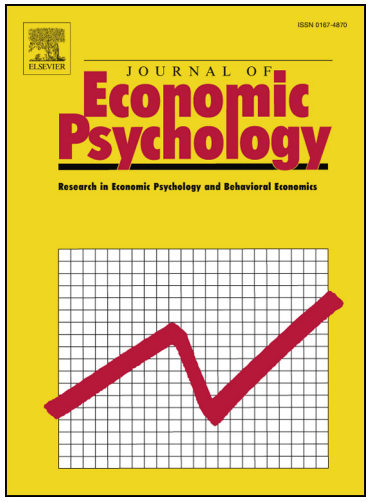

Car Ownership and Hedonic Adaptation

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Abstract

Using panel data from the UK, we study the long-term effect of purchase decisions of automobiles on individuals' happiness. We find a significant and sizable decrease in individual happiness in the years after a car purchase. We develop a model of hedonic adaptation that can explain these results. Applying the model to the data indicates a strong degree of habit persistence of around 80%, and that within five years after a purchase, around one third of the happiness increase is dissipated due to hedonic adaptation.

Keywords: hedonic adaptation, happiness, habit persistence, durable consumption goods

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1. Introduction

Individual decisions such as consumption and the concept of utility have been one of the pillars of economic analysis. At the same time, determinants of individual well-being or happiness have been increasingly investigated empirically by psychologists. Psychological economics has pulled these two strands of theoretical and empirical literature together, and in the last decades, an increasing empirical literature from psychology has contributed to the development of economic theory about individual behavior. And while utility and happiness should not be confounded (Kimball and Willis 2006), they share important common features that lend themselves to an interdisciplinary analysis.

One important feature of both fields of research have been the evolvement of individuals' utility or happiness over time: in the economics literature, starting from the Easterlin (2001) paradox, reference[3] dependence or habit formation in terms of consumption have been put forward as an explanation of stagnant levels of reported well-being despite increasing income and consumption levels. This literature dates back to works by Alfred Marshall (1890) and notably Duesenberry (1949), and since then has been formalized, for example, in Pollak (1970) or more recently in Clark and Oswald (1998) and Carroll et al. (2000).[4]

In Psychology, on the other hand, the concept of the hedonic adaptation (or the hedonic treadmill) has been put forward in different contexts; see, for example, Perez-Truglia (2012) who develop an evolutionary explanation for hedonic adaptation, and see Diener et al. (2006) for an excellent summary of the relevant literature. Happiness trajectories indicating hedonic adaptation to many economic and non-economic life events have been reported in Fujita and Diener (2005) or Clark, Diener, Georgellis and Lucas (2008).[5]

The concepts of hedonic adaptation or habit formation are closely linked, but depend on different concepts of happiness versus utility (Kimball and Willis 2006), and a large literature in both fields has identified a number of different cognitive biases that can be rationalized as explanations. Moreover, the empirical analysis of data on individual behavior and (self-)reported happiness has produced a large literature about the relevance of these concepts (e.g. Easterlin 2001; Frey and Stutzer 2002; Stutzer and Frey 2008; Clark, Frijters and Shields 2008).

For instance, Gilbert et al. (1998) found that people tend to overestimate the duration of their

[3]Such a reference level is often referred to as 'internal' since it depends on one's own past consumption level, as opposed to an external reference level, which is determined by peer groups (e.g. Johansson-Stenman et al. 2002; Alpizar et al. 2005).

[4]It has since then been used including as a possible explanation of the equity premium puzzle (Constantinides 1990; Campbell and Cochrane 1999), and of aggregate consumption patterns over time (Meghir and Weber 1996; Ferson and Constantinides 1991; Dynan 2000; Carrasco et al. 2005; Alessie and Teppa 2009).

[5]See also Lucas et al. (2003) for a study on adaptation to marriage.

affective reactions to negative events. As a consequence, people seem to adapt well to life events such as getting divorced (cf. Clark, Diener, Georgellis and Lucas 2008). Similarly, the notion of getting used to a durable consumption good can be explained by effects of repeated sensory and cognitive stimuli. After a period of enjoyment, the hedonic effects of higher consumption adapt to a base level (Frederick and Loewenstein 1999). Several other psychological biases in consumption have been studied.[6] For instance, Loewenstein et al. (2003) propose a 'projection bias' in the sense that the fluctuation in one's valuation for a particular consumption good over time can lead to sub-optimal buying decisions. Finally, certain consumption goods including as automobiles can convey important extrinsic attributes (material possessions, fame, status or prestige). It has been argued that people might overestimate such extrinsic attributes as compared to intrinsic attributes, see Frey and Stutzer (2008). The authors include underestimation of hedonic adaptation and distorted memories as reasons for this bias.

Our analysis is also closely related to existing work on adaptation to individual income or consumption aspirations such as Guven (2012), Stutzer (2004), D'Ambrosio and Frick (2007), and Di Tella et al. (2010). In particular, Di Tella et al. (2010) study the link between income and life satisfaction. They conclude that after four years of an income increase, around two third of the initial life satisfaction increase disappears due to hedonic adaptation or habit formation. With regard to specific consumption goods, on the other hand, empirical evidence based on a large sample of individuals and long time horizons is scarce, as longitudinal individual consumption data usually does not include information on life satisfaction. Experimental studies on the other hand necessarily focus on a rather short time frame. In this paper we contribute to this literature studying the temporal pattern of individual consumers' utility after the purchase of a durable good. More specifically, we analyze happiness trajectories several years before and after purchasing a car. We focus on buying decisions for automobiles due to the relatively high cost,[7] comparable long life time and availability of data.

