year1991	-0.083**	ybirth1922	0.730***	ybirth1965	0.473***
year1992	-0.198***	ybirth1923	0.447***	ybirth1966	0.383***
year1993	-0.275***	ybirth1924	0.710***	ybirth1967	0.585***
year1994	-0.391***	ybirth1925	0.663***	ybirth1968	0.616***
year1995	-0.459***	ybirth1926	0.604***	ybirth1969	0.663***
year1996	-0.406***	ybirth1927	0.454***	ybirth1970	0.868***
year1997	-0.543***	ybirth1928	0.465***	ybirth1971	0.823***
year1998	-0.482***	ybirth1929	0.929***	ybirth1972	0.844***
year1999	-0.479***	ybirth1930	0.339***	ybirth1973	0.654***
year2000	-0.523***	ybirth1931	0.339***	ybirth1974	0.655***
year2001	-0.433***	ybirth1932	0.340***	ybirth1975	0.754***
year2002	-0.627***	ybirth1933	0.353***	ybirth1976	0.832***
ybirth1888	-1.786***	ybirth1934	0.430***	ybirth1977	0.762***
ybirth1892	-0.954	ybirth1935	0.295***	ybirth1978	1.127***
ybirth1893	0.165	ybirth1936	0.604***	ybirth1979	0.533***
ybirth1894	0.483	ybirth1937	0.334***	ybirth1980	0.964***
ybirth1895	-0.454	ybirth1938	0.380***	ybirth1981	0.986***
ybirth1896	0.681*	ybirth1939	0.440***	ybirth1982	0.477***
ybirth1897	1.447***	ybirth1940	0.406***	ybirth1983	0.643***
ybirth1898	1.255**	ybirth1941	0.556***	ybirth1984	0.833***
ybirth1899	-0.070	ybirth1942	0.455***	ybirth1985	1.180***
ybirth1900	-0.309	ybirth1943	0.320***	Schleswig-Holstein	0.463***
ybirth1901	-0.333	ybirth1944	0.228***	Hamburg	0.063
ybirth1902	-0.132	ybirth1945	0.620***	Lower Saxony	0.212***
ybirth1903	0.014	ybirth1946	0.415***	Bremen	0.337***
ybirth1904	0.467***	ybirth1947	0.401***	North Rhine-Westphalia	0.314***
ybirth1905	0.514***	ybirth1948	0.486***	Hesse	0.410***
ybirth1906	0.159	ybirth1949	0.497***	Rhinel.-Palatinate, Saarl.	0.320***
ybirth1907	0.352***	ybirth1950	0.302***	Baden-Wuerttemberg	0.180***
ybirth1908	0.389***	ybirth1951	0.261***	Bavaria	0.219***
ybirth1909	-0.011	ybirth1952	0.414***	Secondary School	0.386***
ybirth1910	0.567***	ybirth1953	0.312***	Intermediate School	0.664***
ybirth1911	0.281***	ybirth1954	0.448***	Technical School	0.573***
ybirth1912	0.290***	ybirth1955	0.413***	Upper Secondary	0.658***
ybirth1913	0.501***	ybirth1956	0.199***	Other Degree	0.121
ybirth1914	0.458***	ybirth1957	0.574***	In School	0.839***
				cons	6.300***

Note: The reference gender is men, reference region is Berlin and the reference educational group is no degree.
*** Statistically significant at 1%.
** Statistically significant at 5%.
* Statistically significant at 10%.

