THE BIRTH OF A "GREEN" GENERATION? GENERATIONAL DYNAMICS OF RESOURCE CONSUMPTION PATTERNS

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Foreword

Lifestyles are important determinants of resource consumption, energy needs, and environmental impacts. It is easy to agree on the importance of consumer behavior and lifestyles for energy requirements, both in terms of energy services demand as well as how these translate into actual energy use (i.e., the issue of energy end-use efficiencies). It is however, much more difficult to come to grips with an analytical understanding of heterogeneity and the multitude of "hidden" dynamics that are so characteristic of differences and changes in consumption and energy end-use patterns.

This paper by Thomas Büttner and Arnulf Grübler provides multiple perspectives on issues, research questions, and illustrative analytical routes that lead toward a better understanding of evolving consumption patterns. The cohort, or generational perspective developed in the paper is also a much welcome complement to the more traditional approaches in describing heterogeneity in consumer preferences and choices that have, to date, largely focussed on differences in income or family status.

The paper describes an important part of the background research within the ECS project required as input to scenario development, modeling, and environmental impact assessment of long-term energy perspectives. The paper illustrates the need to extend traditional disciplinary boundaries when analyzing the interrelationships between human choices, energy, and the environment. The collaborative work reported here was initiated at IIASA and demonstrates the Institute's comparative strength and interdisciplinary role.

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The Birth of a "Green" Generation? Generational Dynamics of Resource Consumption Patterns

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ABSTRACT

The article discusses a generational perspective on changes in lifestyle and consumption patterns that complement more-traditional approaches of heterogeneity and path dependency of human behavior. An application is given, in developing a model of cohort and gender-specific diffusion of technological artifacts, applied to the case of car ownership in Germany. The article concludes with a number of research questions to address the complexities of changes in human behavior from an interdisciplinary perspective.

Introduction

Global (environmental) change has revived interest in lifestyle and resource consumption patterns and their rates of change, both past and future. Traditional concerns about the physical and economic availability of resources have given way to an increasing awareness of global and long-term environmental impacts of resource consumption. Thus, although perceptions about ultimate constraints limiting prevailing growth trends have changed, the driving forces are still the same: population increase, along with social and economic development (i.e., a rise in per capita consumption).

Often the human dimension of global change tends to be reduced to the issue of population growth. From a quantitative perspective, however, per capita consumption levels and resulting environmental impacts continue to dominate stresses on the global commons, and are likely to prevail over population growth proper for several decades to come. Currently about 20% of the world's population generate and consume over 80% of global economic output, use three-quarters of commercial energy, and two-thirds of major bulk materials. For instance, there is a factor ten difference in the average per capita energy consumption between the developed [7 KWyr/capita (kilowatt-year/year

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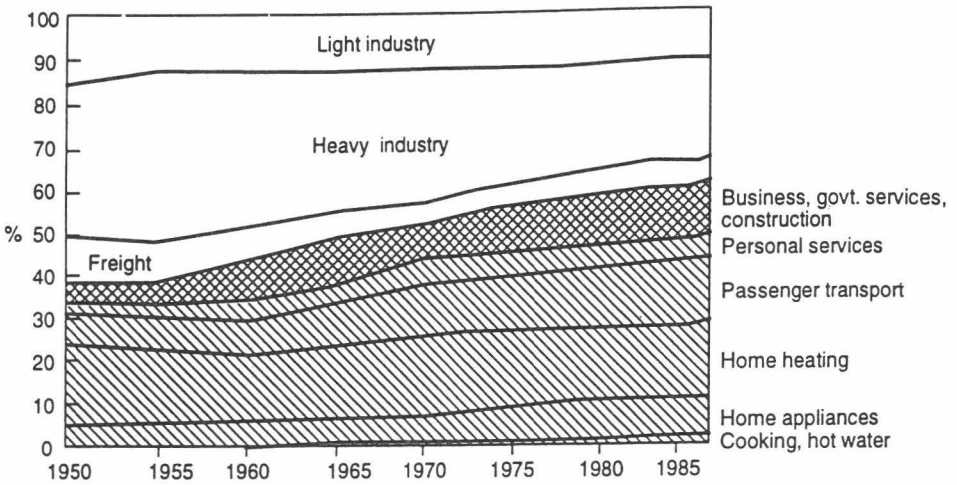

Fig. 1. Changes in the structure of energy end use by sector/human activity for Germany. ***Source:*** **Schipper et al., 1989 [40].**

per capita)] and the developing countries (0.7 KWyr/capita). These differences are even larger between individual countries or between different social strata within/between countries: for instance the per capita commercial energy consumption can differ by a factor of 140 between countries like the USA (10.3 kWyr/capita) and Bangladesh (0.07 kWyr/capita).