Notably, the availability of data in the British Household Panel Survey (BHPS) over a total time span of almost two decades makes this analysis feasible in a very robust panel framework. We find that happiness drops after the consumption decision and that this drop is substantial. This result can be explained by a strong level of hedonic adaptation regarding these consumption

[6] See Kahneman and Thaler (2006) for an overview.

[7] We downloaded OECD data for the year 2014 (https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE5) and computed for various countries the fraction of consumption expenditure used for purchasing and operating own transport vehicles. The mean fraction is 0.11 (11 percent of total consumption expenditure) and the standard deviation is 0.03. The smallest fraction is 5 percent in the Slovak Republik and the largest fraction is 19 percent in Luxembourg. It seems likely that the major share of these costs are devoted for cars and therefore it is reasonable that purchasing cars is an economically important consumption decision.

decisions. We also inquire the robustness of our findings by considering a series of alternative specifications that generate very similar results.

We start by developing a simple model of hedonic adaptation of individual consumption decisions in section two. We summarize the data set we constructed in section three and present the results of the econometric approach in section four. Section five concludes.

2. A model of hedonic adaptation

There are various reasons to assume that consumers are prone to hedonic adaptation in the sense that their utility is affected by the time passed since a given consumption decision. In light of the various channels discussed in the introduction, a potential hypothesis is that experienced utility derived from a particular good (in our case an automobile) is decreasing over time after a purchase. If consumers do not take this adaptation into account, they might make decisions that turn out to be sub-optimal ex-post. In the following, we first develop a simple model of hedonic adaptation similar to economic models of consumption as Constantinides (1990), Clark and Oswald (1998) or Johansson-Stenman et al. (2002). We study the effect of the purchase of a durable good of a fixed value, which we refer to as car, on utility over time, and denote the binary variable of whether a car is bought in period t by c_t. That is, c_t takes on the value of c when a car has been purchased and zero otherwise. The agent experiences hedonic adaptation in the sense that instantaneous utility depends on both her current consumption level and an average of past consumption of the good, denoted as $\bar{c}_t$. We use an additive specification as in Campbell and Cochrane (1999) or Clark and Oswald (1998)[8]. Since we are only interested in the qualitative predictions of the model, we assume a simple linear utility function. Experienced utility by the agent at time t is then given by

$$U_t(c_t, \bar{c}_t) = (1-\gamma)c_t + \gamma\,(c_t - \bar{c}_t) \tag{1}$$

where γ represents the degree to which consumption relative to the habit reference level is important to the agent.[9]

Regarding the habit reference level to which the consumer adapts, $\bar{c}_t$, we follow Fuhrer (2000)

[8] Alternatively, ratio comparison models have been used, as in Abel (1990) or also in Clark and Oswald (1998), which in our context give qualitatively similar results.

[9] Empirical estimates for γ are in the range between 0.35 (Johansson-Stenman et al. 2002) and 0.75 (Lupton 2002), or about one half as Carlsson et al. (2007), who estimate $\gamma = 0.5$.

and assume that it evolves over time according to the process

$$\bar{c}_t = \alpha \bar{c}_{t-1} + (1-\alpha) c_{t-1} \tag{2}$$

where $\alpha \in [0,1]$ measures the degree of persistence of the level of habits. For the case of $\alpha = 0$, the habit reference level is only last period's consumption, while larger values of α imply that the reference level is influenced by consumption further back in time or that the mean lag of the habit reference level is larger. This law of motion implies that the habit reference level can be computed as an exponentially weighted average of past consumption. We also focus on one time purchase decisions, which can be considered reasonable for long-lived durable consumption goods such as cars.

Given the simple binary variable c_t, the level of habits will be a weighted average between the value c and zero. More precisely, the habit reference level $\bar{c}_t$ for any date t after the date of purchase T can be written as

$$\bar{c}_t = (1-\alpha) \sum_{\tau=0}^{t-T-1} \alpha^\tau c \tag{3}$$

and zero for $t \leqq T$. To simplify notation, the time in years after a car purchase is denoted by

$$\Delta t = t - T \; \forall t > T \tag{4}$$

which is equal to zero for $t < T$. Setting the initial habit reference level $\bar{c}_0$ to zero, we can write the habit reference level Δt periods after the purchase as $\bar{c}_t = c(1-\alpha^{\Delta t})$. Then, experienced utility at time t is given by:

$$U_t(c_t) = \begin{cases} c - \gamma c(1-\alpha^{\Delta t}) & \text{if } t > T \\ c & \text{if } t = T \\ 0 & \text{if } t < T \end{cases} \tag{5}$$

If the agent rationally anticipates the hedonic adaptation, her current consumption decisions would maximize this utility function. However, fundamental to the habit-formation model is the fact that the habit persistence is not taken into account when the decision is made. That is, the effect of current consumption on future tastes or utility is not considered (Pollak 1970). The agents' decision utility from the car purchase in the future is instead $V_t(c_t) = c$ for $t > T$.

Another reason for a non-constant utility profile after the purchase of a durable consumption good could be due to depreciation. However, this effect is comparably easy to anticipate and seems more easily to be taken into account in the buying decision. In any case, the consumption profile (5) can be interpreted as combining hedonic adaptation and (unexpected) depreciation over time.

Note that the formulation of (5) can also be interpreted as a "projection bias" of future utility as proposed in Loewenstein et al. (2003).

From the utility function (5) we can derive the hedonic adaptation effect or how utility will likely change over time after a durable good is purchased. Deriving equation (5) with respect to time yields $\frac{\partial U_t}{\partial \Delta t} = \gamma c \alpha^{\Delta t} ln\alpha$ which is negative for $\alpha < 1$. This implies that utility decreases over time due to the building up of the habit reference level where the speed of this decline depends on the degree of hedonic adaptation and the decay of habits over time.