Table 6: MDE Results controlling for time-invariant mean-shifters

	Unrestricted Model	Hedonic Treadmill Model	Prospect Theory		AL Theory
	(1)	(2)	(3)	(4)	(5)
ρ	-0.258829	0	0	-0.265998	-0.262724
	(0.000000)	(—)	(—)	(0.000001)	(0.003169)
θ	0.027971	0	0	0	0.013323
	(0.000002)	(—)	(—)	(—)	(0.013779)
γ	0.950701	1	0	0.949385	0.949963
	(0.000000)	(—)	(—)	(0.000000)	(0.000590)
$\sigma^2_{\epsilon 1}$	1.547892	1.925098	2.875374	1.503767	1.524588
	(0.000002)	(0.000009)	(0.000001)	(0.000001)	(0.020215)
$\sigma^2_{\epsilon 2}$	1.408309	1.638270	2.790726	1.371438	1.388938
	(0.000004)	(0.000006)	(0.000009)	(0.000000)	(0.017727)
$\sigma^2_{\epsilon 3}$	1.513150	1.721667	3.001039	1.474774	1.493028
	(0.000004)	(0.000003)	(0.000001)	(0.000001)	(0.018973)
$\sigma^2_{\epsilon 4}$	1.612166	1.888909	3.320871	1.568448	1.589171
	(0.000003)	(0.000003)	(0.000003)	(0.000001)	(0.019848)
V (μ_{01})	1.736722	0.950282	3.808635	1.748246	1.743471
	(0.000002)	(0.000001)	(0.000017)	(0.000005)	(0.004755)
V (μ_{02})	2.086531	1.152442	4.000000	2.103185	2.096141
	(0.000004)	(0.000001)	(0.279178)	(0.000007)	(0.007567)
V (μ_{03})	2.301945	1.279374	3.733966	2.320083	2.312417
	(0.000002)	(0.000000)	(0.000021)	(0.000006)	(0.008512)
V (μ_{04})	2.606341	1.431955	4.000000	2.629140	2.619420
	(0.000002)	(0.000001)	(0.664189)	(0.000008)	(0.009757)
Obj. function	50.9231	97.0414	1034.72	51.0052	50.9456
χ^2	—	46.1183	983.79	0.0820	0.0225
5% cv	—	7.8147	7.81	5.9915	7.8147*

Note: asymptotic standard errors in parentheses.
* The matrix of restrictions is full rank as long as $\rho \neq 0$, and θ and γ not simultaneously equal to 1.

Table 7: MDE Results controlling for time-invariant mean-shifters and individual specific effects

	Unrestricted Model	Hedonic Treadmill Model	Prospect Theory		AL Theory
	(1)	(2)	(3)	(4)	(5)
ρ	0.371265 (0.000008)	0 (—)	0 (—)	0.000000 (0.124713)	0.371272 (0.000010)
θ	-0.268510 (0.000017)	0 (—)	0 (—)	0 (—)	-0.268512 (0.000014)
γ	-0.004161 (0.000003)	1 (—)	0 (—)	0.192554 (0.010784)	-0.004181 (0.000012)
$\sigma^2_{\epsilon 1}$	1.898448 (0.000050)	1.583567 (0.171338)	1.583562 (0.000003)	1.578783 (0.000553)	1.898451 (0.000037)
$\sigma^2_{\epsilon 2}$	1.820959 (0.000042)	1.504347 (0.117655)	1.504352 (0.000002)	1.499399 (0.000558)	1.820977 (0.000046)
$\sigma^2_{\epsilon 3}$	1.861750 (0.000046)	1.530029 (0.105719)	1.530030 (0.000001)	1.525778 (0.000481)	1.861750 (0.000031)
$\sigma^2_{\epsilon 4}$	2.022223 (0.000038)	1.665239 (0.122683)	1.665234 (0.000003)	1.660432 (0.000547)	2.022230 (0.000029)
V (μ_{01})	2.244955 (0.000052)	0.000000 (0.171340)	2.246065 (0.000011)	2.233411 (0.003440)	2.245003 (0.000002)
V (μ_{02})	2.356088 (0.000079)	0.000000 (0.117648)	2.356979 (0.000015)	2.321634 (0.003712)	2.356133 (0.000030)
V (μ_{03})	1.979927 (0.000008)	0.000000 (0.105719)	1.981500 (0.000012)	1.990608 (0.002918)	1.979936 (0.000008)
V (μ_{04})	2.277203 (0.000012)	0.000000 (0.122691)	2.277935 (0.000018)	2.245981 (0.003372)	2.277202 (0.000010)
Obj. function	46.9309	70.4565	50.7410	50.2985	46.9309
χ^2	—	23.5256	3.8101	3.3675	0.0000
5% cv	—	7.8147	7.8147	5.9915	7.8147*

Note: asymptotic standard errors in parentheses.
* The matrix of restrictions is full rank as long as $\rho \neq 0$, and θ and γ not simultaneously equal to 1.