Demographic changes play an important role in shaping the level and structure of demand and resource consumption. Relevant demographic changes include natural population growth (balance between fertility and mortality), migration (balance between in-migration and out-migration), and changes in the (age) structure of the population. Finally, not only growth rates matter, but also distributional issues like rural versus urban residence, income, educational attainment, and so on. These demographic changes hold important – yet different – implications on resource consumption in both developing[1] and industrialized countries. In the latter, natural growth rates are low (sometimes even negative), but because of high per capita consumption levels, even small increases in population size can translate into sizable additions to the global resource balance.

In the future, however, structural effects are likely to be a more powerful force of change. There are two main reasons for this: first, longer life expectancy and the changing composition of the population toward the elderly; second, the increasing importance of residential, service, and leisure-related activities and consumption. In "postindustrial" societies, lifestyles and private consumption have become more forceful agents of global change than industry. For example, over the last 40 years the share of industry in final energy consumption in Germany declined from two-thirds to one-third, with private and service sector consumption rising accordingly (Figure 1). Particularly personal transportation energy-demand growth has been vigorous, especially due to increasing car ownership rates and increased mobility levels (higher usage rates of automobiles).

The implications of the progressive "greying" of the population in industrialized countries on structure and types of demands for services and goods remain largely open

[1] We acknowledge the critical importance of demographic factors on consumption in developing countries. In this paper however, we concentrate on industrialized countries.

questions.[2] Are older people "preserving" their consumption habits, or do new forms of social behavior become also adopted within older generations? What are the possible dynamics in the adoption of new consumption preferences? Are we anticipating what the possible effects might be, once one-third or more of car drivers will be over age 60? The present paper is an attempt to illustrate particularly how such phenomena could be described and what could be illustrative implications on future resource consumption levels (i.e., energy consumption).

There is yet another reason to be interested in lifestyles. Further improvements in the quality of service, rendered by social infrastructures from health care to transportation, will increasingly be driven by individual consumer decisions, rather than from socially determined measures (e.g., massive public expenditures and infrastructure programs). Thus, for instance, the marginal improvement possibilities of public health care systems (e.g., in terms of contributing to further increases in life expectancy) may well depend more on an individual's decisions concerning food diet, smoking, physical fitness, etc., than on further increases in infrastructures and expenditures in curative[3] health measures. Along a similar vein, one can argue that the marginal utility gains of public investments in transport systems (e.g., to combat congestion) are less than those from individual-determined usage decisions (e.g., use a car more intelligently and selectively) of existing systems. This not only applies to the marginal utility gains, but even more so to the respective costs of improving quality of service.

Understanding how lifestyle and resource consumption patterns have evolved, along with identifying their dynamics, driving forces, and possible leverage for policies furthering changes, are preconditions for discussing the human dimensions of global environmental change [15, 16, 29] and subsequent policy analysis. Lifestyles are not intrinsically given. Nor do they evolve autonomously, or can they be separated from the social, economic, and even natural environment in which people live. As a result, lifestyle patterns are highly heterogeneous: over time, across different social strata, and between different countries. This is well recognized in research fields as diverse as microeconomics [2], family life-cycle analysis [9], or marketing research [6, 49]. Such analysis, however, in our viewpoint, often has an important limitation: the inference from cross-sectional observations to longitudinal projections. For instance, consumption patterns in high-income groups do not necessarily give an adequate indication of future changes in consumption patterns of low-income groups. Along a similar vein, a cross-sectional life-cycle analysis can show how consumption patterns differ between the young and the old. But how do we know if, and to what extent, today's young will adopt the consumption styles of the presently old, once they are of similar age? Or, could it rather be that tomorrow's old will maintain their "young" consumption patterns?

MOTIVATION

The objective of this paper is not to develop a new theory of lifestyle formation or changing consumption patterns. Instead we aim to complement more traditional perspectives from the fields of economics and demography on the heterogeneity of lifestyle and consumption patterns from the perspective of generational or cohort dynamics. In fact, we argue that in a number of instances, changes in lifestyle patterns that appear at first sight as surprise and discontinuity, can be related to cohort phenomena. Thus, it is important to differentiate between period, and cohort-specific changes in lifestyle

[2] For a review of economics research on the elderly see Hurd, 1990 [17].