In order to derive a more tractable version for the estimation, we use an approximation to derive a linear version of this formulation. For small values of Δt, we can use an approximation of the exponential decay by applying a second-order Taylor expansion of $\alpha^{\Delta t}$ around $\Delta t = 3$ which is the median in our sample (considering only positive values for Δt, see below).[10] This yields

$$\alpha^{\Delta t} \backsimeq \alpha^3(1 + 3ln\alpha^{-1} + 3^2(ln\alpha^{-1})^2) - \alpha^3 lna^{-1}(1 + 6ln\alpha^{-1}) \cdot \Delta t + \alpha^3(ln\alpha^{-1})^2 \Delta t^2. \tag{6}$$

Inserting this expression into the utility function finally yields a quadratic approximation of utility as a function of the time since the purchase was made:

$$U_t \simeq c\left\{K_0 - \gamma\alpha^3 lna^{-1}(1 + 6ln\alpha^{-1})\Delta t + \gamma\alpha^3(ln\alpha^{-1})^2\Delta t^2\right\} \text{ if } t > T \tag{7}$$

where $K_0 = (1-\gamma) + \alpha^3(1 + 3ln\alpha^{-1} + 3^2(ln\alpha^{-1})^2)$ represents the time-independent term. That is, the resulting experienced utility profile $U_t(c_t)$ is decreasing after a purchase whereas the decision utility profile without hedonic adaptation $V_t(c_t)$ stays constant over time after the purchase.

We can rewrite this equation for experienced utility over time as

$$U_{it} \simeq cK_0 + \beta_{\Delta t}\Delta t + \beta_{\Delta t^2}\Delta t^2 \text{ if } t > T \tag{8}$$

where the two parameters of the quadratic function are given by

$$\begin{aligned} \beta_{\Delta t} &= -c\gamma\alpha^3 lna^{-1}(1 + 6ln\alpha^{-1}) < 0 \\ \beta_{\Delta t^2} &= +c\gamma\alpha^3(ln\alpha^{-1})^2 > 0. \end{aligned} \tag{9}$$

In the following sections, we will exploit this linear approximation to identify the extent of hedonic adaptation and habit persistence empirically. The point estimates for $\beta_{\Delta t}$ and $\beta_{\Delta t^2}$ have immediate implications for the structural parameters. First, if the habit reference level is constant

[10] The reason for evaluating the decay function at the median of Δt is to obtain a more appropriate approximation of the exponential decay for the values of interest.

and hence $\gamma = 0$ and/or $\alpha = 1$, both $\beta_{\Delta t}$ and $\beta_{\Delta t^2}$ would be zero. Second, if at least one of the coefficients $\beta_{\Delta t}$ and $\beta_{\Delta t^2}$ is different from zero, we can compute the structural parameter α. Rearranging equation (9) yields

$$\alpha = exp\left(\frac{\beta_{\Delta t^2}}{6\beta_{\Delta t^2} + \beta_{\Delta t}}\right). \tag{10}$$

Thus, in the empirical section we discuss several specifications to estimate $\beta_{\Delta t}$ and $\beta_{\Delta t^2}$, and subsequently we use these coefficients to compute α, the degree of habit persistence.

3. Data and empirical specification

In order to identify empirically the parameters of the theoretical model, we need a panel data-set covering both life satisfaction and consumption decisions, which follows the same individuals over several years. We use the British Household Panel Survey (BHPS), a representative survey for the UK that began in 1991 with an initial sample of 10,300 individuals and lasted until 2009.[11] The question eliciting overall life satisfaction is available for waves 6-18 (years 1997-2009) with the exception of wave 11. The question reads "All things considered, how satisfied or dissatisfied are you with your life overall using a 1-7 scale? 1=very dissatisfied, ..., 7=very satisfied". The overall mean value in the sample is equal to 5.25 points with a standard deviation of 1.23. This will be the dependent variable of interest for our analysis.

The main explanatory variable of interest concerns the purchase of an automobile and the time since the last purchase. Given that the sample contains information on the number of cars in any household and exploiting the panel feature of our data, this variable allows to generate a profile of the current stock of cars for each household and the respective out- and inflows. Firstly, we construct a dummy variable indicating the year of purchasing a car for each household ($C_{\{t=T\}}$ or year_of_purchase). Then, we construct a variable containing number of years after the purchase (Δt or delta_t). For example, if in one particular household a car is purchased in the year 2003, the indicator variable $C_{\{t=T\}}$ equals one for the year 2003 and the variable Δt is defined as survey-year minus 2003 for that household. In the years before the purchase it is zero. In order to capture the non-linearity of the effect suggested by equation (8), we also include the squared value of this variable. We further consider a more general form of non-linearity by creating a series of dummy variables indicating the respective year after the car purchase.

Note that the coding scheme of main explanatory variable implies that only positive changes of the stock of cars in a household are coded as purchases such that a simple replacement of an

[11] The data set is available from the UK Data archive: Study Number 5151.

existing car is not counted as a new purchase. Therefore, our estimates could be seen as a lower bound estimate for the hedonic adaptation effect, since a simple replacement will most likely have an even higher effect of hedonic adaptation. In total there are 38,140 of the 119,712 observations or 32% with positive values of Δt. If a household purchased several cars, this introduces another difficulty. For example, if a car is purchased in 2004, then sold and then another car bought in 2006. In such a case the year 2007 could be coded as 3 years after the first purchase and at the same time one year after the second purchase. It is conceivable that each purchase is associated with a positive shift in happiness. Therefore, coding the year 2007 as three years after the purchase would be similar to a replacement of an existing car and lead to an underestimation of the degree of hedonic adaptation. Nevertheless, the robustness section of the paper will consider the different possible coding schemes and show that the results are not affected by this.