Table 8: MDE Results controlling for time-invariant mean-shifters and gaussian random disturbances

	Unrestricted Model	Hedonic Treadmill Model	Prospect Theory		AL Theory
	(1)	(2)	(3)	(4)	(5)
ρ	0.369735	0	0	0.000000	0.369734
	(0.000002)	(—)	(—)	(0.131837)	(0.000003)
θ	-0.262093	0	0	0	-0.262089
	(0.000006)	(—)	(—)	(—)	(0.000004)
γ	0.018092	1	0	0.203191	0.018102
	(0.000004)	(—)	(—)	(0.011877)	(0.000002)
$\sigma^2_{\epsilon 1}$	1.919048	1.617597	1.617602	1.611883	1.919039
	(0.000019)	(0.167238)	(0.000005)	(0.000686)	(0.000017)
$\sigma^2_{\epsilon 2}$	1.838180	1.532327	1.532330	1.526311	1.838180
	(0.000007)	(0.107056)	(0.000003)	(0.000722)	(0.000013)
$\sigma^2_{\epsilon 3}$	1.866134	1.548011	1.548016	1.542858	1.866132
	(0.000011)	(0.097707)	(0.000005)	(0.000619)	(0.000014)
$\sigma^2_{\epsilon 4}$	2.026284	1.683870	1.683875	1.678004	2.026285
	(0.000005)	(0.111115)	(0.000006)	(0.000704)	(0.000012)
V (μ_{01})	2.408860	0.000000	2.404389	2.388478	2.408863
	(0.000085)	(0.167238)	(0.000006)	(0.004221)	(0.000084)
V (μ_{02})	2.562220	0.000000	2.559027	2.514849	2.562216
	(0.000026)	(0.107056)	(0.000006)	(0.004681)	(0.000020)
V (μ_{03})	2.156282	0.000000	2.149761	2.154314	2.156295
	(0.000011)	(0.097707)	(0.000013)	(0.003693)	(0.000021)
V (μ_{04})	2.483736	0.000000	2.480118	2.452356	2.483690
	(0.000041)	(0.111115)	(0.000014)	(0.004314)	(0.000007)
Obj. function	45.1046	72.5591	49.4568	48.8597	45.1046
χ^2	—	27.4544	4.3522	3.7550	0.0000
5% cv	—	7.8147	7.8147	5.9915	7.8147*

Note: asymptotic standard errors in parentheses.
* The matrix of restrictions is full rank as long as $\rho \neq 0$, and θ and γ not simultaneously equal to 1.