[3] The above argument of course does not apply to preventive health care measures.

and consumption patterns (cf. Appendix 1). The research questions raised in this paper include:

1. How to detect changes in social behavior in periods during which the changes observed statistically could be either a result of intrinsic changes in preferences, or simply of changes in the timing of decisions, or perhaps both. Conversely, are there "hidden dynamics" in the process? For instance, changes in the cohort composition of the population (aging) may mask fundamental long-term changes in preferences and behavior of successive generations.
2. How to observe and measure behavioral change? Obviously, from the perspective of this paper, we emphasize in particular the need for better disaggregated longitudinal data series, complementing cross-sectional surveys in such diverse domains as consumer expenditures, activity patterns (time budgets), and family life cycles.
3. How to anticipate changes in behavior? Is action following changes in perception, or is it the other way around? Whereas interviews and questionnaires can shed light on changing values and perceptions of people, their relationship (or contradiction) to action also needs attention. In the context of possible behavior changes, a closer look at "critical" time periods (e.g., in the household-formation stage) and the external (social, material, and natural) "environment" involved may give insights about mechanisms of change.

When emphasizing the concept of cohort in this paper, we acknowledge that there are different definitions of a "cohort" (for a discussion see [20, 37]). Traditionally (and in this paper), a cohort is a group of people characterized by the same year of birth, thus sharing certain experiences in their maturation and socialization. Alternatively, one can define cohorts as groups of people experiencing similar (usually dramatic or far-reaching) experiences. For instance, a cohort of war participants, a cohort of people married in a particular year, or of groups of people experiencing at the same time sudden social policy changes (e.g., the abandonment of legalized abortion in Romania). These latter cohorts are defined by the date of the event that constitutes the group (cohort). As a result, their members can or will be of different ages (i.e., comprising different *birth* cohorts).

SOME PARADOXES

The "Baby Boom" as a Surprise in Social Change?

Ultimately, the most fundamental lifestyle variable is human fertility. The discontinuous rise of the number of children born after World War II at first sight appears as a sudden, discontinuous phenomenon of social change. However, was the "baby boom" indeed a deeper change in social behavior, in terms that women gave birth to more children (over their respective lifetime), or was it just a shift in the timing of births of an otherwise unchanged ratio of children per women?

Ryder [38] in his analysis of trends in American fertility concludes: "most of the baby boom would have occurred without any change whatsoever in the numbers of birth per women, and most of the decline since the baby boom as well. It is evident that the [variation in] numbers of children born were of less importance than their time pattern of birth."

From the above perspective, it becomes clear that there is an ambivalence in interpreting the "baby boom" as an example of an intrinsic social change. The observed fluctuations in period fertility (measured by the Total Fertility Rate) did not reflect that the

average number of children per woman hardly changed, but instead the timing changed. Consequently, not the attitudes toward children (family values) in general changed, but merely the "technical" aspect of placing the birth of children within a life cycle. This does not mean that the "baby boom" is a phantom. The result of changed timing patterns (even though perhaps not qualifying as a genuine change in social behavior) resulted in significantly more children being born during the "boom" time period, thereby creating quantitatively large cohorts, which in turn are felt as possible stresses on the social infrastructure like the schooling system or the labor market.

The Simultaneous Rise of Postmaterialism and the Consumer Society

An important question in the analysis of possible changes in lifestyle patterns is how to get a handle on dimensions, direction, and rates of value changes. Ronald Inglehart [18] has analyzed longitudinal data of what he considers an indicator of materialism in the Japanese society (Figure 2). His analysis reveals clearly that the "decline in materialism" observed is, first of all, the result of an intergenerational population replacement. In 1953, 60% of the age group between 20 and 24 agreed that "money is the most important thing" to teach a child, whereas the percentage of agreement in the same age group dropped to 18% 25 years later. Consent on this particular educational priority for children also dropped with particular age cohorts, but changes were small in comparison with the intergenerational value changes.

Ironically, this decline of "materialism" was accompanied by an unprecedented growth in material welfare that went along with rising incomes and the diffusion of automobiles and consumer durables (Figure 3). Data from the Japanese National Survey of Family Income and Expenditure [19] indicate that rising consumption is a pervasive phenomenon across all generations of the Japanese society. Younger generations (i.e., precisely the ones with the most pronounced postmaterialistic values), however, show *ceteris paribus* (i.e., after accounting for differences in income levels and family status) a systematically higher propensity to consumption as reflected for instance, in their respective higher amounts of consumer credits drawn, or their higher adoption levels of consumer durables.