We enter a large set of control variables including the (logarithm of) annual household income (log_income), work hours per week (hours_worked) and dummy variables for sex, individuals that are born abroad and whether the car is used to commute to work. Further, we enter two dummy variables capturing the employment status; the first dummy indicates unemployed individuals and the second full-time working individuals (fulltime). We also include the household size, the number of children living in the household, the commuting time in minutes (commuting_time) and a dummy indicating whether the household has moved in the current year. Moreover, sets of dummies are used for marital status and educational attainment.

Most of these controls are standard in the literature analyzing life satisfaction; for example, Clark, Diener, Georgellis and Lucas (2008) analyze the association between life satisfaction and employment status, and Stutzer and Frey (2008) study the link between commuting time and life satisfaction.[12] Further, many of these standard controls are potentially correlated with car purchase decisions, for example annual household income, employment status or the current financial situation. It is therefore important to include these controls in order to avoid omitted variable bias regarding the main explanatory variables. The expected correlation is weaker for other variables, e.g. educational attainment. However, even if these variables would be completely unrelated to purchase decisions, including them is useful just in order to reduce the unexplained variance of the regression.

The most important control variables are two questions referring to the financial status which is clearly correlated with purchase decisions. The first question probing the current financial status reads "How well would you say you yourself are managing financially these days? Would you say you are ..." where the possible answers are "Living comfortably (1)", "Doing alright (2)", "Just

[12]Dolan et al. (2008) provide an overview of a large set of studies analyzing different correlates of life satisfaction.

getting by (3)", "Finding it quite difficult (4)" and "Finding it very difficult (5)". Three dummies are created from this variable. The first dummy indicates "just getting by" and serves as the omitted reference category. The two dummies that are actually included in the regression indicate whether the individuals' financial status is better or worse than "just getting by", respectively. They are labeled "good financial situation" and respectively "bad financial situation".

The second question probes for changes in the financial status and reads "Would you say that you yourself are better off, worse off or about the same financially than you were a year ago?". Possible answers are "worse off", "better off" and "about the same". Similar to current financial status, we use "about the same" as the omitted reference category and include one dummy variable labeled "financial status improved" and a second dummy labeled "financial status worsened". The last question related to the financial status asks if a loan repayment has been made in the current year (loan_repayment). The complete list of variables[13] and the associated descriptive statistics are shown in Table 1.

[Table 1 about here.]

In order to see whether our sample is representative of the UK population, we compare the data on car purchases and ownership to the data of the Department of Transport[14] who report that since the year 2000, an average of 40 new cars are bought per 1000 inhabitants and about 45% of the population owns exactly one car. Our BHPS sample matches these statistics rather well with an estimated 55 new cars per 1000 inhabitants including used cars and 49% of the households possessing exactly one car on average over the years 2000-2009.

The central econometric specification is a panel estimation where we regress the level of individual self-reported well-being on the time since the last car purchase and a set of control variables. Formally, we will estimate the econometric counterpart of the analytical relationship outlined in equation (8) as

$$U_{it} = \beta_0 + \beta_c C_{\{t=T\}} + \beta_{\Delta t}\Delta t + \beta_{\Delta t^2}\Delta t^2 + X'_{it}\Xi + \alpha_i + \gamma_t + \eta_{it} \tag{11}$$

where we omit the individual subscripts of the distance variables for ease of presentation. In this equation, U_{it} represents the reported level of happiness by individual i at time t, Δt the time since the car purchase as discussed before, and we also add a dummy variable $C_{\{t=T\}}$ for the year in a which a car is purchased. Moreover, X'_{it} contains the set of control variables like income,

[13] Some of the controls are correlated with each other, for example working hours and the dummy distinguishing between part-time and full-time employment. The coefficients for these controls are potentially difficult to evaluate. However, as explained, these variables are included because they are potentially correlated with purchase decisions.

[14] http://www.dft.gov.uk/pgr/statistics/datatablespublications/vehicles/licensing/

age, education, employment status, marital status, household size, etc., as discussed before. The coefficients $\{\beta_c, \beta_{\Delta t}, \beta_{\Delta t^2}\}$ capture the main effect of interest, i.e. the impact of car purchases on happiness over time. We also include time fixed effects γ_t in the estimation to capture business cycle effects.

We mostly discuss our results obtained from specifications where unobserved individual characteristics α_i are assumed to be fixed over time. Consequently, time invariant variables like gender are omitted in this formulation.[15] While the fixed effects model allows the individual heterogeneity to be correlated with other regressors, it raises problems regarding the identification of age and time effects. We therefore additionally consider a random effects assumption for α_i and estimate equation (11) by generalized least squares. Since individuals living in the same household share the same car purchases, we also considered a multi-level model which takes the nested structure (individuals in the household) into account.[16] As we will see, this does not qualitatively affect the results.

Since the temporal pattern of reported well-being after a car purchase is potentially non-linear, we further include a quadratic term. However, as a robustness check we relax the functional assumption with respect to the hedonic adaptation process. In particular, we replace the two distance variables by a series of dummy variables capturing the years after the purchase for each individual. Omitting once more the individual subscripts for the distance variables, the respective regression equation reads

$$U_{it} = \beta_0 + \beta_{t-0} p_{t-0} + \beta_{t-1} p_{t-1} + \beta_{t-2} p_{t-2} + \cdots + \beta_{t-6} p_{t-6} + X'_{it}\Xi + \alpha_i + \varepsilon_{it} \qquad (12)$$

where $p_{t-\Delta t}$ is a dummy variable indicating a car purchase Δt periods before t. The dummy variable p_{t-0} indicates the year of purchasing the car and all prior years. This dummy acts as the reference category and is therefore omitted.

