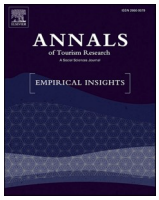
Annals of Tourism Research Empirical Insights 5 (2024) 100155

Contents lists available at ScienceDirect

Annals of Tourism Research Empirical Insights

journal homepage: www.sciencedirect.com/journal/annals-of-tourism-research-empirical-insights



Disentangling temporal changes in travel behavior: An age-period-cohort analysis based on German travel demand

Elisabeth Bartl [a], Alexander Bauer [b], Maximilian Weigert [c], Marion Karl [d,*], Jürgen Schmude [a], Helmut Küchenhoff [b]

[a] Department of Geography, Ludwig-Maximilians University Munich, Luisenstrasse 37, 80333 Munich, Germany
[b] Department of Statistics, Statistical Consulting Unit StaBLab, Ludwig-Maximilians University Munich, Ludwigstrasse 33, 80539 Munich, Germany
[c] Department of Statistics, Statistical Consulting Unit StaBLab & Munich Center for Machine Learning (MCML), Ludwig-Maximilians University Munich, Ludwigstrasse 33, 80539 Munich, Germany
[d] School of Hospitality and Tourism Management, University of Surrey Stag Hill, Guildford, Surrey GU2 7XH, United Kingdom

ARTICLE INFO

Editor: Lorenzo Masiero

Keywords:
Travel behavior
Temporal change
Generational theory
Life cycle
Meaning of travel
Age-period-cohort analysis

ABSTRACT

Travel behavior changes over the temporal dimensions age, period, and cohort. However, longitudinal studies that simultaneously analyze and separate these temporal effects are missing. This study aims to disentangle the temporal changes in travel behavior (participation, frequency, expenses) and explain these changes through different theoretical lenses. Our analysis builds on large-scale representative secondary data from a repeated cross-sectional survey in Germany on the leisure travel behavior between 1983 and 2018 ($N = 198{,}000$) and uses generalized additive regression. Age and period are main drivers for changes in travel participation, cohort and age main drivers for changes in travel frequency over time. Relative travel expenses do not substantially change over time. Understanding temporal changes in travel behavior can support long-term planning in tourism.

1. Introduction

Changes in travel behavior over time occur in three temporal dimensions (McKercher, 2023): Throughout someone's life (age effect), over time depending on external developments (period effect), and between generations (cohort effect). Travel behavior studies generally investigate a certain point in time but "instead of being seen as an isolated episode/period in life, [travel] must be viewed from a temporal, life course lens" (Fu et al., 2022, p. 1). Although research already targeted these temporal changes in travel behavior several decades ago (e.g., Oppermann, 1995), most studies still only focus on one (e.g., Huber et al., 2019) or two (e.g., Bernini & Cracolici, 2015) temporal dimensions individually, which prevents conclusions about the main temporal driver for changes in travel behavior over time. Focusing on one dimension or theory to interpret change in tourist behavior will consequently not display a full picture and explanation of temporal changes in travel behavior. The few studies that explore all three temporal dimensions reveal that temporal changes in travel behavior do not occur in isolation, but are triggered simultaneously by age, period, and cohort effects (Lin et al., 2023; Weigert et al., 2022). While Lin et al. (2023) analyze the impact of risk aversion on travel behavior and Weigert et al. (2022) examine travel distances, information about changes in travel behavior in relation to changes in the meaning of travel - a central driver in the travel decision-making process (e.g., Chen et al., 2019; Karl et al., 2020; McKercher et al., 2020) - over time is still missing.

Vacation trips gained priority in the lives of recent generations and obtained the status of a right, not just a privilege (McKercher et al., 2020). This implies that the meaning of travel, referring to the priority and importance traveling has in somebody's life (e.g., Chen et al., 2019; McKercher et al., 2020), may have changed over time reflecting some of the changes in travel behavior. To date, changes in the meaning of travel are predominantly analyzed in qualitative studies (e.g., Fu et al., 2022; Huber et al., 2019; Li et al., 2023) or quantitative cross-sectional surveys (McKercher et al., 2020) where retrospective questions about the meaning of travel indicate a temporal change. However, as recently stated in a conceptual paper by McKercher (2023), analyzing temporal change in the attitudes, motives or behaviors of travelers needs to

* Corresponding author.
E-mail addresses: elisabeth.bartl@lmu.de (E. Bartl), alexander.bauer@stat.uni-muenchen.de (A. Bauer), maximilian.weigert@stat.uni-muenchen.de (M. Weigert), m.karl@surrey.ac.uk (M. Karl), j.schmude@lmu.de (J. Schmude), kuechenhoff@stat.uni-muenchen.de (H. Küchenhoff).

https://doi.org/10.1016/j.annale.2024.100155
Received 23 January 2024; Received in revised form 18 September 2024; Accepted 15 October 2024
Available online 22 October 2024

consider three temporal dimensions. To date, an empirical quantitative and longitudinal study exploring temporal change in travel behavior and describing these changes using the concept of meaning of travel is still missing.

To address this research gap, we disentangle the three temporal effects and analyze them simultaneously but separately. Theories linked to changes in each temporal dimension are used to explain how travel behavior has changed in the past decades. Thus, we explore the central research question: *How does travel behavior change over the temporal dimensions of age, period, and cohort?*

We focus on three central components of travel behavior: (1) if someone travels (*travel participation* - the decision to make at least one long trip of five days and longer per year), (2) how often someone travels (*travel frequency* - the number of long trips per year), and (3) how much someone spends on traveling (*travel expenses* - the share of income spent on main vacation trips). The assumption is that people who go on vacation, travel more frequently for leisure and spend more money on vacations attribute a higher priority to travel, i.e. find traveling more meaningful. With the broader aim of enhancing the understanding of travel behavior, we apply age-period-cohort (APC) analysis to estimate how these three components of travel behavior change over the temporal dimensions and which of the temporal effects are the respective main drivers. Constraining factors impacting or inhibiting traveling (Karl et al., 2021) are included in the analysis to account for the fact that someone may not be able to travel due to various reasons. We discuss if and how travel behavior changes over time can be attributed to changes in the meaning of travel by linking our results to concepts and insights from generational and life cycle theory.

The German market serves as an example of the travel behavior of a Western society where financial and temporal restrictions hindering regular traveling are limited and changes in the meaning of travel take a more predominant role than changes in travel constraints over time (Karl et al., 2020). Applying age-period-cohort analysis to a large-scale representative dataset on the leisure travel behavior of Germans between 1983 and 2018 ($N = 198{,}000$) allows for novel insights into the dynamics of change in travel behavior which will not only be of interest to tourism academics but also to the tourism industry. These insights lead to a better understanding of travel behavior, which enables more precise tourism demand forecasting and thus supports destinations in preparing for changes in the future.

2. Literature review

2.1. Temporal changes in travel behavior

Travel behavior is time-variant. Changes in travel behavior happen in three temporal dimensions (McKercher, 2023): individual circumstances in the course of life (age effect) (Bernini & Cracolici, 2015), due to overarching external changes over time (period effect) (Pennington-Gray et al., 2002) and between generations (cohort effect) (You & O'Leary, 2000). Thus, travel behavior is triggered simultaneously by the strongly connected age, period, and cohort effects. Few studies on these temporal changes include all temporal dimensions simultaneously. Table A.1 summarizes relevant studies investigating the same or similar central components of travel behavior as in this study: participation, frequency, and expenses. Some of the early studies simultaneously analyze age, period, and cohort effects, but perform purely descriptive analyses, not able to adequately separate the temporal effects (e.g., Oppermann, 1995; Pennington-Gray et al., 2002), and consequently lead to (differently) biased results. A source of often more severe bias is the negligence of individual dimensions, for example performed by several studies that only analyze one or two temporal effects (e.g., Lohmann & Danielsson, 2001; You & O'Leary, 2000). In general, all of these studies do not provide solid, unbiased conclusions about temporal changes in travel behavior.

Two recently published tourism studies use APC analysis, a statistical approach for separating the temporal effects (Lin et al., 2023; Weigert et al., 2022). Weigert et al. (2022) demonstrate the applicability of this approach on travel distances and highlight how complex, time-related structures can be adequately visualized and communicated. Lin et al. (2023) explore how the effect of risk aversion on travel participation and expenditure changes over the three temporal dimensions. Both studies provide first insight into the relevance of different temporal factors for travel behavior change regarding a particular aspect. We build on these methodological advancements and aim to empirically test and explain why travel behavior changes, based on different theoretical frameworks with specific focus on the meaning of travel as a core factor influencing travel decision-making (e.g., Chen et al., 2019; Karl et al., 2020; McKercher et al., 2020).

Before discussing the meaning of travel and its relation to manifested travel behavior, we first outline how and why travel behavior changes over the individual temporal dimensions.

The **age effect** is commonly explained with life cycle theory, attributing changes in travel behavior to age-related life cycle stages (Wells & Gubar, 1966). Wells and Gubar (1966) define nine such stages, some of which strongly influence travel behavior, like life stages linked to child care and other family responsibilities (Randle et al., 2019). Research on travel participation in the U.S. (e.g., Pennington-Gray et al., 2002), the Italian source market (Bernini & Cracolici, 2015) and China (Lin et al., 2023) reveals that travel participation decreases with age (negative age effect), while studies on different (cultural) contexts (e.g., the Japanese source market) hint at travel participation to be increasing with age (Sakai et al., 2000). Qualitative studies link age (also based on life events like the birth of a child) to changing travel frequencies (e.g., Huber et al., 2019). Unlike studies regarding the participation, quantitative studies on frequency do not find a consistent age effect (e.g., Mattioli et al., 2022; Oppermann, 1995). Finally, only a few studies explore potential age effects on travel expenses. Those that do most prominently find that younger people spend less on tourism than older people (e.g., Bernini & Cracolici, 2015).

The **period effect** comprises external influences from the macro environment that affect people of all ages and generations simultaneously and lead to changes in travel behavior (Pennington-Gray et al., 2002). The PESTEL framework categorizes such external factors into six categories (Political, Economic, Social, Technical, Environmental, Legal). An economic factor can be an economic crisis that forces people to prioritize their purchases, thereby also impacting travel decisions (Dolnicar et al., 2012). While such a crisis, however, only mildly affects the decision to go on vacation (i.e. travel participation), it has a strong effect on travel expenditure (Bronner & de Hoog, 2011). Other historical events affecting travel behavior on a macro-level are the COVID-19 pandemic (Abraham et al., 2021) and the terror attacks of 9/11 (Walters et al., 2019). Technical factors that influence travel behavior are, for example, technological advances in transport (Cohen et al., 2014). For instance, declining costs and the increase of low-cost carriers made air travel affordable for a greater share of society (Cohen et al., 2014) and the increase in travel distances over time is (partly) linked to technological advances in transport (Weigert et al., 2022). Social factors refer to processes like the democratization of traveling (i.e. enhancing the accessibility of vacations across all segments of society) (Gardiner et al., 2013). Macro-environmental changes have been explored individually in the past (studies on changes in social norms, etc.), but only few studies have included period effects in their analyses on travel behavior (Table A.1). For instance, Lin et al. (2023) reveal a decline in travel expenses over time (negative period effect).

The **cohort effect** describes changes in travel behavior between generations like the "Baby Boomers" and "Generation Y", and can be explained with generational theory (Mannheim, 1952), according to which people from similar birth cohorts are shaped by similar major events and thus form a "collective memory". Consequently, developed common values and attitudes remain stable for a lifetime (Schewe & Noble, 2000) and partly shape a generation's travel behavior. For

instance, while Baby Boomers (born 1947–1966) have a "free-spending mindset", the contrary is the case for Generation X (1967–1982) (Schewe & Noble, 2000) who grew up during less prosperous economic times (Davis et al., 2006). However, even though Generation X is less consumption-oriented, they still tend to spend money on traveling, considering it an opportunity to achieve a balanced lifestyle (Gardiner et al., 2014). Generation Y (1983–1994) is again more consumption-oriented and spends more on traveling, on average (Gardiner et al., 2014). Besides such common values, generational differences also stem from passing on travel habits from one generation to the next. Mattioli et al. (2022) show that children from well-educated and well-traveled parents are more inclined to do international trips later in life. Regarding general travel behavior, previous studies found that later generations show lower travel participation (You & O'Leary, 2000), higher travel frequency (Mattioli et al., 2022; McKercher et al., 2020; Oppermann, 1995; Pennington-Gray et al., 2002), and overall higher travel expenses (positive cohort effects) (Bernini & Cracolici, 2015).

The estimation of how behavior change is driven by the individual temporal dimensions is a methodological challenge, also due to the need for valid, long-term data. Past travel behavior studies applied different methodological approaches to deal with this challenge (Table A.1). Compared to the often limited scope of qualitative studies, typically focusing on an in-depth analysis of only one temporal dimension, like age (e.g., Huber et al., 2019), quantitative studies partly tackle this challenge by using tourism-specific secondary data (e.g., Sakai et al., 2000). This facilitates the investigation of a broader range of travel behavior components and often only renders such studies possible. However, due to the lack of suitable large-scale long-term surveys in tourism, secondary data studies are mostly restricted to small or medium sample sizes, rendering the estimation of complex temporal models hardly feasible. Other studies utilize broader, not tourism-specific secondary data (e.g., Bernini & Cracolici, 2015). Such datasets enable the investigation of specific components of traveling (e.g., expenditure) but are usually not well-suited to capture travel behavior comprehensively. Overall, a comprehensive analysis of potential behavioral alterations over age, period and cohort requires both adequate data and the application of adequately complex statistical methods. The latter also comprises controlling for further influencing factors - e.g., a person's individual income -, due to the outlined complexity of travel behavior change.