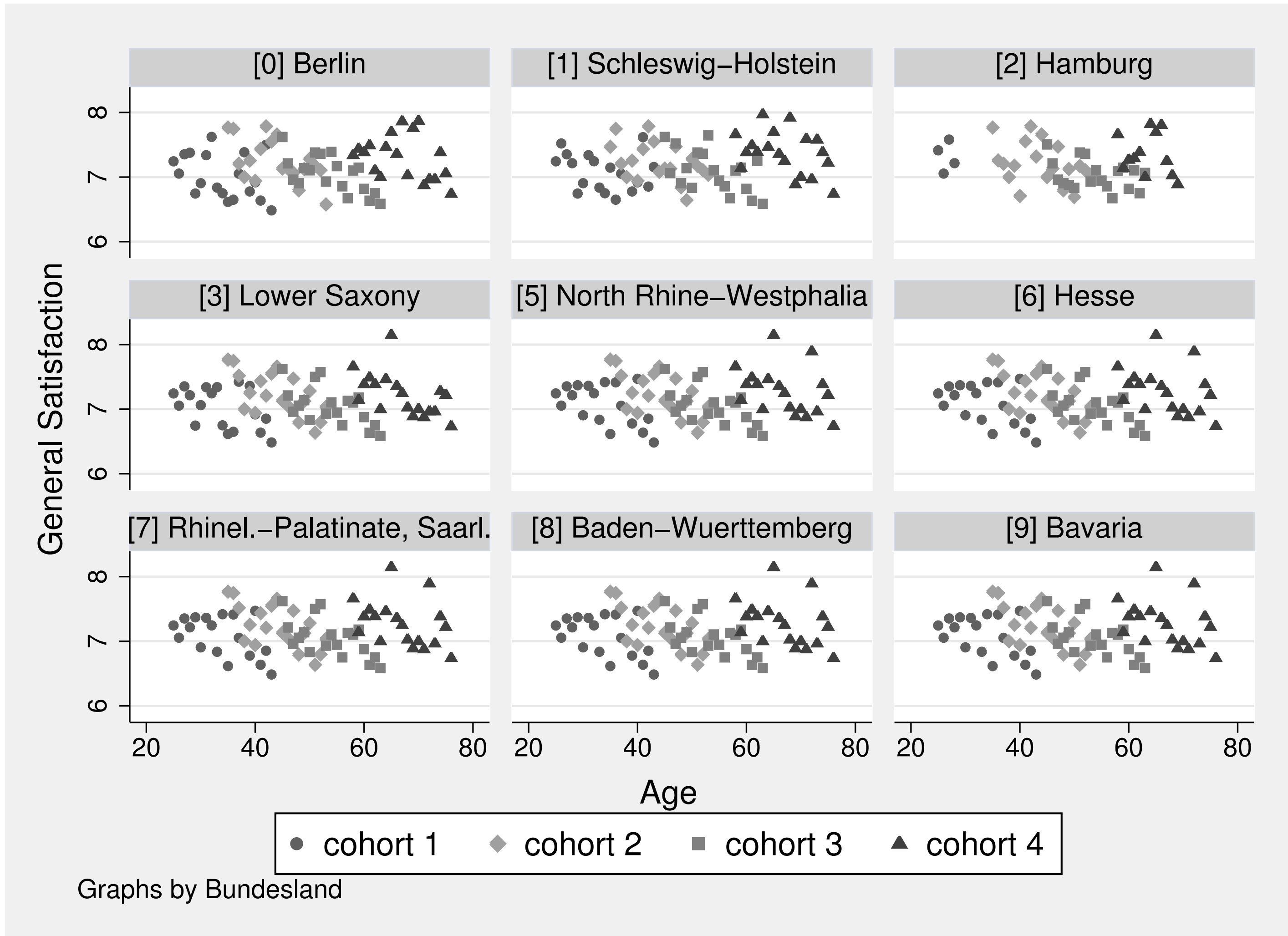

Figure 1: Satisfaction cohort evolution: conditioning on *Bundesland*

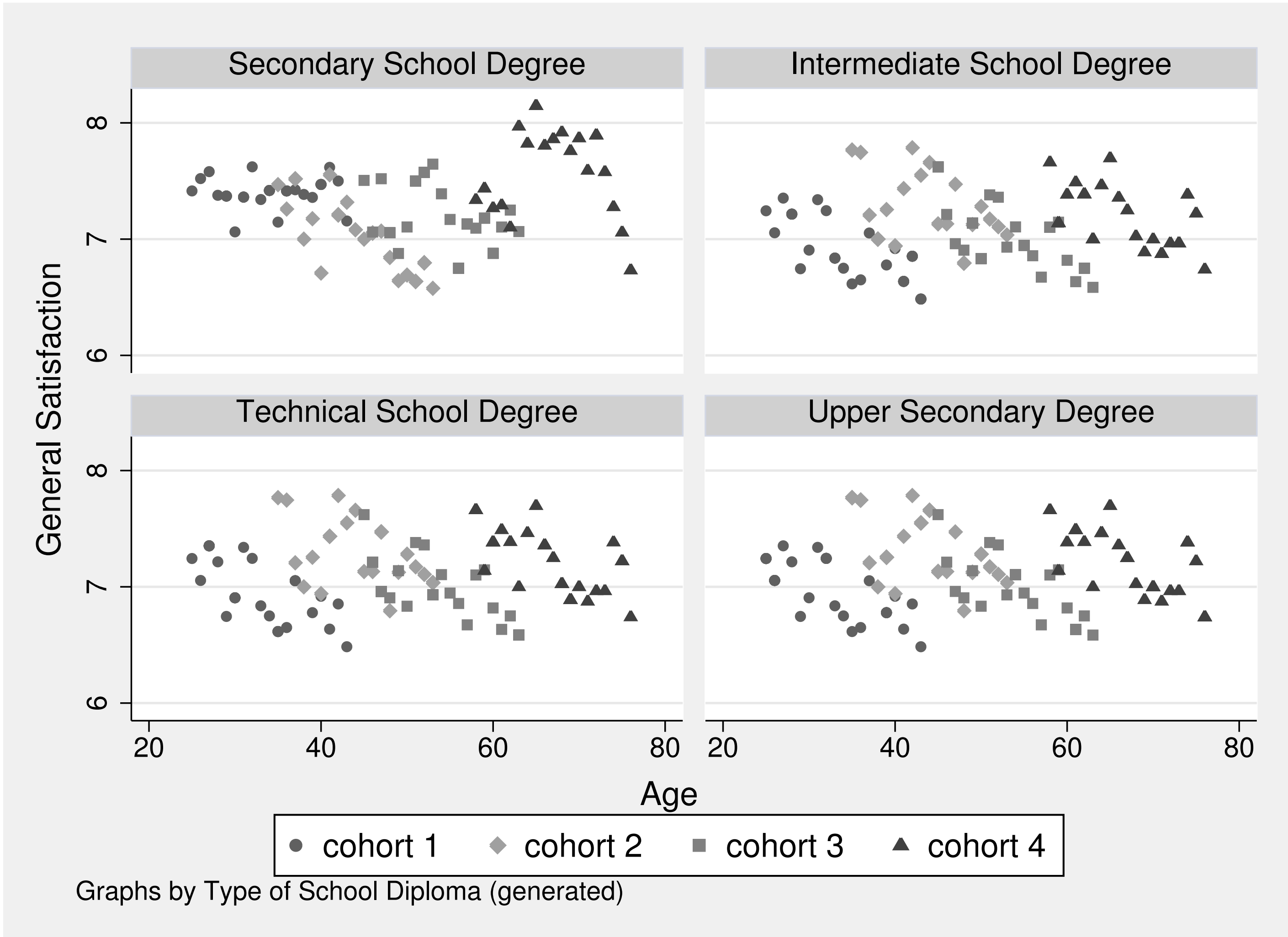

Figure 2: Satisfaction cohort evolution: conditioning on educational degree

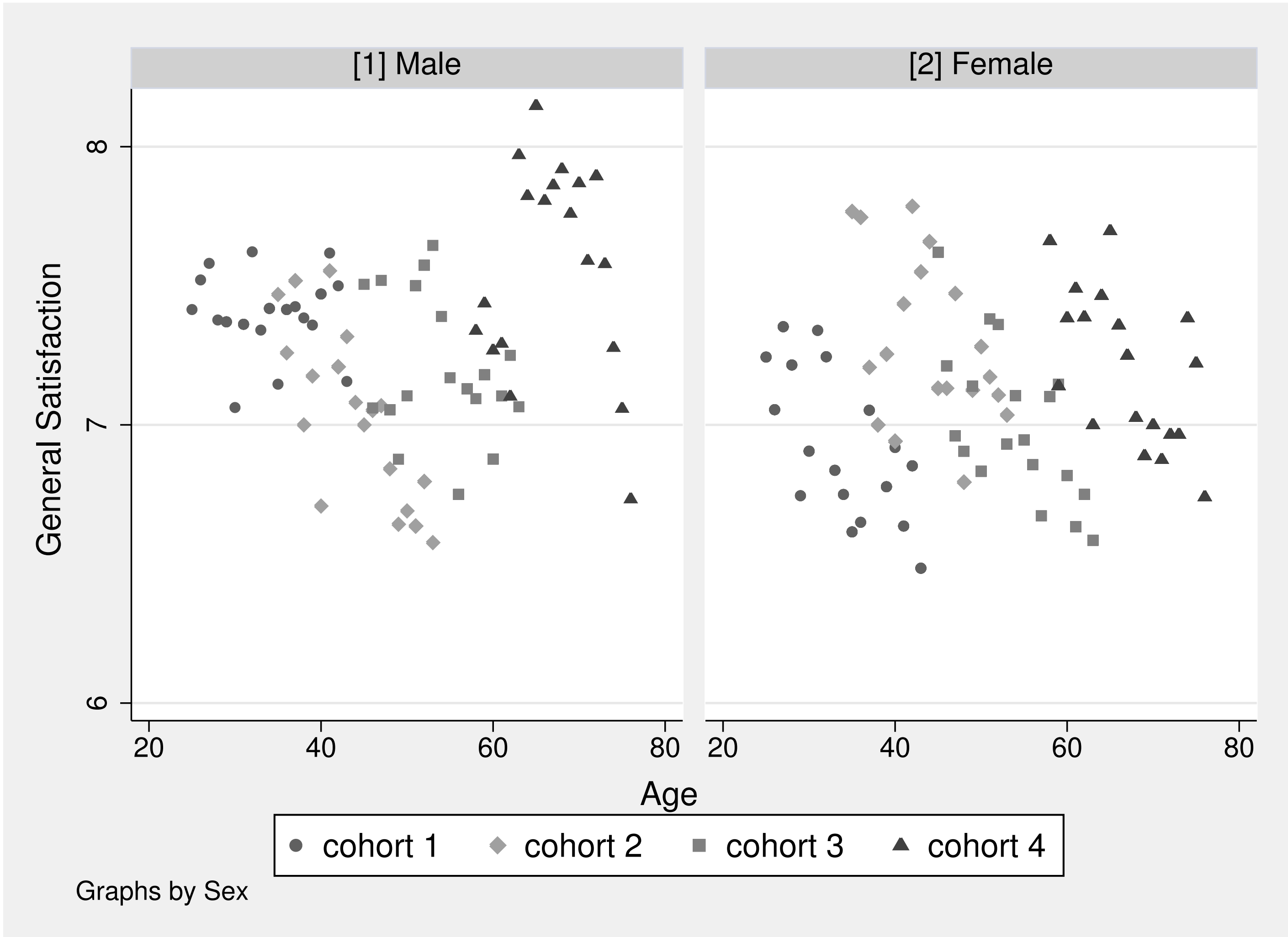

Figure 3: Satisfaction cohort evolution: conditioning on gender

A General Satisfaction Variable - Response impact of Variations in the question of interest

The exact phrasing of the relevant question, from 1985 up to 1997, was:

> And finally, we would like to ask you about your satisfaction with your life in general. Please answer by using the following scale, in which 0 means totally unhappy, and 10 means totally happy.
>
> How happy are you at present with your life as a whole?

For the other waves, words such as "as a whole" were replaced by "all things considered", or "And finally" by "At the end" or "In conclusion". The layout of the question or the adjacent questions did vary across questionnaires. In 1998, 2000 and 2002 samples, the question resorted to a graphical scale so that individuals could visually realise where they were situating themselves