[15] Cf. Carrasco et al. (2005) who study hedonic adaptation regarding aggregate consumption. They conclude that controlling for individual-specific heterogeneity can crucially alter the results.

[16] In general, a multi-level model is interesting for two main reasons. First it allows to assign the unobserved heterogeneity to different levels and therefore estimates a separate variance parameter for each level (and covariance parameters). The second feature is that the standard errors of the included regressors reflect the sampling situation. For example, if repeated information from the same individual is included, the usual OLS standard errors are too small since all observations are treated as independent observations. We are mainly interested in this correction of the standard errors and therefore include a random intercept for each household and for each individual. As we will see in the following section, the results from a usual random effects model and the results from the multi-level model are virtually identical.

4. Empirical results

Table 2 presents the estimation results for the main specification (equation 11). As explained in the previous section, we include time fixed effects in this specification, but omit the respective coefficients for ease of presentation. The first column presents the pooled OLS results, while column (2) includes individual random effects into the model. Column (3) summarizes the results from the multilevel-model that takes the clustering of individuals living in the same household into account. Column (4) presents the results from a usual FE (individual fixed effects) model.

[Table 2 about here.]

Overall, the results of the different specifications are very similar. The two main coefficients of interest are the point estimates of $\beta_{\Delta t}$ and $\beta_{\Delta t^2}$. This vector of distance coefficients obtained from using OLS (column 1) is $(\beta_{\Delta t}, \beta_{\Delta t^2}) = (-0.045, +0.0036)$, while the respective estimates from the RE model (column 2) are $(\beta_{\Delta t}, \beta_{\Delta t^2}) = (-0.03, +0.0036)$. Compared to these RE estimates, the results are virtually unchanged when the nested structure is considered by applying a multilevel-model (column 3), or when unobserved individual heterogeneity is assumed to be fixed over time; the FE results (column 4) are $(\beta_{\Delta t}, \beta_{\Delta t^2}) = (-0.02, +0.0033)$. The coefficients are precisely estimated and significant at the 1% or 5% level. The coefficients for the control variables are also very similar across the different specifications. We therefore discuss only the FE results (column 4) in more detail.

The purchase year coefficient β_c is close to zero (-0.0028) and insignificant in this specification. At first glance, this appears to be at odds with the model of consumption decisions, as an initial increase in happiness after the purchase could be expected. However, it is possible that this initial boost is small and it may last only for a couple of weeks or months. In such a case, the annual data disguises this initial boost. Small and imprecise coefficients for the first year after an event are also found in other studies of hedonic adaptation, see for example the evolution of life satisfaction over time after child birth in the study by Clark, Diener, Georgellis and Lucas (2008).[17]

We can use the two main coefficients to evaluate the trajectory of life satisfaction following the car purchase. For example, the estimated change in life satisfaction three years after the car purchase ($\Delta_t = 3$) is approximately equal to $-0.02 * 3 + 0.0033 * 9 \approx -0.0303$ life satisfaction

[17] Feelings of stress, for example caused by taking a loan in order to purchase the car, might be a further possible explanation. A parallel finding is observed in the area of parenting; becoming parents is often associated with lower levels of life satisfaction and this unexpected finding can be explained by the time stress felt by the parents (Anand 2015). Note that our control variables probing for the financial situation should control for loan-related stress. However, it is possible that the questions do not fully capture all aspects of the financial situation. Moreover, subjective well-being effects due to important (consumption) decisions can always be manifold, see e.g., Coates et al. (2013).

points. This calculation uses the years before the purchase as the reference and therefore sets the effect of the purchase year to zero. Using the imprecise point estimate yields a predicted change in life satisfaction equal to $-0.02 * 3 + 0.0033 * 9 - 0.0028 \approx -0.0331$ three years after the purchase. Hence, the impact of this insignificant point estimate is negligible.

As explained in section two, we now use the main coefficients to recover the structural parameter α (equation 10). Using the fixed effect specification yields $\alpha = 0.86$. The estimate using the random effects specification is $\alpha = 0.73$. For all specifications, the estimated degree of habit persistence α is between 0.70 to 0.90 on a yearly basis. This indicates a strong degree of habit persistence in the sense that the past reference level enters the most recent habit reference level with a weight of about 80%.

Further, this estimated degree of habit persistence has implications concerning $(c_t - \bar{c}_t)$, which denotes the part of individuals' utility that is affected by hedonic adaptation. After three years, this difference shrinks to about 50 percent due the increased habit reference level $\bar{c}_t$, and after five years the difference $c_t - \bar{c}_t$ has decayed to about one third. In order to quantify the effect on the individual happiness level, we need the weight γ that governs how individuals' utility is affected by the difference $(c_t - \bar{c}_t)$. As discussed in section two, empirical estimates for γ range from around 0.35 to 0.75, so we choose an intermediate value of $\gamma = 0.5$ as in Carlsson et al. (2007). Based on equation (5), this implies that after five years, about $\gamma(1 - \alpha^{\Delta t}) = 0.34$ or 34% of happiness vanishes due to hedonic adaptation.

With respect to the control variables, the coefficients of the variables show the expected signs. The coefficients of other controls are also in line with the previous literature. For example, the education coefficients are small and imprecisely estimated which is consistent with a small amount of within-individual-variation (see, for example, Dolan et al. 2008). Being married and being employed rather than unemployed[18] is associated with a positive shift in happiness (cf. Dolan et al. 2008).