2.2. Meaning of travel shaping travel behavior

Fundamental need-based theories from social psychology, such as Maslow's (1943) hierarchical pyramid of needs, establish the relationship between human behavior and need fulfillment. Travel behavior can be understood as a fulfillment of travel needs, motivating people to go on vacation for reasons like relaxation or experiencing other cultures. This core motivation for travel has been explored in tourism research under the umbrella of *meaning of travel* (Chen et al., 2019; Li et al., 2023; McKercher et al., 2020). It explains why people engage in travel (Crompton, 1979), referring both to its initiation (McKercher et al., 2020) and intensity (Chen et al., 2019; Hong et al., 2005). If people view traveling as an important activity, they are more likely to go on vacation (McKercher et al., 2020), travel more frequently (Chen et al., 2019), and spend a larger share of their income on traveling, thus prioritizing travel expenditure in their overall expenses (Hong et al., 2005). The latter even holds under challenging circumstances (Dolnicar et al., 2012) like economic crises (Bronner & de Hoog, 2016). The importance of this very individual meaning of travel is a concept that is deep-rooted and can already be observed with children (Li et al., 2023).

Research on temporal changes in the meaning of travel indicates substantial time-variance. Changes occur over the three outlined temporal dimensions: the course of life (age effect) (Fu et al., 2022), due to overarching external changes (period effect) (Chen & Petrick, 2016) and between generations (cohort effect) (McKercher et al., 2020). Randle et al. (2019) conceptually explore the **age effect** and claim that the importance ascribed to travel is directly related to life challenges. For example, raising a small child or the impact of old age may reduce the importance of vacations in people's lives. Qualitative studies from a life course perspective argue that travel behavior is crucially influenced by such changes in the meaning of travel (e.g., Fu et al., 2022; Huber et al., 2019) as values also change with age (Fitzenberger et al., 2022). Gunter and Smeral (2016) empirically analyze temporal change in the meaning of travel due to external factors (**period effect**) - utilizing the change in income elasticity - and find that traveling has become more important. This coincides with findings that traveling has become a habitual practice in modern societies (Chen & Petrick, 2016) insofar as sufficient financial resources are available (Bernini & Cracolici, 2015). McKercher et al. (2020) use a cross-sectional survey to analyze travel behavior, attitudes towards travel, and the meaning of travel of four Chinese generations and find that the meaning increases over generations (**cohort effect**). Leijen et al. (2022) backs this empirical finding and concludes that - similar to the life cycle - changes in values can also be attributed to generations. Thus, considering the meaning of travel and its temporal change is essential to explain why travel behavior changes over the temporal dimensions. Until now, discussions on changes in the meaning of travel have primarily taken a conceptual perspective (Randle et al., 2019) or relied on quantitative cross-sectional surveys (McKercher et al., 2020) or retrospective qualitative approaches (Huber et al., 2019) rather than a comprehensive quantitative approach.

2.3. Travel constraints and sociodemographic factors shaping travel behavior

People are not always able to fulfill their travel needs because of temporary or permanent constraints restricting their travel plans (Karl et al., 2021). People who consider traveling important will only travel more frequently if not faced by severe travel constraints (Chen et al., 2019). Consequently, the direct link between the meaning of travel and travel behavior is impacted by these constraining "life challenges" (Randle et al., 2019).

Travel constraints restrict people's travel decisions and need to be negotiated before vacations can take place, leading to changes in travel behavior (Karl et al., 2021). Three types of such constraints have been identified in past studies (Crawford & Godbey, 1987). Structural constraints, such as family obligations or financial restrictions, are particularly strong influencing factors of travel behavior (Karl et al., 2020). Financial restrictions comprise two elements: The current income as a direct constraint restricting travel expenses (Nicolau & Más, 2005) and the prospect of future income as an indicator for financial flexibility in the long-term (Bernini & Cracolici, 2015), particularly relevant in times of financial insecurity on the macro-level. Further restrictions are intrapersonal constraints, such as the state of health (You & O'Leary, 2000), or interpersonal constraints, including the lack of a travel partner (Karl et al., 2021).

In addition to travel constraints, past research has identified several key sociodemographic factors that influence travel behavior (see Filimon et al., 2022 for a summary). For instance, women tend to travel more frequently (Collins & Tisdell, 2002, Losada et al., 2016). When studying temporal changes of travel behavior, it is crucial to control for such effects of (temporally varying) sociodemographic factors and travel constraints to draw conclusions about the part of behavior change actually linked to time.

3. Methods and material

3.1. Dataset

Our study uses pseudo-panel data consisting of annual individual-level data derived from a cross-sectional survey focusing on leisure travel, encompassing around 7500 individuals each year in Germany

(FUR, 2020). The survey is representative regarding federal state, city size, age, sex, household size and income, education level and citizenship. Full details on the study design (exemplarily for the 2016 survey) can be found in FUR (2018). The data covers the travel years 1983 to 2018. We exclude the years of the COVID-19 pandemic as these data would negatively affect model estimation, due to the (temporally) varying political restrictions that (severely) affected personal travel decision-making. In every year's cross-sectional survey, respondents report on all trips conducted in the previous year with a minimum length of five days in face-to-face interviews, with an annual response rate of approximately 75 %. The questionnaire comprises questions on travel participation, frequencies, expenses, destinations, activities and motivations. Only respondents aged 18 to 80 with German citizenship living in the region of former West Germany were included in our study. The exclusion of East German respondents was done to ensure a stable population and source region. Appendix D contains the results of a sensitivity analysis, re-estimating our main models on the data of all German citizens, which leads to structurally similar findings. People under 18 were excluded to guarantee that respondents had autonomously made travel decisions, without being influenced by legal or financial obligations associated with being a minor. People over 80 were excluded because heavy travel constraints, especially health-related, might limit a free decision-making process, as there's an increase in illnesses, especially chronic ones, as people enter a later life stage (Maresova et al., 2019) with 90 % of Germans aged 80 and older being classified as multimorbid (i.e. having multiple illnesses) (Zimmermann et al., 2022). Furthermore, the years 1986 and 1992 to 1994 were excluded due to overall implausible data regarding income and travel expenses. Other years did not show relevant implausibilities. In total, 198,000 respondents remain in our dataset, 146,000 of whom traveled in the respective year. Due to the high quality of the face-to-face interviews, none of these observations had missing information regarding any of the analyzed dependent or independent variables. We describe central sociodemographic and travel-related variables in Appendix B.

3.2. Research models

We develop three research models to analyze temporal changes, each regarding one aspect of the travel decision-making process, influenced by changes in the meaning of travel: (1) Does a person travel? (*travel participation*), (2) if someone travels, how often does someone travel? (*travel frequency*), and (3) how much money is spent on vacations? (*travel expenses*).

The three models rely on different underlying **(sub)samples** and **dependent variables** (Fig. 1). While the participation model analyzes all survey respondents, the frequency and expenses model only analyze travelers. Accordingly, the first model provides information about the whole population whereas the latter two models only refer to the traveling population, excluding anyone who has not taken any trip in the respective year.

The selection of models is based on the central assumptions that, when individuals perceive travel as a meaningful pursuit, they are more likely to participate in leisure travel (McKercher et al., 2020), travel more frequently (Chen et al., 2019) and allocate a greater share of their income to traveling (Hong et al., 2005).

The participation model reflects the most fundamental manifestation of the meaning of travel, i.e. the decision to make at least one trip - of at least five days length - per year (McKercher et al., 2020). **The frequency model** analyzes the number of such trips a person takes per year, and is a relevant dimension based on Chen et al. (2019), who find a positive association between the meaning of travel and travel frequency. Since the exact number of conducted trips is not available for all years, we base the frequency model on the binary question whether a traveler performs one or multiple trips. This decision only leads to a minor loss of information, as about 95 % of our travelers do not travel more than twice a year. **The expenses model** refers to the share of available income a person spends on their main vacation trip (based on the questionnaire item"What were the overall travel costs (in €): Journey, accommodation, food and other costs in total for all members of your household traveling?", adjusted to reflect the average cost per person). We assume that this reflects changes in the meaning of travel because people who prioritize vacations in their overall expenses are shown to

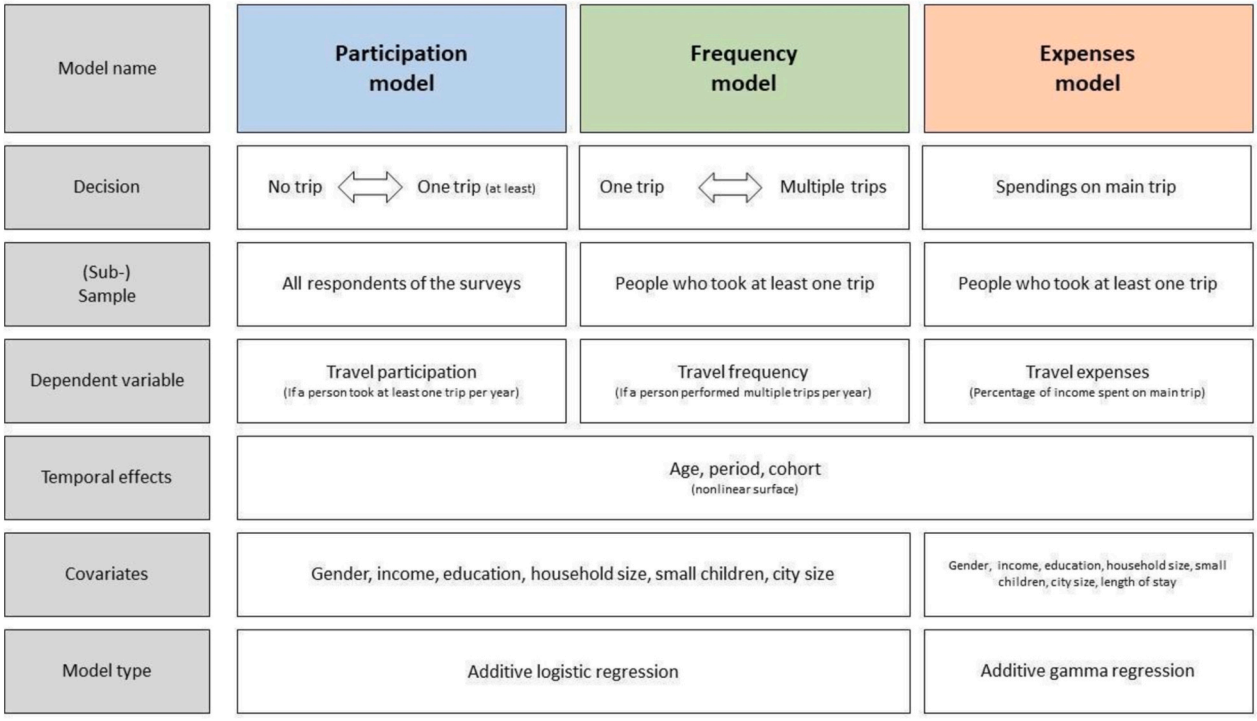


Fig. 1. Overview of research models with underlying model specifications.

attribute higher importance to traveling (Hong et al., 2005). Focus on the main vacation trip ensures comparability over the whole study period since our survey until 1996 only contains such travel expenses that refer to the main vacation trip. Appendix C contains the results of sensitivity analyses, re-estimating our main models on partial datasets - including all years where travel expenses are available for all performed trips -, which lead to structurally similar results. To account for financial synergy effects within households, we use the OECD-modified equivalence scale by Hagenaars et al. (1995) to adjust the household net income based on household size and the number of travelers. Since a person's travel group often differs from its household, we analyze relative travel expenses per adjusted traveler. Both travel expenses and net income were inflation adjusted.

Fig. 2 visualizes the distribution of every **dependent variable** (participation, frequency, expenses). For each one of them, its respective research model aims to disentangle the three **temporal effects** (age, period, cohort) to describe its variation structure. Regarding the cohort effect, we consider five birth cohorts (Silent Generation 1939–1946, Baby Boomer 1947–1966, Generation X 1967–1982, Generation Y 1983–1994, Generation Z 1995–2010).

Further influencing factors (travel constraints and sociodemographic factors) are accounted for by including a range of **covariates** in the research models. Besides technically ensuring the comparison of individuals with similar initial conditions in their travel decision-making process, this also allows for a more differentiated approach as we separate the effects of travel constraints and sociodemographic factors from the temporal effects. We control for the presence of young children in the family up to age five (youngest age group available in the data), household income, education, household size, gender, and city size (Table B.1). For full comparability in the expenses model, we also include the length of stay to account for travel-related characteristics. External factors (e.g., political or macro-economic developments) are represented by the estimated period effect.