in the scale. Further, in the first four waves, individuals were being asked, after satisfaction with current life, about their satisfaction with life one year ago and subsequently, with life in one year's time. Then, from 1991 onwards, they were asked about their lives five years from then (in 2000, they were further asked to choose a graph representing the evolution of their well-being over the last 10 years). If individuals do read these subsequent questions in advance, requiring them to recall their life one year or five years ago might change the mental construals they invoke in their evaluation (see Schwarz and Strack, 1999, for an extensive discussion of these and other cognitive processes underlying reports of happiness). Table 9 shows the results of the mean comparison tests of the subsamples associated with each precise formulation of the question and indeed, for most age levels, phrasing, visual scales or the adjacent questions do not seem to matter.

Finally, not all interviews were carried out orally, some were just partially verbal. In face-to-face interviews, it is more likely that respondents may reveal a satisfaction level different from their judgement due to self-presentation or social desirability concerns, which would weaken the quality of the data. However, within-groups estimation of the impact of the survey instrument on the variable of interest, controlling for year and age, reveal that this too seems to be innocuous[19]. Table 10 shows the p-values of the survey instrument dummies, where interviews by telephone was the omitted category.

B Estimation Method

Let h_{it} be the happiness data of individual i at time t, whether this is the self-reported measure directly taken from the GSOEP, or the OLS residual of individual i at time t, $\forall i = 1, \ldots, N$ and $\forall t = 1, \ldots, 19$. The data modelled in this paper is however the variances and covariances associated with the happiness data. Hence, let $\mathrm{V}(h_{at})$ be the variance of happiness of cohort a at time t, computed as $\frac{\sum_{i \in a}\left(h_{it} - \bar{h_{at}}\right)^2}{N_{at}}$, and let $\mathrm{cov}(h_{at}, h_{at-s})$ be the average cohort

[19] Chose within-groups to account for the potential self-selection into type of interview.