As explained, the two most important control variables refer to the financial status. The coefficient for the dummy variable indicating bad financial status is equal to -0.33. Hence, reporting a bad financial status (rather than a medium status) is associated with a economically large decrease of 0.33 life satisfaction points. Similarly, a worsening of the financial situation (compared to no

[18] We can use the coefficients of the control variables for a further quantification of the effect of habit persistence. For example, the negative impact of unemployment on life satisfaction equals -0.13 in the FE model. Hence, the decrease in life satisfaction three years after purchasing a car (≈ -0.0331) equals roughly one fourth of the effect associated with becoming unemployed. Given that becoming unemployed has a tremendous negative impact on happiness (e.g. Clark, Diener, Georgellis and Lucas 2008), the loss in happiness of one fourth of the 'unemployment effect' can be considered as important. This finding is once again in line with the idea that the process of hedonic adaptation is very important in the context of durable goods like cars.

change) is associated with a decrease of −0.12 life satisfaction points. These controls are particularly important, as –see our discussion above– they are obvious confounding variables.[19] For example, an individual might decide to purchase a car and might shortly afterwards experience an unexpected bad financial situation. If she is willing to sell the car to improve the financial situation but unable to do so, the negative car purchase coefficients might pick up this effect. Moreover, we included the dummy variable coded as one for the question "Do you or anyone in your household have to make repayments on hire purchases or loans?" (*loan_repayments*), which also bears the expected sign and captures the effect of car purchases increasing a household's debt position. Since we condition on income and the financial situation, the purchase coefficient will be mainly driven by the "non-monetary" factors – that is the effect due to hedonic adaptation.

Robustness checks.

[Table 3 about here.]

We inquire the robustness of the results by carrying out a number of robustness checks. First, we allow a higher degree of non-linearity by entering a series of dummy variables indicating the various years after the purchase. Second, we have also considered fixed effects ordered logit models instead of linear regression models. Finally, as explained in section 3, we employed different coding schemes regarding the time variables in case of multiple purchases.

Table 3 compiles the results obtained from the specification outlined in equation (12), thereby allowing a flexible time schedule of the hedonic adaptation process. In these estimations we check the robustness of our findings with respect to the functional form by entering a series of dummy variables indicating the various years after purchasing a car. Table 3 shows once again that the different specifications provide the same qualitative results. As before, the coefficients of the FE models are slightly smaller compared to the RE models. Note that the specification in the third column enters time effects. As expected, due to the collinearity between purchase and time dummies, the purchase coefficients are smaller compared to the other specifications. However, for instance the significantly estimated value of −0.031 matches exactly the estimated decrease of life satisfaction three years after the purchase decision obtained from the FE baseline specification in Table 2. If we exclude the set of time dummies in the fixed effect specification (column 4),

[19] We have also considered four additional specifications to check whether our results are driven by confounding control variables. The first specification omits all control variables to check whether our results are only found after conditioning on this large set of controls. The second additional specification drops only the income variable. The third additional specification drops the income-variable and the variable capturing working hours. Finally, the fourth additional specification omits income, working hours and the dummy variable indicating full-time working individuals. The results (see tables S1 - S4 in the supplementary online appendix) clearly indicate that the coefficients capturing the happiness trajectory over time are virtually identical in these additional specifications.

the effects become again much stronger and significant. Figure 1 plots the two different sets of specifications for all three estimation techniques (Tables 2 and 3) for $t = T + 1$ to $t = T + 6$.

[Figure 1 about here.]

A car purchase is associated with a strong decrease in life satisfaction for several years. In the two parameter model, the estimates of the vector $(\beta_{\Delta t}, \beta_{\Delta t^2})$ suggest that the angular point of the parabola is around three to four years after purchasing a car. The alternative specifications using dummy variables and individual random or fixed effects indicate that the strongest decrease in happiness occurs 4-5 years after the purchase. After passing this turning point (3-5 years depending on the specification), life satisfaction returns back to the baseline level before the purchase was made.

Second, we considered a series of ordered logit models. The results from these models are in line with the results from the linear models and therefore relegated to the online appendix.[20] Finally, we used different coding schemes for the main variables capturing the time of and after a car purchase. As explained, in case of multiple car purchase the present coding scheme maximizes the number of observations by coding the median purchase as the relevant purchase. Tables S6 and S7 in the online appendix use the earliest and respectively the last purchase as the relevant purchase and generate the same qualitative findings. In summary, all additional specifications produce qualitatively the same results.

5. Conclusion

Hedonic adaptation is a well-established theory of individual behavior and patterns of well-being. Empirically, it has been established mainly based on the overall level of income or consumption, as well as in the dynamics of individual happiness levels following important life events such as marriage, being laid-off, having a child etc. With respect to consumption decisions about specific consumption goods, on the other hand, evidence is rather scarce. In this paper we find the hedonic adaptation effect for the purchase of an automobile using a long time series of UK data. The results are obtained by following the same persons over several years before and after a car purchase and analyzing their happiness trajectories. The robust panel framework allows to control for potential confounding factors like changes in the financial situation of the individual. Further, the longitudinal data set permits us to control for selection effects by using individual fixed effects. The main result implies that within 5 years, happiness decreases by about one third due to hedonic

[20] Table S5 in the online appendix compiles the results.

adaptation. Individuals neglect this hedonic adaptation process and therefore follow a non-optimal consumption plan.