3.3. Statistical analysis

We use age-period-cohort (APC) analysis to separate the age, period, and cohort effects that underlie observed changes in the dependent variables. The analysis is based on a statistically robust and comprehensive statistical APC approach by Weigert et al. (2022), providing innovative visualization techniques and a flexible modeling approach to circumvent the identification problem, i.e. that each of the three temporal dimensions is a combination formed through linear relationships with the others (Clayton & Schifflers, 1987). We now apply this approach to a complex concept in tourism science, backed by a solid theoretical foundation. Full details on the statistical method and its estimation scheme can be found in Weigert et al. (2022). Age, period, and cohort effects are separated by estimating generalized additive regression models (GAMs, Wood, 2017), utilizing a tensor product spline basis to flexibly estimate a nonlinear interaction surface between age and period, with the cohort effect represented along the diagonals. The regression models have the structure

$$g(\mu_i) = \beta_0 + f(age_i, period_i) + \eta_i, i = 1, \ldots, n,$$

with μ_i the conditional expected value of the response variable for observation i, $g(.)$ the link function for the respective model class and n

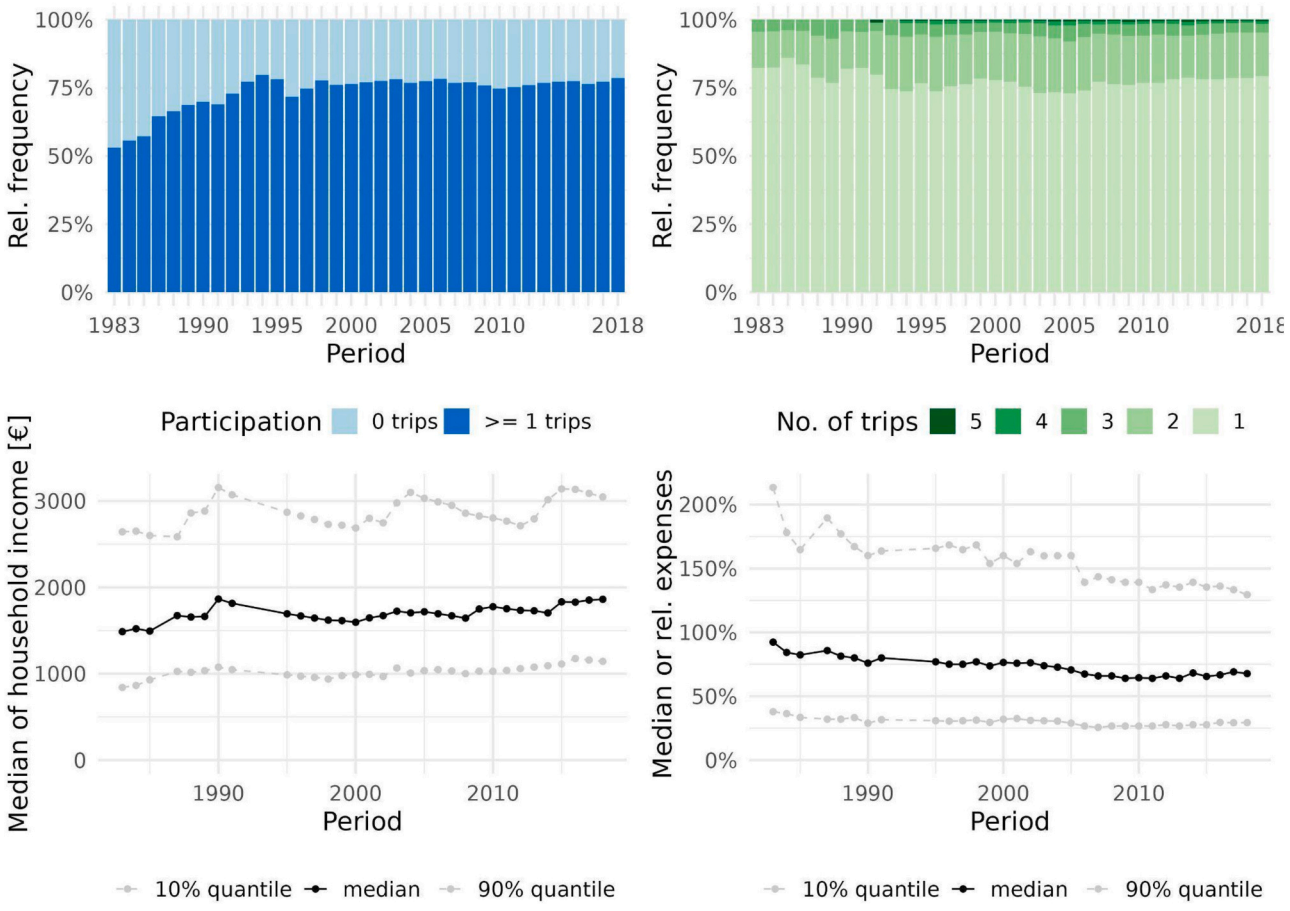


Fig. 2. Relative frequency of travel participation (top left pane) and travel frequency (top right), and person- and inflation-adjusted median income (bottom left) and total annual expenses relative to the monthly income (bottom right); bottom plots show the annual 10 %, 50 % (median) and 90 % quantiles of the respective distribution.

the number of individuals. The linear predictor is formed by the intercept β_0, the bivariate tensor product surface $f(age_i, period_i)$ and the term η_i containing the additional covariates outlined below. We include all categorical and continuous covariates with linear and nonlinear effects, respectively. All nonlinear effects (including the tensor product surface) are based on P-splines (Wood, 2017), with ten basis functions per dimension. Marginal effects for a specific age, period, or cohort are extracted from the bivariate surface by averaging over all values belonging to that specific age, period, or cohort, respectively (Weigert et al., 2022). While we will only interpret such marginal effects in the following, the estimated APC surface estimates can be found in Appendix B.

The **model type** of the participation model and the frequency model is an additive logistic regression with a logit link. Due to the right-skewed distribution of expenses with positive values only, we use additive gamma regression with a log link for the expenses model. All models control for the outlined travel constraints and sociodemographic variables (Appendix B). Model evaluation showed acceptable goodness of fit of the individual models (Appendix B).

The open-source software R was used for all statistical analyses (R Core Team, 2022). Models are estimated with package 'mgcv' (Wood, 2017). Visualizations are based on the package 'APCtools' (Bauer et al., 2022). Together with a data subsample, our software code is publicly available in the accompanying open-source GitHub repository (Bauer & Weigert, 2024).

4. Results and discussion

Comparing this study's results to previous studies investigating temporal change is challenging for two main reasons. First, most previous research is based on case studies of certain source markets (e.g., Japan; Sakai et al., 2000), leading to differences in the results simply due to travel behavior being influenced by different cultural backgrounds. Second, most previous studies do not analyze the three temporal effects simultaneously (e.g., only cohort; Lohmann & Danielsson, 2001) or properly disentangle the temporal effects based on adequate statistical models (e.g., Oppermann,1995). Consequently, temporal effects may be over- or underestimated if other temporal dimensions are not controlled for. The bias is presented in detail by McKercher (2023) who critiques the sole application of generational theory within cross-sectional studies. The few studies that separate temporal effects do not focus on the same components of travel behavior or the same dimension of the travel decision (e.g., risk aversion; Lin et al., 2023; travel distance change; Weigert et al., 2022). Since travel behavior change may not manifest uniformly across all aspects, their comparability is also often not given.

In the following, we first compare the estimated temporal effects and explore which temporal dimension affects behavior change most. Subsequently, we discuss the individual effects in more detail.

4.1. Comparison of temporal effects

Our APC analysis reveals how the three aspects of travel behavior (participation, frequency, expenses) change over the three temporal dimensions and which of the three effects is the main driver for travel behavior change. The results suggest that age and period are the main drivers for participation change, while cohort and age are the main drivers for frequency change (Table 1). Accordingly, the decision if someone travels is predominantly driven by life cycle and macro-environmental changes, while the decision how often someone travels is predominantly shaped by generational membership and life cycle. Travel expenses show no substantial main driver as the ratios between the maximum and minimum exponentiated effects of age, period, and cohort are in a similar range (Table 1).

For the participation and frequency model, the estimated effects are ratios between the odds to travel and the odds to travel more frequently (odds ratios, OR), respectively. For the travel expenses model, in contrast, exponentiated effects (EE) relate to multiplicative changes in the expected travel expenses. Thus, the range of obtained effects for travel participation and frequency cannot be directly compared to the range of effects for travel expenses. The following example illustrates the difference in interpretation: The age effect for participation shows that the chance to make at least one long vacation trip is 164 % higher for people aged 18 (estimated OR 1.11) compared to people aged 80 (OR 0.42) since the effects show a difference in the odds of around +164 % (= 100 * [1.11 / 0.42–1]). The respective age effect of relative expenses indicates that for people aged 40 (estimated EE 1.04) the expected relative travel expenses are 10 % (= 100 * [1.04 / 0.95–1]) higher than for people aged 18 (EE 0.95). All interpretations and tendencies are made under the assumption of keeping all covariates constant.

Fig. 3 displays the estimated marginal effects for all three research models, visualized on an exponential scale, and illustrates how travel behavior changes over all three temporal dimensions. While the age effects for participation and expenses are highest for middle-aged people (30–45), the tendency to make several trips per year is highest for older ages (60–75). The period effects indicate that the number of people making at least one trip and tending to travel more often rose until the mid-1990s. From then onwards, the period effect for participation stabilizes. Interestingly, from the mid-2000s onwards those who travel at least five days tend to travel less frequently over the investigated time period. Similar structures can be observed for the cohort effects, where later generations tend to participate more often while going on long trips less frequently.

Our **participation** model confirms results by Pennington-Gray et al. (2002) who found that whether someone travels primarily depends on individual circumstances (age effect). In addition, our period effect - steeply increasing until mid-1990 - reveals that overarching external effects are also decisive for the decision to travel, consistent with Lin et al. (2023). The main drivers for changes in travel **frequencies** are cohort and age effects. Besides a decreasing cohort effect towards later

Table 1
Overview of estimated age, period, and cohort effects.

Model	Effect	Value with maximum effect	Value with minimum effect	Maximum OR/EE	Minimum OR/EE	Ratio
Participation	Age	41	80	1.21	0.42	**2.89**
	Period	2001	1983	1.22	0.49	**2.47**
	Cohort	1996	1939	1.37	1.01	1.36
Frequency	Age	69	27	1.60	0.67	**2.39**
	Period	1995	1985	1.23	0.78	1.58
	Cohort	1939	1990	1.38	0.50	**2.75**
Expenses	Age	39	80	1.04	0.91	1.14
	Period	2018	1996	1.04	0.95	1.09
	Cohort	2000	1988	1.07	0.98	1.09

Note: For each model and effect, the following information is listed: Variable value where the effect reaches its maximum/minimum; maximum/minimum odds ratio (OR) or exponentiated effect (EE); ratio between the respective maximum and minimum odds ratio or exponentiated effect. The maximum ratios per model are highlighted in bold. Cohort effects are considered for birth years from 1939 onwards only.

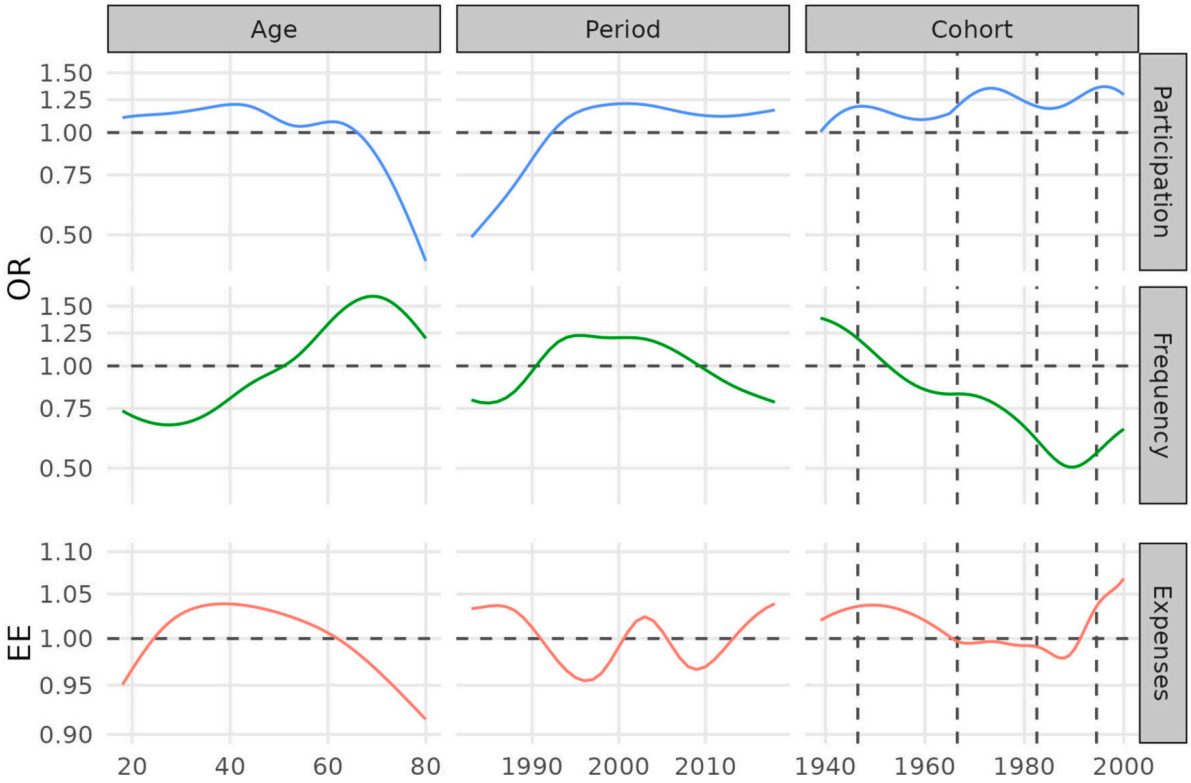


Fig. 3. Estimated marginal age (left column), period (middle), and cohort (right) effects for travel participation (top row), travel frequency (middle row), and relative expenses (bottom row) on a log2 scale in terms of odds ratios (OR) and exponentiated effects (EE). The cohort effect is displayed for birth years from 1939 onwards only. Dashed vertical lines mark the boundaries between the defined generations.

generations, travel frequencies are shaped by individual circumstances and changes between life cycle stages (increasing age effect between age 27 and 69). To some degree, similar findings are reported in the studies by Lohmann and Danielsson (2001) who find that travel behavior is determined by generational affiliation (even though they do not include age and period) as well as You and O'Leary (2000) (who do not include the period effect). The travel **expenses** model reveals that age, period, and cohort are all nearly equally strong drivers for travel spending.