Table 9: Do changes in the relevant question matter? A few tests and descriptives

		H_a :	Adjacent Questions matter		Phrasing matters		Visual Scales matter	
Age	Mean	SD	t-student	p-value	t-student	p-value	t-student	p-value
20	7.219	1.849	0.345	0.730	-0.257	0.797	0.569	0.570
21	7.245	1.826	-1.721	0.086	-0.043	0.965	-0.309	0.758
22	7.252	1.770	-0.036	0.971	-0.893	0.372	-0.693	0.489
23	7.243	1.765	-1.401	0.162	-0.038	0.970	-0.176	0.861
24	7.262	1.770	0.057	0.955	-0.404	0.686	-0.836	0.404
25	7.338	1.711	0.589	0.556	0.480	0.631	0.007	0.995
26	7.296	1.721	0.191	0.849	-0.501	0.616	0.090	0.928
27	7.250	1.682	-0.892	0.373	-0.604	0.546	-0.375	0.708
28	7.270	1.688	0.407	0.684	-0.310	0.756	-1.007	0.315
29	7.306	1.693	-0.608	0.543	-3.590	0.000	0.792	0.429
30	7.274	1.669	2.198	0.028	-1.111	0.267	-1.482	0.139
31	7.231	1.717	1.575	0.116	-2.068	0.039	1.466	0.143
32	7.211	1.728	0.158	0.875	-1.553	0.121	0.038	0.970
33	7.212	1.705	0.435	0.664	-2.212	0.027	0.103	0.918
34	7.158	1.743	2.047	0.041	-0.445	0.657	-1.742	0.082
35	7.162	1.744	2.157	0.031	-1.044	0.297	-0.198	0.843
36	7.157	1.715	1.108	0.268	-1.369	0.171	0.264	0.792
37	7.176	1.741	2.336	0.020	-0.293	0.770	-1.244	0.214
38	7.144	1.728	2.040	0.042	1.017	0.309	-2.673	0.008
39	7.154	1.721	0.432	0.666	0.169	0.866	-1.837	0.067
40	7.138	1.737	3.151	0.002	-0.572	0.567	-1.552	0.121
41	7.110	1.796	1.432	0.153	0.620	0.536	-1.759	0.079
42	7.120	1.762	2.298	0.022	1.075	0.282	-4.455	0.000
43	7.120	1.780	3.270	0.001	0.471	0.637	-2.345	0.019
44	7.099	1.810	3.653	0.000	0.502	0.616	-3.367	0.001
45	7.105	1.784	4.433	0.000	0.248	0.804	-1.185	0.236
46	7.038	1.845	3.041	0.002	1.441	0.150	-2.696	0.007
47	7.101	1.832	2.429	0.015	0.690	0.490	-2.057	0.040
48	7.119	1.811	3.018	0.003	0.581	0.561	-2.006	0.046
49	7.072	1.847	1.970	0.049	0.972	0.331	-3.122	0.002
50	7.084	1.818	1.300	0.194	1.722	0.085	-1.494	0.136
51	7.125	1.830	1.798	0.073	2.675	0.008	-3.471	0.001
52	7.038	1.862	-1.485	0.138	1.667	0.096	-0.835	0.405
53	7.073	1.826	1.375	0.170	-0.304	0.761	-1.429	0.154
54	7.042	1.873	0.926	0.355	0.937	0.349	-2.365	0.019
55	7.029	1.895	2.627	0.009	-0.528	0.598	-2.734	0.007
56	7.111	1.921	3.236	0.001	-0.511	0.610	-0.583	0.560
57	7.152	1.877	2.415	0.016	0.784	0.434	-0.119	0.906
58	7.100	1.924	3.731	0.000	0.261	0.794	-1.130	0.259
59	7.142	1.878	1.392	0.164	-0.218	0.828	-1.164	0.245
60	7.180	1.832	2.892	0.004	0.908	0.364	-1.517	0.130
61	7.233	1.858	3.054	0.002	2.725	0.007	-3.148	0.002
62	7.265	1.902	5.251	0.000	0.027	0.979	-2.337	0.020
63	7.295	1.889	2.940	0.003	2.201	0.028	-3.848	0.000
64	7.204	1.949	0.587	0.557	2.739	0.006	-2.317	0.021
65	7.282	1.941	1.404	0.161	3.460	0.001	-3.770	0.000

Table 10: Impact of the survey instrument on satisfaction self-reports.