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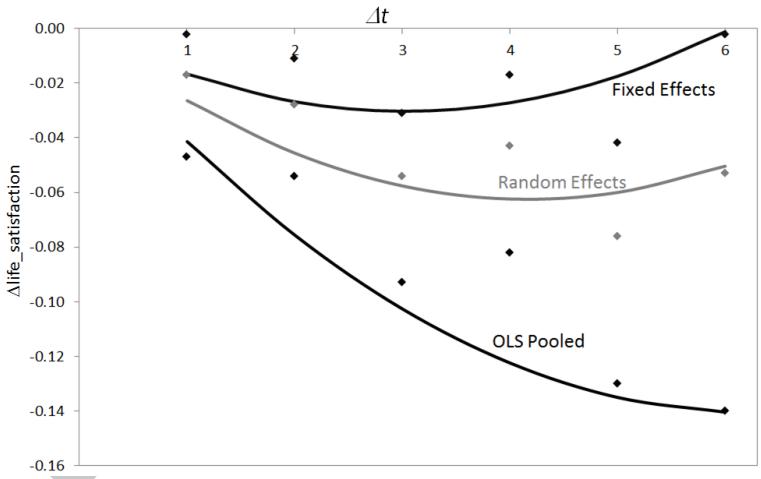

Figure 1: Estimated hedonic adaptation effects (solid lines: quadratic specification, squares: year-specific estimates)

	mean	sd	min	max
life_satisfaction	5.25	1.23	1.0	7
year_of_purchase	0.11	0.31	0.0	1
delta_t	0.87	1.60	0.0	11
delta_t if positive	2.72	1.73	1.0	11
log_income	6.52	4.35	0.0	14
hours_worked	19.73	18.55	0.0	99
car_to_work	0.40	0.49	0.0	1
fulltime	0.52	0.50	0.0	1
unemployed	0.03	0.17	0.0	1
married	0.59	0.49	0.0	1
living as couple	0.12	0.33	0.0	1
widowed	0.04	0.19	0.0	1
divorced	0.05	0.41	0.0	1
hhsize	3.03	1.35	1.0	16
nkids	0.67	1.00	0.0	8
commuting_time	13.19	19.34	0.0	500
degree	0.14	0.35	0.0	1
a_level	0.41	0.49	0.0	1
o_level	0.23	0.42	0.0	1
no_qualification	0.19	0.40	0.0	1
female	0.53	0.50	0.0	1
born_abroad	0.00	0.05	0.0	1
good_financial_situation	0.71	0.45	0.0	1
bad_financial_situation	0.07	0.25	0.0	1
financial_situation_improved	0.29	0.45	0.0	1
financial_situation_worsened	0.22	0.41	0.0	1
loan_repayments	0.33	0.47	0.0	1
moved	0.09	0.29	0.0	1
N	116773			

Table 1: Descriptive Statistics

Table 2: Life satisfaction trajectories after a car purchase

	(1) OLS		(2) RE		(3) Multilevel		(4) FE	
purchase year	-0.044***	(0.012)	-0.017*	(0.0096)	-0.013	(0.0097)	-0.0028	(0.0098)
Δt	-0.045***	(0.0069)	-0.030***	(0.0061)	-0.026***	(0.0061)	-0.020**	(0.0082)
Δt^2	0.0036***	(0.0011)	0.0036***	(0.00083)	0.0033***	(0.00083)	0.0033***	(0.0011)
log income	0.023***	(0.0014)	0.0073***	(0.0013)	0.0076***	(0.0013)	-0.000078	(0.0016)
hours worked	-0.0015***	(0.00034)	-0.00035	(0.00038)	-0.00045	(0.00037)	0.00023	(0.00045)
car to work	0.043***	(0.0086)	0.014	(0.0094)	0.016*	(0.0093)	-0.0073	(0.011)
age	-0.057***	(0.0015)	-0.036***	(0.0019)	-0.036***	(0.0018)		
agesq	0.00064***	(0.000017)	0.00042***	(0.000020)	0.00042***	(0.000020)		
fulltime	-0.057***	(0.011)	-0.046***	(0.012)	-0.047***	(0.012)	-0.045***	(0.015)
unemployed	-0.21***	(0.026)	-0.16***	(0.019)	-0.16***	(0.019)	-0.13***	(0.027)
married	0.30***	(0.012)	0.24***	(0.015)	0.24***	(0.014)	0.19***	(0.022)
living as couple	0.24***	(0.013)	0.21***	(0.014)	0.20***	(0.014)	0.21***	(0.020)
widowed	-0.057**	(0.026)	-0.13***	(0.029)	-0.13***	(0.029)	-0.16***	(0.056)
divorced	-0.099***	(0.021)	-0.028	(0.023)	-0.036	(0.022)	0.046	(0.035)
hhsize	-0.0078*	(0.0041)	-0.014***	(0.0043)	-0.016***	(0.0043)	-0.019***	(0.0058)
nkids	-0.014**	(0.0053)	-0.0020	(0.0057)	-0.0037	(0.0057)	0.011	(0.0080)
commuting_time	-0.0010***	(0.00019)	-0.00031	(0.00020)	-0.00028	(0.00020)	-0.000097	(0.00022)
degree	-0.055***	(0.013)	-0.0095	(0.021)	-0.0065	(0.021)	-0.081*	(0.045)
a-level	-0.033***	(0.011)	0.024	(0.016)	0.024	(0.016)	0.022	(0.035)
o-level	-0.0078	(0.011)	0.018	(0.017)	0.013	(0.017)	0.021	(0.038)
female	0.018**	-0.0012	(0.014)	0.0076	(0.013)			
born_abroad	0.17**	0.13**	(0.060)	0.11*	(0.061)			
good_financial_situation	0.48***	(0.0091)	0.26***	(0.0078)	0.27***	(0.0078)	0.19***	(0.0092)
bad_financial_situation	-0.59***	(0.019)	-0.40***	(0.013)	-0.40***	(0.013)	-0.33***	(0.018)
financial_situation_improved	0.0087	(0.0080)	0.059***	(0.0071)	0.060***	(0.0071)	0.077***	(0.0072)
financial_situation_worsened	-0.19***	(0.0096)	-0.13***	(0.0077)	-0.13***	(0.0077)	-0.12***	(0.0085)
loan_repayments	-0.060***	(0.0074)	-0.025***	(0.0069)	-0.025***	(0.0069)	-0.0080	(0.0076)
moved	0.010	(0.012)	0.028***	(0.0099)	0.029***	(0.0099)	0.037***	(0.011)
Constant	5.88***	(0.036)	5.70***	(0.043)	5.67***	(0.043)	5.12***	(0.039)
Time Fixed Effects	Yes		Yes		Yes		Yes	
$log\sigma_{hh}$					-1.19***	(0.056)		
$log\sigma_i$					-0.26***	(0.0075)		
$log\sigma_{it}$					-0.16***	(0.0023)		
Observations	116773		116773		116773		116773	