In contrast to previous studies, not analyzing all three temporal dimensions simultaneously (Table A.1), our study reveals the relative strength of the temporal effects in a comparative way and shows how much travel behavior changes according to each temporal dimension: life cycle (age), macro-level developments (period), and generational affiliation (cohort). Whenever previous studies neglected a specific temporal effect, it is actually comprised in the respective other estimated effects. For instance, while other model-based studies (e.g., Bernini & Cracolici, 2015) assume that the period effect is neglectable, we uncover that the period effect is present and relevant in all three models for our investigated timeframe. The period effect is even a main driver for travel participation and has the same direction as the cohort effect. This confirms results from a previous study on travel distance change over time (Weigert et al., 2022) and re-affirms the argument of McKercher (2023) on the relevance of macro-level developments.

4.2. Individual temporal effects

To analyze the three temporal effects in depth, we now separately discuss all three models (participation, frequency, expenses) for each temporal effect (age, period, cohort).

Age effects. The **participation model** indicates that age has a negative effect on travel participation, confirming previous studies (e.g., Bernini & Cracolici, 2015; Lin et al., 2023; Pennington-Gray et al., 2002). People between the ages 18 and 50 have the highest tendency to travel at least once per year, with a peak at 41 (OR 1.21). From the age of 50 onwards, travel participation increases temporarily before it decreases continuously from age 61 (OR 1.08) onwards. The **frequency model** reveals a unimodal structure with one peak. The results show that travel frequency reaches its minimum at age 27 (OR 0.67). People's tendency to travel two or more times per year then increases until it peaks at 69 years of age (OR 1.60), followed by a steady decrease with growing age. The **expenses model** reveals that relative travel expenses increase until age 39 (EE 1.04) and then decrease with age, showing that young and older people spend a smaller share of their income on traveling than middle-aged people. Besides reinforcing existing knowledge, our results indicate that middle-aged people spend the most on travel, unlike Bernini and Cracolici (2015) who find that tourism expenditure increases quite consistently with age. Further, our analysis empirically confirms qualitative studies (Huber et al., 2019; Randle et al., 2019) and demonstrates that age can substantially influence the three measured components of travel behavior (Fig. 3).

Period effects. The **participation model** reveals that the chance to undertake at least one trip per year increases from the 1980s until the end of the century. The chance to make at least one vacation trip is 158 % higher for people in 1999 (OR 1.23) compared to people in 1983 (OR 0.48). Travel participation then remained stable, reflecting a consistent absence of participation in travel within a specific segment of the population (Popp et al., 2021). The **frequency model** - analyzing the people's tendency to perform at least two trips per year - shows an increasing period effect from 1985 to 1995, which declines slightly afterward. This development up until the mid-1990s confirms findings by Oppermann (1995) and may be due to the back then increasing popularity of short trips (Losada et al., 2016), not considered in the current study as of the focus on longer vacations. The period effect in the **expenses model** shows a wavelike development of relative travel expenses, with a low in 1996 (EE 0.95), a peak in 2003 (EE 1.02), and another low in 2009 (EE 0.97) while starting and ending at a rather high

level (1983, EE 1.03, 2018: EE 1.04). Accordingly, people with the same sociodemographic and economic information and similar travel constraints spent less (relatively) in 2008 than in 2018. This overall development emphasizes how closely related people's decision to spend their income on tourism is with external developments.

Cohort effects. The **participation model** shows that generational differences in the likelihood to travel at least once per year exist, confirming previous studies (Bernini & Cracolici, 2015; Mattioli et al., 2022; McKercher et al., 2020; You & O'Leary, 2000). The model indicates that later generations are more likely to travel at least once a year than earlier generations. The cohort effect for participation increases wave-like with three peaks. The first and lowest peak emerges in the Silent Generation (birth years 1939–1946; OR 1.12), followed by a higher peak in Generation X (1967–1982; OR 1.29) and a third peak in Generation Z (1995–2010; OR 1.34). In contrast to Oppermann (1995), Pennington-Gray et al. (2002) and Mattioli et al. (2022), we find that later generations tend to travel less frequently as the **frequency model** indicates steadily decreasing travel frequencies from the Baby Boomers (1947–1966) to Generation Y (1983–1994). Relative travel **expenses** mainly decrease until Generation Y and increase again for the youngest generations. Conversely, Bernini and Cracolici (2015) found an overall increase in travel expenditure over generations. These discrepancies might be due to previous studies including domestic travel and/or shorter vacation trips. For all three models, the cohort effect of the later generations (Generations X and Z) must be interpreted with caution because it partly reflects the observed age differences, as these youngest cohorts do only contain young people up to the age of 35 in our dataset.

Covariate effects. Obtained covariate effects (Appendix B) are in line with literature (e.g., Bernini & Cracolici, 2015; Karl et al., 2020; Nicolau & Más, 2005). Women (participation: OR 1.06; frequency: OR 1.11), people with a higher level of education (participation: OR 2.48 for university or college compared to junior high school; frequency: OR 2.61), from larger cities (participation: OR 1.41 for people from cities with more than 500,000 inhabitants compared to people from villages with less than 5000 inhabitants; frequency: 1.24), with larger household size (participation: OR 1.56 for households with five or more people compared to single-person-households; frequency: OR 1.40) and higher income (participation: OR 5.26 for household income 6000€ compared to household income 1000€; frequency: OR 3.52) tend to rather participate and travel more frequently. In contrast, people with young children tend to travel less frequently (participation: OR 0.74; frequency: 0.92).

In the expenses model, the dominant factor is trip duration. The longer the trip, the more travelers spend. The expected expenses are about four times higher for people spending more than 30 days compared to people spending only five days (EE 3.99). Higher income (EE 0.34 for household income 6000€ compared to household income 1000€) and larger household size (EE 0.84 for households of five or more people compared to single-person-households) are associated with lower relative travel expenses for trips of equal length.

4.3. Explaining temporal changes in travel behavior through different theoretical lenses

We now explain the temporal changes in travel participation, frequency and expenses using generational and life cycle theory. We further include potential reasons for changes in travel behavior due to changes in the meaning of travel.

As outlined, life cycle theory (Wells & Gubar, 1966) links age groups to specific life stages. We find that people in the "full nest stage" - i.e. middle-aged, generally married people with young children - tend to participate more in tourism and spend a larger share of their income on traveling than other age groups. One possible explanation for the increase in travel activity during this life cycle is the role of vacations as a time for family bonding (Lehto et al., 2009). This aligns with research indicating that family cohesion explains the high crisis resistance of vacation trips (Bronner & de Hoog, 2016). Moreover, crisis resistance provides insights into the meaning of travel, as a crisis forces people to further prioritize consumer goods. Our findings on the high meaning of travel provide some empirical evidence for the theoretical explanation of Randle et al. (2019), who discuss how the meaning of travel changes over age. In the life stage when people enter retirement, they still participate in tourism, and - even though faced with stronger financial constraints due to generally lower income - tend to travel more often, but spend a lower share of their income on traveling. A potential explanation is that retirees have more discretionary time due to fewer work and family-related commitments (Karl et al., 2020) and may attach more meaning to traveling (Huber et al., 2019). In later life stages, people reduce their travel activities because of increasing health and mobility restrictions in older age (You & O'Leary, 2000). These restrictions make traveling difficult, and our study clearly shows that people tend to either give up traveling or travel less often with increasing age.

The uptake in travel participation over time reflects the democratization of travel, a social change enhancing the availability of vacations for everyone in society (Gardiner et al., 2013). Traveling becomes the social norm and a habitual practice in modern societies (Chen & Petrick, 2016), and tourism takes a more important role in people's lives, implying an overall increase in the meaning of travel. One reason for the better accessibility of travel are the technological advancements in transport that made traveling more affordable for the wider society (Cohen et al., 2014). Temporal changes in relative travel expenses may mirror economic and technological developments on the macro-level. The global tourism sector is impacted by the threat of terrorism (Walters et al., 2019). For instance, people in the US spent substantially less money on leisure travel subsequent to the terror attacks of September 11, 2001 (Floyd et al., 2004). Relative travel expenses also dropped in 2009, potentially in relation to the economic crisis in 2008, forcing people to prioritize their limited financial resources on essential purchases (Dolnicar et al., 2012). However, an economic crisis does not fully deter people from traveling but leads them towards spending less on vacations, as also indicated by Bronner and de Hoog (2011). Traveling for pleasure and going on at least one annual vacation has become a normal good rather than a luxury over the last decades (Gunter & Smeral, 2016).

While life cycle theory and macro-level developments offer directly applicable explanation frameworks for changes in travel behavior and the meaning of travel between age groups and over time in general, similar conclusions about the actual drivers of differences between cohorts remain more abstract. Being the most practicable theory to date, we utilize the sociological theory of generations developed by Mannheim in 1928 (published in English in 1952). Mannheim's (1952) theory of generations assumes that social change over time occurs because cohorts with similar social norms, attitudes and behaviors (i.e. generations) appear or disappear, and these cohorts shape the overall society during their time. We translated this theory to explain travel behavior change between generations, assuming that people from the same birth cohorts with shared memories and experiences develop a similar travel behavior because of attributing a similar meaning or value to leisure travel (Leijen et al., 2022). Three generational aspects seem particularly relevant: First, younger generations are socialized early with traveling (Mattioli et al., 2022) because their parents are already accustomed to traveling and take their children with them. Accordingly, vacations have become a habit (MacInnes et al., 2022) and an important element of life (McKercher et al., 2020) for people from younger generations. A recent study demonstrates how children already form a meaning of travel through their travel experiences (Li et al., 2023). The second generational difference are values and norms regarding the work-travel-balance (Gardiner et al., 2014). For instance, Generation X, who values a balanced lifestyle and considers leisure time more meaningful than other generations (Gardiner et al., 2014), were found to participate more often in traveling than older generations. The last

generational difference is the spending mindset. In our study, Baby Boomers who were born during prosperous economic times (Davis et al., 2006) have a free-spending mindset - even if it means paying for purchases on credit (Schewe & Noble, 2000). A similar consumption-oriented mindset can be attributed to Generation Y (Gardiner et al., 2014). People in Generation X, however, are more cautious about purchases and tend to be thrifty (Davis et al., 2006), leading to the lowest relative travel expenses observed.

5. Conclusions

5.1. Implications for tourism research

Previous studies investigating temporal changes in travel behavior do not include all temporal dimensions (McKercher, 2023), or miss separating them adequately. Motivated by the conviction that closing this gap can benefit the understanding of travel behavior, this study strove to explore the temporal changes in travel behavior and explain them through life cycle and generational theory, and the meaning of travel. By means of an integrated research design incorporating three central components of travel behavior, we were able to disentangle these temporal dimensions. Most studies on temporal changes in travel behavior focus on one or two temporal dimensions, often excluding external factors (period effect) on the assumption that they are a minor effect. We uncover not only the existence of the period effect in all three models, but even - in addition to age effects - identify it as a main driver for travel participation. Another consequence of neglecting the period effect is that other temporal effects may be biased, i.e. they are potentially over- or underestimated. In our results, not only are all three temporal effects existent for our observed travel behavior components, but they are varying in strength for the two travel behavior components frequency and participation.

This study continues efforts to advance methodological approaches in tourism research by applying a semiparametric APC approach (Weigert et al., 2022) to empirically explore changes in travel behavior. The results support indications that vacations are becoming a necessity rather than a luxury for Western developed countries (e.g., Gunter & Smeral, 2016), and further break this development down into changes in values between generations and variations in people's priorities and focus throughout the life cycle. The analysis offers a statistically robust, flexible representation of the temporal structures using large-scale, long-term data on individual level. Based on the accompanying software package *APCtools* (Bauer et al., 2022), both the descriptive and model-based statistical concepts can easily be applied to other topics and datasets, including panel or repeated cross-sectional, individual or aggregated data.

5.2. Practical implications

Besides contributions to tourism research, our findings are of relevance to the tourism industry. The tourism industry and policymakers need evidence-based knowledge on the change in travel behavior over time to inform long-term planning and investment in specifically targeted infrastructure. We find that travel behavior is continuously changing over all temporal dimensions, making continuous market analysis - including sound predictions of future developments like the travel behavior of certain age groups - vital for the tourism industry. By separating the three temporal effects, we provide the tourism industry with more precise information on age and generational differences. For instance, our findings reveal that age groups and generations show very distinct travel behavior patterns, calling for clear age-related and generational target group marketing approaches. Tour operators should consider the entire lifespan when tailoring their offerings. Implementing specific life stage packages would cater to the unique needs at each life stage. While our results provide general implications, more specific implications could be drawn from Fu et al. (2022). For example, these packages could provide an opportunity to engage in profound self-reflection for those in later stages, which is a key aspect in that life stage. As members of a generation are united in their common values and have a certain similarity in travel patterns (Schewe & Noble, 2000), tourism operators can adapt more precisely to tourists' needs, knowing how their generational membership and the changes over a life cycle will affect travel demands. While more people of later generations take at least one vacation trip per year, their travel frequency decreases. To address this decreasing frequency of long trips among later generations, destination management organizations can, for instance, aim at facilitating workation opportunities.