Survey Instrument	p-value
Oral	0.522
Written	0.408
Oral and Written	0.763
CAPI	0.467

a covariance of happiness between period t and $t-s$, computed as $\frac{\sum_{i\in a}\left(h_{it}-\bar{h_{at}}\right)\left(h_{it-s}-\bar{h_{at-s}}\right)}{N_{at}}$, where N_{at} is the number of individual observations in agegroup a at time t. Given the model in Eq. **??**, and setting $h_{i1}=\mu_{i0}$, $h_{i2}=\gamma\mu_{i0}+\varepsilon_{i2}$, the data generating process associated with these 76 variances is $\mathrm{V}\left(h_{at}\right)=\mathrm{V}\left(\mu_{at}\right)+\mathrm{V}\left(\nu_{at}\right)+2\mathrm{cov}\left(\mu_{at},\nu_{at}\right)$, such that:

$$\begin{aligned}
\mathrm{V}\left(\mu_{a1}\right) &= \mathrm{V}\left(\mu_{a0}\right)\\
\mathrm{V}\left(\mu_{a2}\right) &= \gamma^2\mathrm{V}\left(\mu_{a0}\right)\\
\mathrm{V}\left(\mu_{at}\right) &= \gamma^2\mathrm{V}\left(\mu_{at-1}\right)+\rho^2\sigma^2_{\varepsilon a},\forall t>2\\
\mathrm{V}\left(\nu_{a1}\right) &= 0\\
\mathrm{V}\left(\nu_{at}\right) &= \theta^2\mathrm{V}\left(\nu_{at-1}\right)+\sigma^2_{\varepsilon a},\forall t>1\\
\mathrm{cov}\left(\mu_{a1},\nu_{a1}\right) &= 0\\
\mathrm{cov}\left(\mu_{a2},\nu_{a2}\right) &= 0\\
\mathrm{cov}\left(\mu_{a2},\nu_{a2}\right) &= \gamma\theta\mathrm{cov}\left(\mu_{at-1},\nu_{at-1}\right)+2\rho\theta\sigma^2_{\varepsilon a},\forall t>2.
\end{aligned}$$

Similarly, the covariances are modelled according to $\mathrm{cov}\left(h_{at},h_{at-s}\right)=\mathrm{cov}\left(\mu_{at},\mu_{at-s}\right)+\mathrm{cov}\left(\nu_{at},\nu_{at-s}\right)+\mathrm{cov}\left(\mu_{at},\nu_{at-s}\right)+\mathrm{cov}\left(\mu_{at-s},\nu_{at}\right)$, where:

$$\begin{aligned}
\mathrm{cov}\left(\mu_{at},\mu_{a1}\right) &= \gamma^{t-1}\mathrm{V}\left(\mu_{a0}\right)\\
\mathrm{cov}\left(\mu_{at},\mu_{a2}\right) &= \gamma^{t}\mathrm{V}\left(\mu_{a0}\right)\\
\mathrm{cov}\left(\mu_{at},\mu_{at-s}\right) &= \gamma\mathrm{cov}\left(\mu_{at},\mu_{at-s-1}\right)+\rho^2\gamma^s\sigma^2_{\varepsilon},\forall t-s>2\\
\mathrm{cov}\left(\nu_{at},\nu_{a1}\right) &= 0\\
\mathrm{cov}\left(\nu_{at},\nu_{at-s}\right) &= \theta\mathrm{cov}\left(\nu_{at},\nu_{at-s-1}\right)+\theta^s\sigma^2_{\varepsilon},\forall t-s>1\\
\mathrm{cov}\left(\mu_{at},\nu_{a1}\right) &= 0\\
\mathrm{cov}\left(\mu_{at},\nu_{at-s}\right) &= \theta\mathrm{cov}\left(\mu_{at},\nu_{at-s-1}\right)+\rho\gamma^{s-1}\sigma^2_{\varepsilon},\forall t-s>1\\
\mathrm{cov}\left(\mu_{a1},\nu_{at}\right) &= 0\\
\mathrm{cov}\left(\mu_{a2},\nu_{at}\right) &= 0\\
\mathrm{cov}\left(\mu_{at-s},\nu_{at}\right) &= \gamma\mathrm{cov}\left(\mu_{at-s-1},\nu_{at}\right)+\rho\theta^{s+1}\sigma^2_{\varepsilon},\forall t-s>2
\end{aligned}$$

Hence, the EWMD estimator of $\Theta = \left(\rho, \theta, \gamma, \mathrm{V}\left(\mu_{a0}\right), \sigma^2_{\varepsilon a}\right)$ is just $\arg\min_{\tilde{\Theta}} \sum_j \left(o_j - m_j\left(\tilde{\Theta}\right)\right)^2$, where o_j is observation j, whether variance or covariance, and m_j is the hypothesised data generating process, which is in turn a function of the parameters to be estimated.

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