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 3: Life satisfaction trajectories after a car purchase (categories)

	(1) OLS		(2) RE		(3) FE		(4) FE	
p_{t-1}	-0.047***	(0.012)	-0.017*	(0.0100)	-0.0023	(0.010)	-0.032***	(0.0088)
p_{t-2}	-0.054***	(0.013)	-0.028**	(0.011)	-0.011	(0.013)	-0.045***	(0.0098)
p_{t-3}	-0.093***	(0.015)	-0.054***	(0.013)	-0.031*	(0.016)	-0.066***	(0.011)
p_{t-4}	-0.082***	(0.017)	-0.043***	(0.015)	-0.017	(0.019)	-0.052***	(0.012)
p_{t-5}	-0.13***	(0.021)	-0.076***	(0.018)	-0.042*	(0.023)	-0.075***	(0.015)
p_{t-6}	-0.14***	(0.020)	-0.053***	(0.020)	-0.0022	(0.028)	-0.031*	(0.017)
log income	0.023***	(0.0014)	0.0073***	(0.0013)	-0.00012	(0.0016)	0.000014	(0.0016)
hours worked	-0.0015***	(0.00034)	-0.00035	(0.00038)	0.00023	(0.00045)	0.00035	(0.00045)
car to work	0.043***	(0.0086)	0.014	(0.0094)	-0.0074	(0.011)	-0.0084	(0.011)
age	-0.057***	(0.0015)	-0.036***	(0.0019)				
agesq	0.00064***	(0.000017)	0.00041***	(0.000020)				
fulltime	-0.057***	(0.011)	-0.047***	(0.012)	-0.046***	(0.015)	-0.043***	(0.015)
unemployed	-0.21***	(0.026)	-0.16***	(0.019)	-0.13***	(0.027)	-0.13***	(0.027)
married	0.30***	(0.012)	0.24***	(0.015)	0.19***	(0.022)	0.18***	(0.022)
living as couple	0.24***	(0.013)	0.21***	(0.014)	0.21***	(0.020)	0.20***	(0.020)
widowed	-0.056**	(0.026)	-0.13***	(0.029)	-0.16***	(0.056)	-0.18***	(0.056)
divorced	-0.099***	(0.021)	-0.027	(0.023)	0.048	(0.035)	0.034	(0.035)
hhsize	-0.0077*	(0.0041)	-0.014***	(0.0043)	-0.019***	(0.0058)	-0.017***	(0.0058)
nkids	-0.014***	(0.0053)	-0.0017	(0.0057)	0.012	(0.0080)	0.011	(0.0080)
commuting_time	-0.0010***	(0.00019)	-0.00031	(0.00020)	-0.000097	(0.00022)	-0.00011	(0.00022)
degree	-0.055***	(0.013)	-0.0096	(0.021)	-0.081*	(0.045)	-0.12***	(0.044)
a-level	-0.033***	(0.011)	0.025	(0.016)	0.023	(0.035)	0.00084	(0.035)
o-level	-0.0078	(0.011)	0.018	(0.017)	0.022	(0.038)	0.012	(0.038)
female	0.018**	(0.0073)	-0.0012	(0.014)				
born_abroad	0.16**	(0.082)	0.13**	(0.060)				
good_financial_situation	0.48***	(0.0091)	0.26***	(0.0078)	0.19***	(0.0092)	0.19***	(0.0092)
bad_financial_situation	-0.59***	(0.019)	-0.40***	(0.013)	-0.34***	(0.018)	-0.33***	(0.018)
financial_situation_improved	0.0087	(0.0080)	0.059***	(0.0071)	0.077***	(0.0072)	0.080***	(0.0072)
financial_situation_worsened	-0.19***	(0.0096)	-0.13***	(0.0077)	-0.12***	(0.0085)	-0.11***	(0.0084)
loan_repayments	-0.060***	(0.0074)	-0.025***	(0.0069)	-0.0081	(0.0076)	-0.0066	(0.0076)
moved	0.010	(0.012)	0.028***	(0.0099)	0.037***	(0.011)	0.040***	(0.011)
Constant	5.88***	(0.036)	5.69***	(0.043)	5.12***	(0.039)	5.12***	(0.037)
Time Fixed Effects	Yes		Yes		Yes		No	
Observations	116773		116773		116773		116773	

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

Highlights

- We develop a model of hedonic adaptation for durable goods and apply it to car purchases
- We use a panel dataset for the UK to test the model
- Hedonic adaptation to car ownership has a sizable negative and significant effect on happiness
- Within five years after a purchase, around one third of the happiness increase is dissipated due to adaptation
- We estimate habit reference levels to be rather persistent at around 80%