5.3. Limitations and future research

Several limitations underlie this study. First, we faced limited selection options regarding the variables. In general, when secondary data is used for research some limitations need to be considered and weighed against the benefits of using a rich, long-term and large-scale secondary dataset. For example, the selection of the central travel behavior components and covariates is limited to consistently observed measurements available in our underlying long-term secondary dataset. We have chosen three components shaped by the meaning of travel, which are central drivers in the travel decision-making process. The inclusion of further components would allow for more comprehensive insights, however due to the limitation of using an established long-term dataset, these three travel components represent a reasonably good approximation for this research study. To make model structures comparable, we include similar covariates in all three models. A second limitation of this study is that we used a case study approach by basing our results on pleasure travel data among Germans. This case study approach limits the generalizability of research findings to other source markets, in particular those with different demographic and economic characteristics. However, the size of the German source market in terms of international tourism spending, along with its demographic and economic characteristics, and its abundance of vacation days compared to other regions, suggests notable similarities to other Western European source markets, potentially leading to important implications for various travel destinations and source markets. Third, because each of the temporal dimensions is a linear combination of the other two effects (Clayton & Schifflers, 1987), perfect separation of temporal effects is generally not possible, rendering the statistical estimation problem not perfectly identifiable (Weigert et al., 2022). However, given the repeated cross-sectional and annually representative data and the integrated research design (based on a state-of-the-art statistical approach and the inclusion of further control variables), our study design allows for a good approximative separation. The coverage of multiple decades and a broad range of age and cohort groups by our dataset is an essential prerequisite for being able to soundly disentangle the temporal association structures. Finally, while we work with a large-scale, high-quality cross-sectional dataset, its cross-sectional nature underlies specific limitations compared to more informative panel studies. Most notably, cross-sectional data only allow for the interpretation of overall, "on average" developments, but not for conclusions on how developments and association structures behave on the scale of individual travel biographies. Future research - even though being a long-term, expensive investment - needs to strive towards collecting such long-term panel data on tourist behavior to analyze the temporal effects and individual travel biographies as accurately as possible.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the German Research Foundation (DFG) [grant number KU 1359/4-1, SCHM 850/22-1, and KA 4976/2-1]. The authors of this work take full responsibility for its content.

CRediT authorship contribution statement

Elisabeth Bartl: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Alexander Bauer:** Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Maximilian Weigert:** Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Marion Karl:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Jürgen Schmude:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Helmut Küchenhoff:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgements

The authors would like to thank Forschungsgemeinschaft Urlaub und Reisen e.V. (FUR) for providing the underlying data and help regarding questions of any type to the dataset.

Appendix A. Temporal dimensions

Table A.1
Overview of literature on temporal dimensions and their impact on travel behavior components (participation, frequency, expenses) (selected studies).

Authors (Year)	Research topic	Approach	Sample	Impact on …	Studied effects			Core findings
					Age	Period	Cohort	
Oppermann (1995)	Changing tourism patterns	Quantitative (descriptive)	German tourists (n = 124)	Travel frequency, intensity, destination choice, succession	x	x	x	Generation influences travel frequency; tourism patterns change over all three dimensions; Frequency is higher for later generations
Sakai, Brown, and Mak (2000)	Demographic change and international travel demand	Quantitative (linear regression)	Secondary data on Japanese overseas travelers, (JTB)* (n = 140)	Propensity to travel abroad	x		x	Cohort effects influence the propensity to travel abroad more than age effects; seniors have a higher propensity to travel
You and O'Leary (2000)	Changes in travel behavior patterns	Quantitative (MANOVA, ANOVA, cluster analysis) (linear effects)	Japanese senior travelers (n = 691)	Travel propensity, destination, activity, participation, and travel philosophy	x		x	Travel characteristics of senior travelers change over time; the older travel market is becoming more active; dominance of the cohort effect
Lohmann and Danielsson (2001)	Future travel behavior of senior citizens	Quantitative (descriptive)	Secondary data on travel behavior of German residents, (n = 7500)	Travel participation, destination choice			x	Tourist demand and travel behavior are determined by generations
Collins and Tisdell (2002)	Influence of life cycle on travel patterns	Quantitative (descriptive)	Secondary data on travel behavior of Australian residents, (n = unknown)	Travel participation (by gender and purpose)	x			Gender has a major influence on travel demand; life cycle travel patterns for men and women vary considerably
Pennington-Gray, Kerstetter, and Warnick (2002)	Forecasting international travel patterns	Quantitative (Palmore's 1978 triad method) (linear effects)	Secondary data on travel behavior of US residents, (SMRB)* (n = 104,424)	International travel participation, international travel frequency	x	x	x	Later generations show higher travel frequency; participation decreases over age; period effects primarily affect travel behavior
Bernini and Cracolici (2015)	Influence of age and cohort on travel participation and expenditure	Quantitative (hurdle model) (non-linear effects)	Secondary data on Italian residents, (BF)* (n = 265,028)	Travel participation and travel expenditure for domestic and international travel	x		x	Participation decreases with age and is lower for later generations; expenditure increases with age and is higher for later generations
Huber, Milne, and Hyde (2019)	Influence of life events on tourism behavior	Qualitative	Biographical interviews with German seniors (n = 23)	Travel frequency, travel partner, motivation, trip duration, transport	x			Life events are diverse and have an impact on seniors' tourism behavior; the meaning of travel changes over time
McKercher, Lai, Yang, and Wang (2020)	Change in values over generations	Quantitative (descriptive, t-tests)	Chinese residents (n = 449)	Travel propensity, importance of travel, attitudes to travel			x	Generational factors influence tourism propensity, intensity, and experience; the meaning of travel increases over generations
Fu, Kirillova, and Lehto (2022)	Tourism consumption over the life course	Qualitative	Biographical interviews with US residents (n = 25)	Travel participation, travel frequency, motivation,	x			Travel frequency increases and decreases over the course of life

(*continued on next page*)

Table A.1 (*continued*)

Authors (Year)	Research topic	Approach	Sample	Impact on …	Studied effects			Core findings
					Age	Period	Cohort	
				destination, trip duration, travel party				
Mattioli, Scheiner, and Holz-Rau (2022)	Socialization effects of international travel	Quantitative (Poisson, neg. binomial regression) (linear effects)	German residents ($n = 7695$)	Travel frequency, age at first vacation			x	Frequency is higher for later generations
Lin, Jiang, Li, and Qin (2023)	The effect of risk aversion on travel participation and expenditure	Quantitative (Heckman model with a hierarchical apc model) (linear effects)	Chinese households ($n = 71,191$)	Travel participation, expenditure	x	x	x	Participation decreases with age and is lower for later generations; important period effect on travel participation; Expenditure decreases with age, over time and is lower for later generations

Note: *JTB = Japan Tourist Bureau, SMRB = Simmons Market Research Bureau, BF = Households Budget Survey by the Italian Office of Statistics. More specific information on the secondary data sources can be found in the original publications.

Appendix B. Descriptive statistics and estimated effects

Table B.1
Overview of sociodemographic and travel-related covariates among all survey respondents and all travelers in the considered years.

Variable	Value	n		%	
		Overall	Travelers	Overall	Travelers
Age	18–30 years	37,064	27,813	18,9	19.3
	31–40 years	37,956	29,285	19,3	20,3
	41–50 years	37,200	29,173	18.9	20,2
	51–60 years	34,153	25,648	17.4	17,8
	61–70 years	31,488	21,959	16.0	15.2
	71–80 years	18,490	10,549	9.4	7.3
Travel year (period)	1983–1989	29,114	18,231	15.1	12.8
	1990–1999	56,546	42,385	29.4	29.7
	2000–2010	58,275	44,940	30.3	31.5
	2011–2018	48,706	37,332	25.3	26.1
Birth cohort	Born before 1939	43,147	26,184	21.8	17.9
	Silent generation	26,217	19,638	13.2	13.5
	Baby Boomer	79,520	61,143	40.1	41.9
	Generation X	38,584	30,456	19.5	20.9
	Generation Y	9745	7621	4.9	5.2
	Generation Z	1064	848	0.5	0.6
Gender	Male	90,766	67,724	45.8	46.4
	Female	107,546	78,175	54.2	53.6
Household net income (weighted and inflation-adjusted)	<1000€	10,478	5337	5.3	3.7
	1000–1999€	56,926	35,166	28.7	24.1
	2000–2999€	62,545	47,096	31.5	32.3
	3000–3999€	41,588	34,738	21.0	23.8
	4000–4999€	12,659	11,002	6.4	7.5
	5000–5999€	7718	6778	3.9	4.6
	≥ 6000€	6398	5782	3.2	4.0
Education	Junior high school	100,186	64,262	50.5	44.0
	Secondary school	59,858	48,545	30.2	33.3
	High school	21,500	18,370	10.8	12.6
	University or college	16,768	14,722	8.5	10.1
Household size	1	52,858	35,981	26.7	24.7
	2	75,650	57,117	38.1	39.1
	3	32,534	24,793	16.4	17.0
	4	27,723	21,388	14.0	14.7
	>4	9547	6620	4.8	4.5
Young children (under 5 years)	yes	21,027	14,739	10.6	10.1
	no	177,285	131,160	89.4	89.9
City size	< 5000 inhabitants	26,885	18,302	13.6	12.5
	5000–49,999 inhabitants	87,389	63,236	44.1	43.3
	50,000–99,999 inhabitants	19,743	14,698	10.0	10.1
	100,000–499,000 inhabitants	32,944	25,692	16.6	17.6
	>500,000 inhabitants	31,351	23,971	15.8	16.4
Trip length	5 days	–	2968	–	2.0
	6–8 days	–	23,027	–	15.8
	9–12 days	–	21,577	–	14.8
	13–15 days	–	55,033	–	37.8
	16–19 days	–	7708	–	5.3

(*continued on next page*)

Table B.1 (*continued*)

Variable	Value	n		%	
		Overall	Travelers	Overall	Travelers
	20–22 days	–	22,653	–	15.5
	23–26 days	–	2603	–	1.8
	27–29 days	–	4372	–	3.0
	>30 days	–	5787	–	4.0

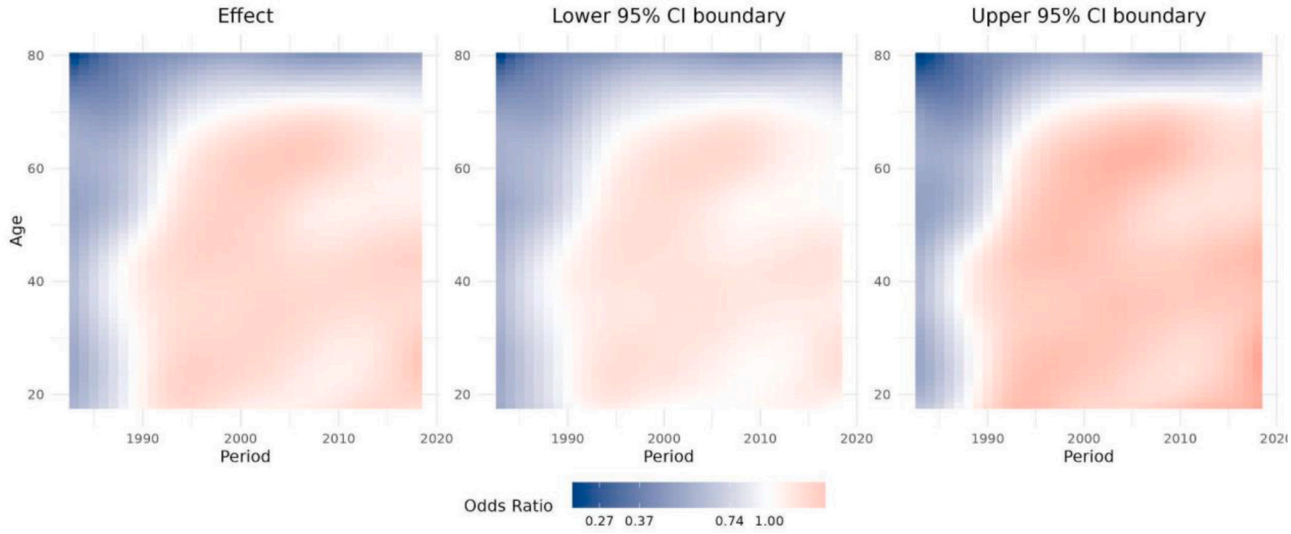


Fig. B.1. Estimated APC effect surface for the travel participation model, including lower and upper 95 % confidence interval (CI) boundaries.

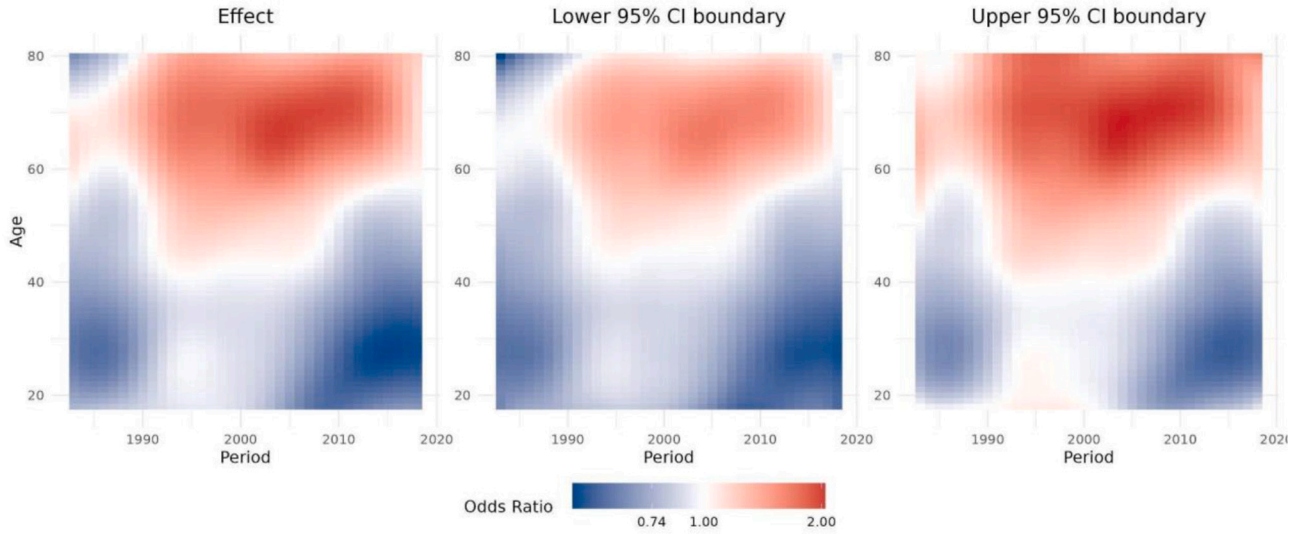


Fig. B.2. Estimated APC effect surface for the travel frequency model, including lower and upper 95 % confidence interval (CI) boundaries.

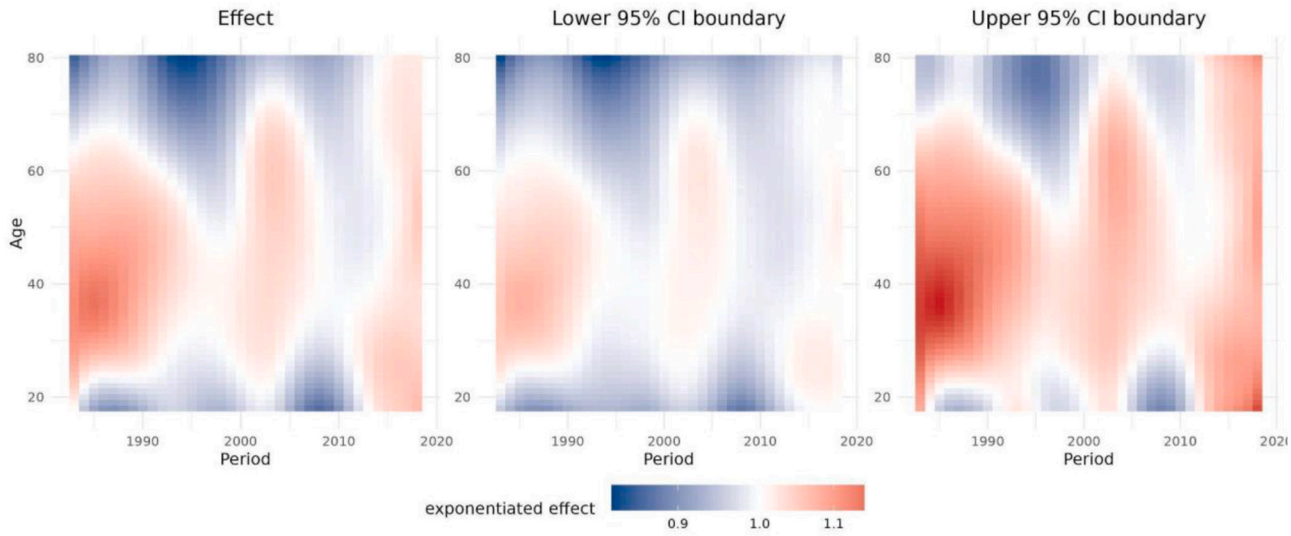


Fig. B.3. Estimated APC effect surface for the travel expenses model, including lower and upper 95 % confidence interval (CI) boundaries.

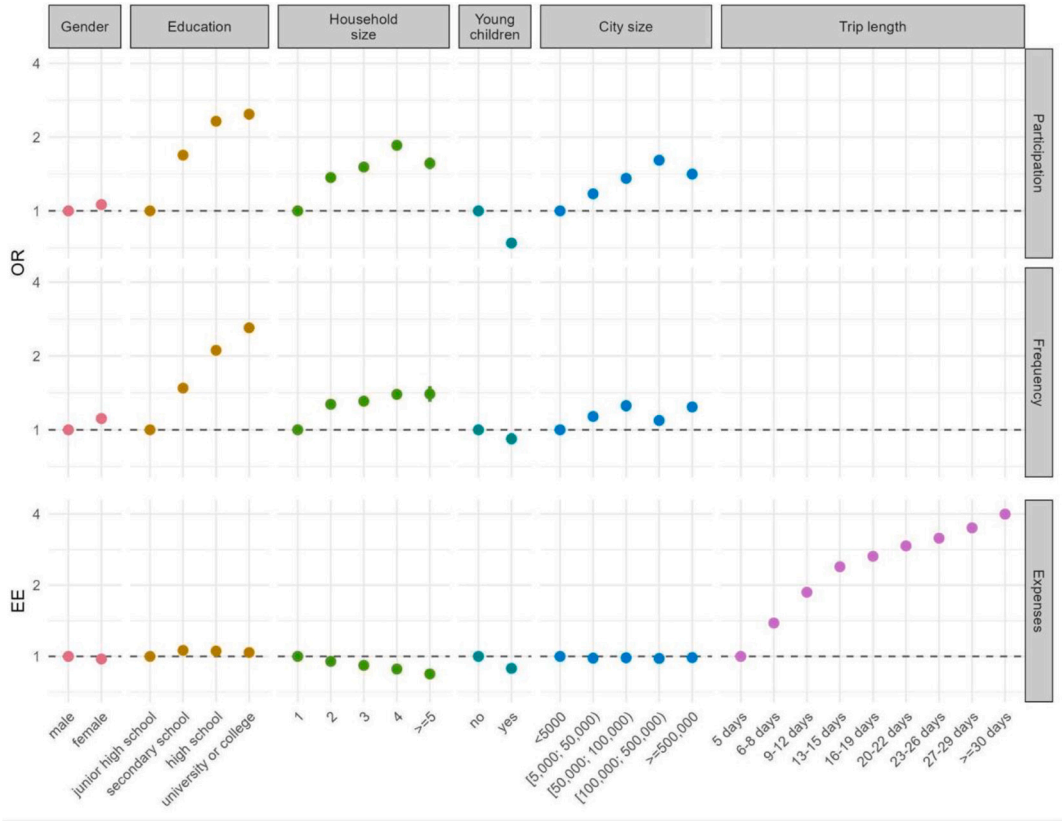


Fig. B.4. Estimated exponentiated effects of the variables gender (reference category: male), education (reference: junior high school), household size (reference: 1), young children (reference: no), city size (reference: <5000) and trip length (reference: 5 days), for travel participation (top row), travel frequency (middle row) and rel. expenses (bottom row) on a log2 scale in terms of odds ratios (OR) and exponentiated effects (EE).

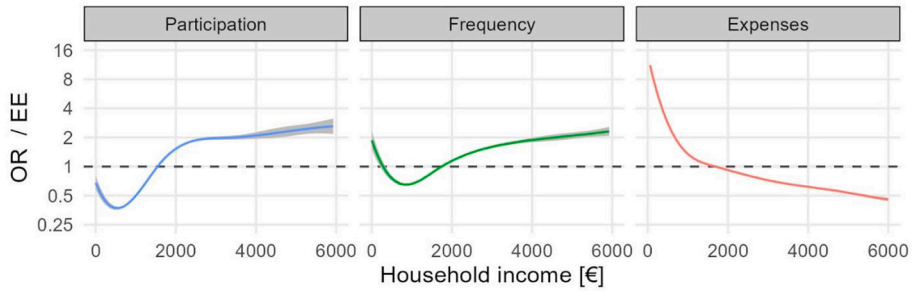


Fig. B.5. Nonlinear effects of household incomes in terms of odds ratios (OR) and exponentiated effects (EE). The x-axis only spans income values until 6000€ as higher incomes occur too rarely (see Table A.1) to ensure a stable effect estimate.

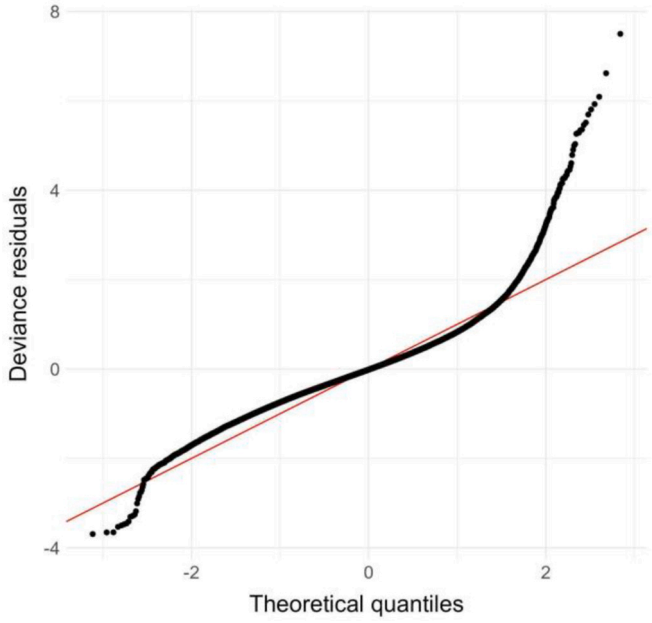


Fig. B.6. QQ plot for the regression model for relative expenses. Deviance residuals obtained from the model are displayed against theoretical quantiles based on the direct randomization method (Augustin et al., 2012).

Model evaluation showed acceptable goodness of fit of all models. The logistic regression models for travel participation and travel frequency had area under the curve (AUC) values of 0.72 and 0.66, respectively, computed on a 20 % hold-out test set (Japkowicz & Shah, 2011). Dispersion parameters of these two models were 1.01 and 1.00, respectively, indicating no overdispersion. The Gamma regression model for travel expenses showed 37 % explained deviance (compared to 32 % of Beta regression and 34 % of log-normal regression) on the training set and a median absolute percentage error (MdAPE; Hyndman & Koehler, 2006) of 0.34 on the same hold-out test set. The corresponding QQ plot (Wood, 2017) above shows that the distributional assumption for the residuals is mainly fulfilled with some deviation at the top margin of the distribution. Sample size calculations were not performed before the study since we used a sufficiently large secondary dataset.

Appendix C. Sensitivity analysis for expenses over all trips

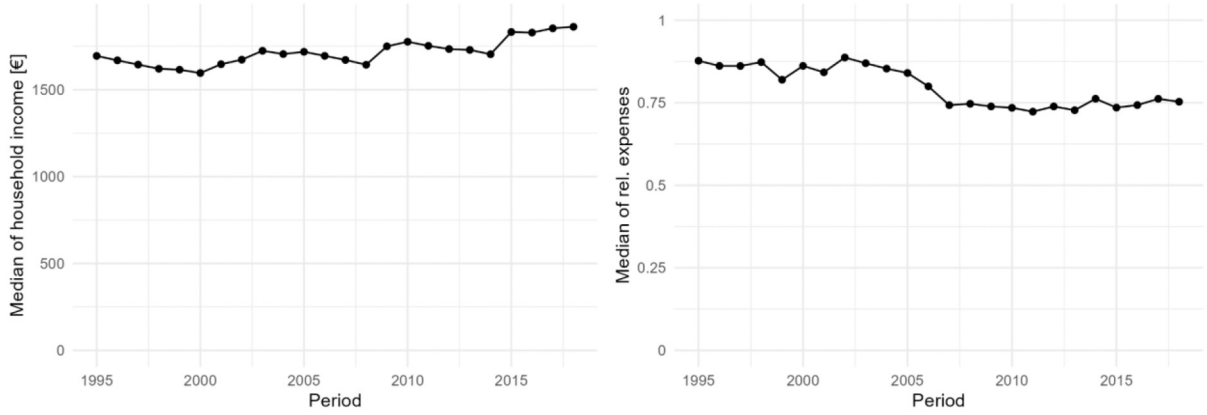


Fig. C.1. Person- and inflation-adjusted median income (left pane) and relative expenses (right), based on data including the expenses for all respective trips of a person in a year.

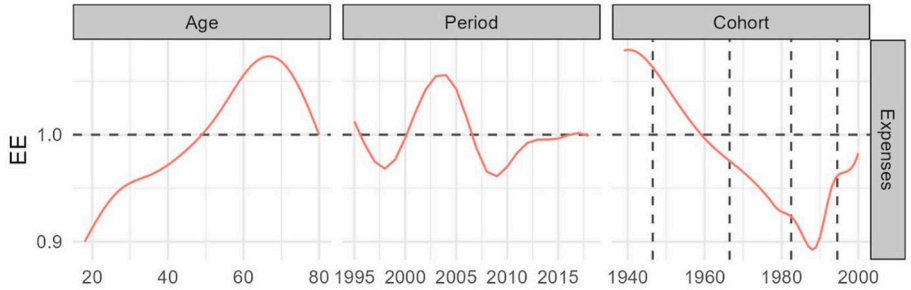


Fig. C.2. Estimated exponentiated marginal age (left pane), period (middle) and cohort (right) effect for the relative expenses model on a log2 scale, based on data including the expenses for all respective trips of a person in a year. The cohort effect is displayed for birth years from 1939 onwards only. The dashed vertical lines in the cohort plots mark the boundaries between the generations defined in the conceptual framework.

Table C.1
Overview of marginal age, period and cohort effects, based on data including the expenses for all respective trips of a person in a year.

Model	Effect	Value with maximum effect	Value with minimum effect	Maximum EE	Minimum EE	Ratio
Expenses	Age	67	18	1.08	0.90	1.20
	Period	2004	2009	1.06	0.96	1.10
	Cohort	1940	1988	1.09	0.89	**1.22**

Note: For each model and effect, the following information is listed, from left to right. Variable value where the estimated effect reaches its maximum/minimum; maximum/minimum of the exponentiated effect (EE); ratio between the respective maximum and minimum exponentiated effect. The maximum ratios per model are highlighted in bold. According to the generations defined in the "Data" section, cohort effects are considered for birth years from 1939 onwards only.

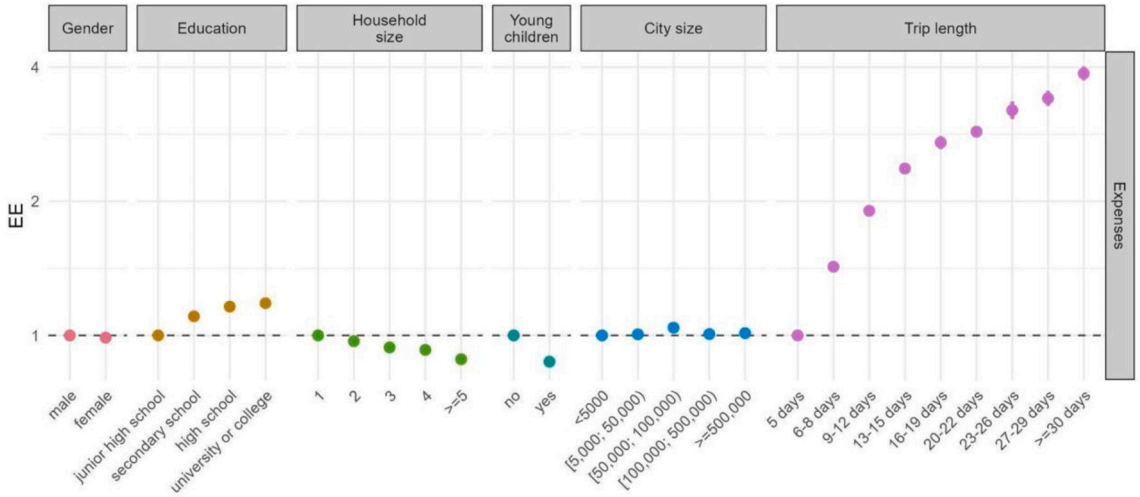


Fig. C.3. Estimated exponentiated effects (EE) of the variables gender (reference category: male), education (reference: junior high school), household size (reference: 1), young children (reference: no), city size (reference: <5000) and trip length (reference: 5 days), for expenses (bottom row) on a log2 scale, based on

data including the expenses for all respective trips of a person in a year.

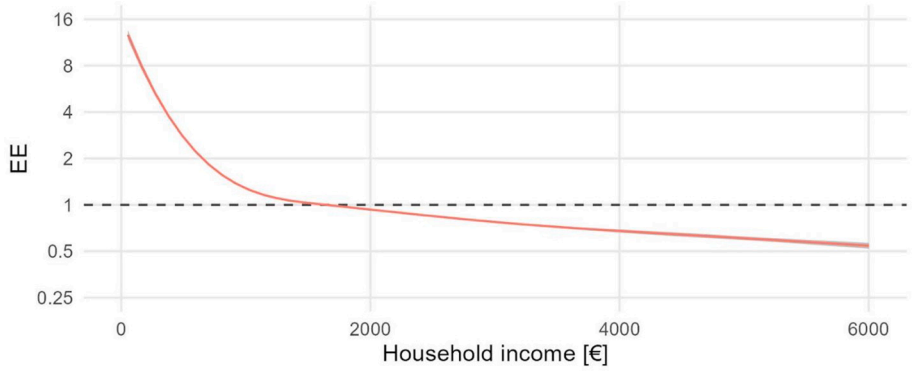


Fig. C.4. Nonlinear effect of household income in terms of exponentiated effects (EE), based on data including the expenses for all respective trips of a person in a year. The x-axis only spans income values until 6000€ as higher incomes occur too rarely (see Table A.1) to ensure a stable effect estimate.

Appendix D. Analysis for Eastern Germany

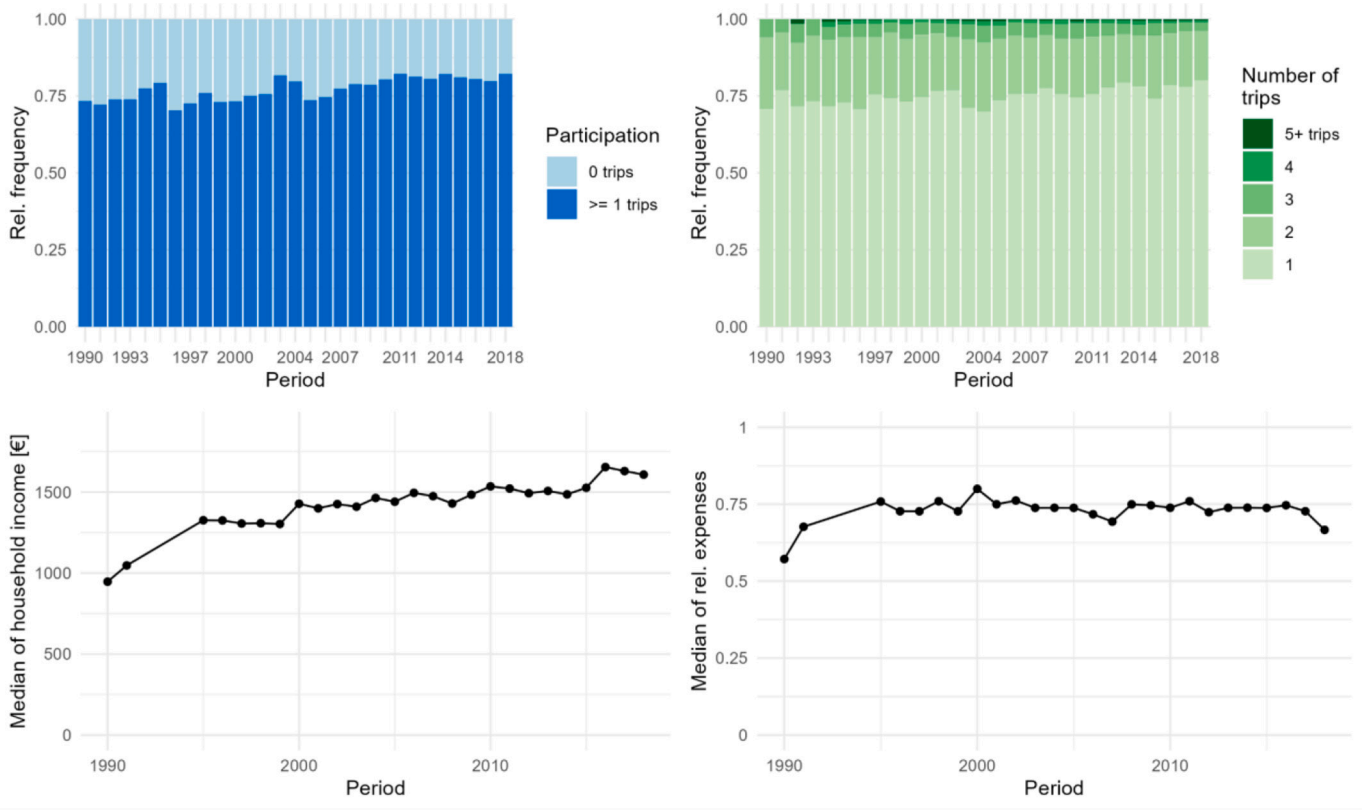


Fig. D.1. Relative frequency of travel participation (top left pane) and travel frequency (top right) as well as person-adjusted and inflation-adjusted median income (bottom left) and relative expenses (bottom right), only based on data of people living in Eastern German federal states.

Fig. D.2. Estimated marginal age (left column), period (middle) and cohort (right) effects for travel participation (top row), travel frequency (middle row) and rel. Expenses (bottom row) on a log2 scale in terms of odds ratios (OR) and exponentiated effects (EE), only based on data of people living in Eastern German federal states. The cohort effect is displayed for birth years from 1939 onwards only. The dashed vertical lines in the cohort plots mark the boundaries between the generations defined in the conceptual framework.

Table D.1
Overview of marginal age, period and cohort effects, only based on data of people living in Eastern German federal states.

Model	Effect	Value with maximum effect	Value with minimum effect	Maximum OR/EE	Minimum OR/EE	Ratio
	Age	33	80	1.18	0.59	2.01
Participation	Period	2014	2001	1.15	0.88	1.30
	Cohort	2000	1953	1.82	0.90	**2.02**
	Age	71	26	1.74	0.70	2.50
Frequency	Period	1990	2018	1.51	0.65	2.32
	Cohort	1939	1991	1.46	0.51	**2.88**
	Age	43	80	1.02	0.96	1.07
Expenses	Period	2014	1990	1.07	0.66	**1.62**
	Cohort	1995	1988	1.05	1.00	1.05

Note: For each model and effect, the following information is listed, from left to right. Variable value where the estimated effect reaches its maximum/minimum; maximum/minimum odds ratio (OR) or exponentiated effect (EE); ratio between the respective maximum and minimum odds ratio or exponentiated effect. The maximum ratios per model are highlighted in bold. According to the generations defined in the "Data" section, cohort effects are considered for birth years from 1939 onwards only.

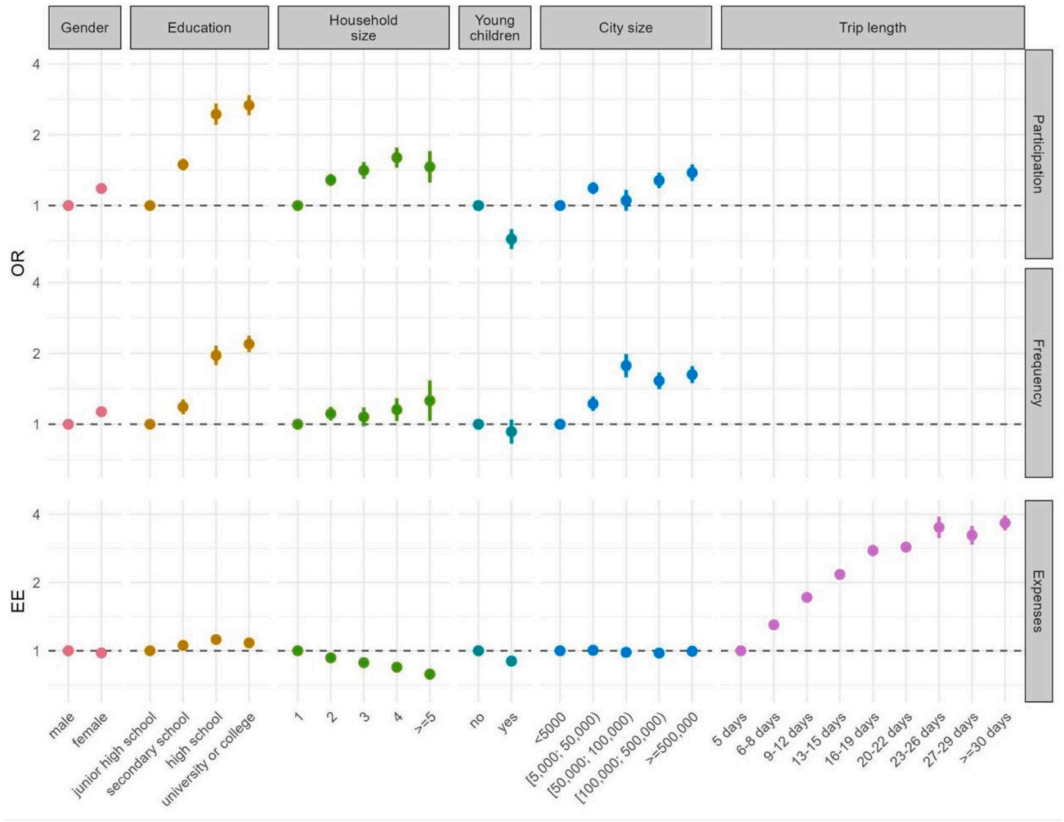


Fig. D.3. Estimated exponentiated effects of the variables gender (reference category: male), education (reference: junior high school), household size (reference: 1), young children (reference: no), city size (reference: <5000) and trip length (reference: 5 days), for travel participation (top row), travel frequency (middle row) and rel. Expenses (bottom row) on a log2 scale in terms of odds ratios (OR) and exponentiated effects (EE), only based on data of people living in Eastern German federal states.

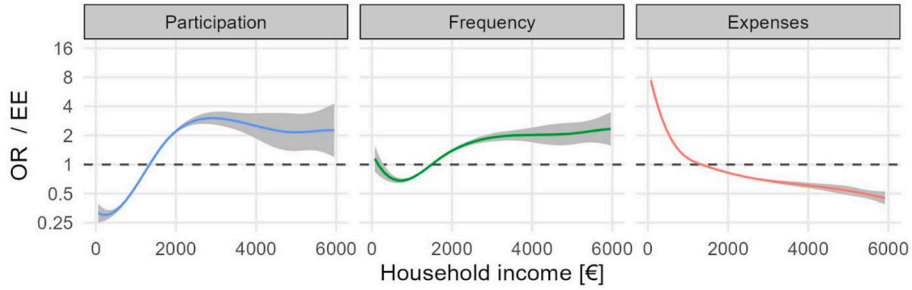


Fig. D.4. Nonlinear effects of household income in terms of odds ratios (OR) and exponentiated effects (EE), only based on data of people living in Eastern German federal states. The x-axis only spans income values until 6000€ as higher incomes occur too rarely (see Table A.1) to ensure a stable effect estimate.

References

Abraham, V., Bremser, K., Carreno, M., Crowley-Cyr, L., & Moreno, M. (2021). Exploring the consequences of COVID-19 on tourist behaviors: Perceived travel risk, animosity and intentions to travel. *Tourism Review, 76*(4), 701–717.

Augustin, N. H., Sauleau, E. A., & Wood, S. N. (2012). On quantile plots for generalized linear models. *Computational Statistics & Data Analysis, 56*(8), 2404–2409.

Bauer, A., & Weigert, M. (2024). TravelBehaviorAPC: Supplementary code. https://github.com/bauer-alex/TravelBehaviorAPC (accessed 19 October 2024).

Bauer, A., Weigert, M., & Jalal, H. (2022). APCtools: Routines for descriptive and model-based APC analysis. *Journal of Open Source Software, 7*(73), 4056. https://doi.org/10.21105/joss.04056

Bernini, C., & Cracolici, M. F. (2015). Demographic change, tourism expenditure and life cycle behaviour. *Tourism Management, 47*, 191–205.

Bronner, F., & de Hoog, R. (2011). Economizing behaviour during travel: Strategies and information sources used. *Journal of Vacation Marketing, 17*(3), 185–195.

Bronner, F., & de Hoog, R. (2016). Crisis resistance of tourist demand: The importance of quality of life. *Journal of Travel Research, 55*(2), 190–204.

Chen, C.-C., & Petrick, J. F. (2016). The roles of perceived travel benefits, importance, and constraints in predicting travel behavior. *Journal of Travel Research, 55*(4), 509–522.

Chen, C.-C., Zou, S., & Petrick, J. F. (2019). Is travel and tourism a priority for you? A comparative study of American and Taiwanese residents. *Journal of Travel Research, 58*(4), 650–665.

Clayton, D., & Schifflers, E. (1987). Models for temporal variation in cancer rates. II: Age–period–cohort models. *Statistics in Medicine, 6*(4), 469–481.

Cohen, S. A., Prayag, G., & Moital, M. (2014). Consumer behaviour in tourism: Concepts, influences and opportunities. *Current Issues in Tourism, 17*(10), 872–909.

Collins, D., & Tisdell, C. (2002). Gender and differences in travel life cycles. *Journal of Travel Research, 41*(2), 133–143.

Crawford, D. W., & Godbey, G. (1987). Reconceptualizing barriers to family leisure. *Leisure Sciences, 9*(2), 119–127.

Crompton, J. L. (1979). Motivations for pleasure vacation. *Annals of Tourism Research, 6*(1), 408–424.

Davis, J. B., Pawlowski, S. D., & Houston, A. (2006). Work commitments of baby boomers and gen-Xers in the IT profession: Generational differences or myth? *Journal of Computer Information Systems, 46*(3), 43–49.

Dolnicar, S., Yanamandram, V., & Cliff, K. (2012). The contribution of vacations to quality of life. *Annals of Tourism Research, 39*(1), 59–83.

Filimon, S., Schiemenz, C., Bartl, E., Lindner, E., Namberger, P., & Schmude, J. (2022). Travel participation of Germans before and during the COVID-19 pandemic–the effects of sociodemographic variables. *Current Issues in Tourism, 25*(24), 4031–4046.

Fitzenberger, B., Mena, G., Nimczik, J., & Sunde, U. (2022). Personality traits across the life cycle: Disentangling age, period and cohort effects. *The Economic Journal, 132* (646), 2141–2172.
Floyd, M. F., Gibson, H., Pennington-Gray, L., & Thapa, B. (2004). The effect of risk perceptions on intentions to travel in the aftermath of September 11, 2001. *Journal of Travel & Tourism Marketing, 15*(2–3), 19–38.
Fu, X., Kirillova, K., & Lehto, X. Y. (2022). Travel and life: A developmental perspective on tourism consumption over the life course. *Tourism Management, 89*, Article 104447. https://doi.org/10.1016/j.tourman.2021.104447
FUR. (2018). *Reiseanalyse [travel survey Germany] 2016*. Cologne: GESIS Data Archive. ZA6985 Data file Version 1.0.0.
FUR. (2020). *Reiseanalyse 2020. [Travel demand analysis Germany]*.
Gardiner, S., Grace, D., & King, C. (2014). The generation effect. *Journal of Travel Research, 53*(6), 705–720.
Gardiner, S., King, C., & Grace, D. (2013). Travel decision making: An empirical examination of generational values, attitudes, and intentions. *Journal of Travel Research, 52*(3), 310–324.
Gunter, U., & Smeral, E. (2016). The decline of tourism income elasticities in a global context. *Tourism Economics, 22*(3), 466–483.
Hagenaars, A. J. M., de Vos, K., & Zaidi, M. A. (1995). Armutsstatitik der 80er Jahre. In *[Poverty statistics 1980s]. Amt für amtliche Veröffentlichungen der Europäischen Gemeinschaften*. Luxemburg: Bundesanzeiger-Verlag.
Hong, G.-S., Fan, J. X., Palmer, L., & Bhargava, V. (2005). Leisure travel expenditure patterns by family life cycle stages. *Journal of Travel & Tourism Marketing, 18*(2), 15–30.
Huber, D., Milne, S., & Hyde, K. F. (2019). Conceptualizing senior tourism behaviour: A life events approach. *Tourist Studies, 19*(4), 407–433.
Hyndman, R. J., & Koehler, A. B. (2006). Another look at measures of forecast accuracy. *International Journal of Forecasting, 22*(4), 679–688.
Japkowicz, N., & Shah, M. (2011). *Evaluating learning algorithms: a classification perspective*. New York: Cambridge University Press.
Karl, M., Bauer, A., Ritchie, W. B., & Passauer, M. (2020). The impact of travel constraints on travel decision-making: A comparative approach of travel frequencies and intended travel participation. *Journal of Destination Marketing & Management, 18*, Article 100471. https://doi.org/10.1016/j.jdmm.2020.100471
Karl, M., Sie, L., & Ritchie, B. W. (2021). Expanding travel constraint negotiation theory: An exploration of cognitive and behavioral constraint negotiation relationships. *Journal of Travel Research, 61*(4), 762–785.
Lehto, X. Y., Choi, S., Lin, Y.-C., & MacDermid, S. M. (2009). Vacation and family functioning. *Annals of Tourism Research, 36*(3), 459–479.
Leijen, I., van Herk, H., & Bardi, A. (2022). Individual and generational value change in an adult population, a 12-year longitudinal panel study. *Scientific Reports, 12*, 17844. https://doi.org/10.1038/s41598-022-22862-1
Li, M., Wang, Y., Wan, Y., Huang, X., & Yang, Y. (2023). The meaning of travel: Anecdotes from children. *Annals of Tourism Research, 103*, Article 103664. https://doi.org/10.1016/j.annals.2023.103664
Lin, V. S., Jiang, F., Li, G., & Qin, Y. (2023). Impacts of risk aversion on tourism consumption: A hierarchical age-period-cohort analysis. *Annals of Tourism Research, 101*, Article 103607. https://doi.org/10.1016/j.annals.2023.103607
Lohmann, M., & Danielsson, J. (2001). Predicting travel patterns of senior citizens: How the past may provide a key to the future. *Journal of Vacation Marketing, 7*(4), 357–366.
Losada, N., Alén, E., Domínguez, T., & Nicolau, J. L. (2016). Travel frequency of seniors tourists. *Tourism Management, 53*, 88–95.
MacInnes, S., Grün, B., & Dolnicar, S. (2022). Habit drives sustainable tourist behaviour. *Annals of Tourism Research, 92*, Article 103329. https://doi.org/10.1016/j.annals.2021.103329
Mannheim, K. (1952). The sociological problem of generations. *Essays on the Sociology of Knowledge, 306*, 163–195.
Maresova, P., Javanmardi, E., Barakovic, S., Barakovic Husic, J., Tomsone, S., Krejcar, O., & Kuca, K. (2019). Consequences of chronic diseases and other limitations associated with old age–a scoping review. *BMC Public Health, 19*, 1–17.
Maslow, A. (1943). A theory of human motivation. *Psychological Review, 50*(4), 370–396.
Mattioli, G., Scheiner, J., & Holz-Rau, C. (2022). Generational differences, socialisation effects and 'mobility links' in international holiday travel. *Journal of Transport Geography, 98*, Article 103263. https://doi.org/10.1016/j.jtrangeo.2021.103263
McKercher, B. (2023). Age or generation? Understanding behaviour differences. *Annals of Tourism Research, 103*, Article 103656. https://doi.org/10.1016/j.annals.2023.103656
McKercher, B., Lai, B., Yang, L., & Wang, Y. (2020). Travel by Chinese: A generational cohort perspective. *Asia Pacific Journal of Tourism Research, 25*(4), 341–354.
Nicolau, J. L., & Más, F. J. (2005). Stochastic modeling. *Annals of Tourism Research, 32* (1), 49–69.
Oppermann, M. (1995). Travel life cycle. *Annals of Tourism Research, 22*(3), 535–552.
Pennington-Gray, L., Kerstetter, D. L., & Warnick, R. (2002). Forecasting travel patterns using Palmore's cohort analysis. *Journal of Travel & Tourism Marketing, 13*(1–2), 125–143.
Popp, M., Schmude, J., Passauer, M., Karl, M., & Bauer, A. (2021). Why don't they travel? The role of constraints and motivation for non-participation in tourism. *Leisure Sciences, 46*(3), 211–236.
R Core Team. (2022). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. R-Project https://www.R-project.org/.
Randle, M., Zhang, Y., & Dolnicar, S. (2019). The changing importance of vacations: Proposing a theoretical explanation for the changing contribution of vacations to people's quality of life. *Annals of Tourism Research, 77*, 154–157.
Sakai, M., Brown, J., & Mak, J. (2000). Population aging and Japanese international travel in the 21st century. *Journal of Travel Research, 38*(3), 212–220.
Schewe, C. D., & Noble, S. M. (2000). Market segmentation by cohorts: The value and validity of cohorts in America and abroad. *Journal of Marketing Management, 16* (1–3), 129–142.
Walters, G., Wallin, A., & Hartley, N. (2019). The threat of terrorism and tourist choice behavior. *Journal of Travel Research, 58*(3), 370–382.
Weigert, M., Bauer, A., Gernert, J., Karl, M., Nalmpatian, A., Küchenhoff, H., & Schmude, J. (2022). Semiparametric APC analysis of destination choice patterns: Using generalized additive models to quantify the impact of age, period, and cohort on travel distances. *Tourism Economics, 28*(5), 1377–1400.
Wells, W. D., & Gubar, G. (1966). Life cycle concept in marketing research. *Journal of Marketing Research, 3*(4), 355–363.
Wood, S. N. (2017). *Generalized additive models: An introduction with R*. Boca Raton/London/New York: CRC Press.
You, X., & O'Leary, J. T. (2000). Age and cohort effects: An examination of older Japanese travelers. *Journal of Travel & Tourism Marketing, 9*(1–2), 21–42.
Zimmermann, J., Brijoux, T., & Zank, S. (2022). *Erkrankungen, Pflegebedürftigkeit und subjektive Gesundheit im hohen Alter* (pp. 63–87). Universität zu Köln, Cologne Center for Ethics, Rights, Economics, and Social Sciences of Health (ceres).

Elisabeth Bartl (elisabeth.bartl@lmu.de) focuses on touristic travel behavior in a spatiotemporal context.

Alexander Bauer applies advanced statistical methods in interdisciplinary research settings.

Maximilian Weigert applies advanced statistical methods and machine learning methods in interdisciplinary research settings.

Marion Karl combines geographic and psychological theories to study cognitive processes of travel decisions.

Jürgen Schmude researches climate change and tourism, tourists' behavior, safety and security in tourism.

Helmut Küchenhoff is involved in many interdisciplinary projects in applied statistics.