It seems to us that this paradox of value change in the direction of postmaterialism, coinciding with the rising consumption of material goods, points to a deeper dilemma in our understanding of social behavioral change. Can we extrapolate changes in perceptions and values toward changes in consumer choices and actions? Alternatively, does the rise of postmaterialistic values follow the fulfillment of much of the material demands of people?

There is yet another complexity in inferring from people's perceptions and externally projected values (e.g., to the interviewer) their ultimate behavior and actions. Perceptions and actions may differ. Such gaps have been identified in various fields, for example, as difference between subjective and probabilistic assessments of technological risks; differences between stated consumption preferences (like alcoholic beverages), and commitment toward materials recycling and the analysis of the contents of people's trash-cans [32]; or between the subjective perceptions of time allocation to different activities at the workplace, as opposed to observational records [22], or the mismatch between the perception of increasing scarcity of free time [41] with the results of detailed inquiries into people's daily activity patterns and time budgets [8, 36]. In short, stated preferences and values may differ from actual behavior. Such differences in themselves contain useful information for social science research, however, they should be kept in mind before inferring from stated values and perceptions to ultimate human behavior.

Critical Periods for Change

Cohort dynamics as a driving force of social value change holds important implications for the analysis of lifestyle patterns. Keyfitz [21] argues that as young people

	1953	1958	1963	1968	1973	1978	Change Within Given Cohort, 1953–1978	
	%		%	%	%	%		
Age Group:								
20–24	60	–	43	34	22	18		
25–29	66	–	55	49	36	26		
30–34	63	–	58	58	42	37		
35–39	62	–	56	59	43	43		
40–44	65	–	63	59	46	49		
45–49	66	–	62	62	46	56	→ – 4	mean: –6
50–54	72	–	68	65	49	51	→ –15	
55–59	72	–	72	67	60	56	→ – 7	
60–64	77	–	76	66	59	62	→ 0	
65–69	78	–	72	73	59	62	→ – 3	
Spread between youngest and oldest:	+18	–	+29	+39	+37	+44		

Fig. 2. Value change as a generational phenomenon. Percentage of Japanese agreeing that "money is the most important thing to teach a child." *Source*: Inglehart, 1984 [18].

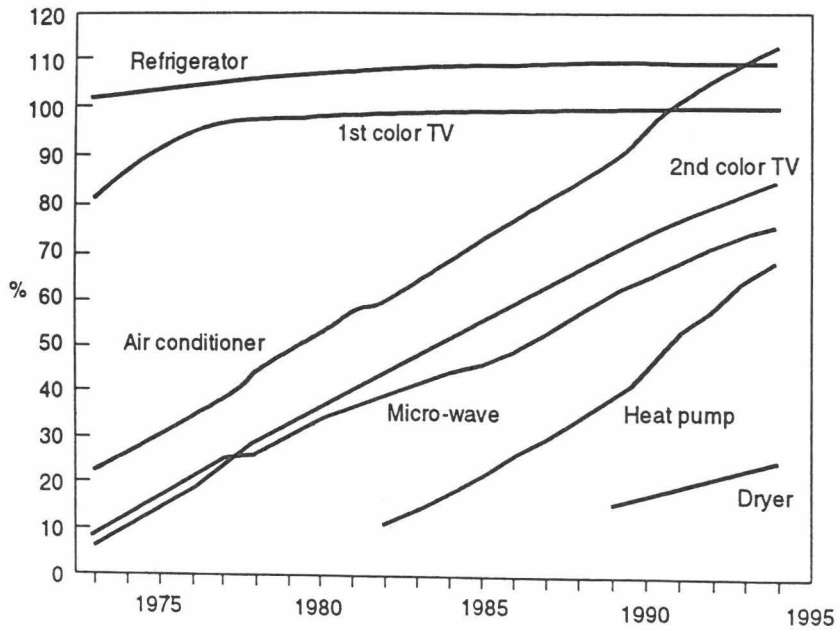

Fig. 3. Diffusion of consumer durables in Japanese households. *Source*: MITI, 1993 [26].

become independent of their parents, they choose a particular way of life: in acquiring a given "package" of artifacts (housing, most likely a car, a telephone, a refrigerator, stereo equipment, etc.) and in organizing their life in a particular social and spatial-temporal context as illustrated in the work of Hägerstrand [12]. Such decisions affect, for instance, where to reside and where to work, how to commute in between, and how much time is devoted to different activities, such as caring for a child or working in an office. Cohorts thus experience important formative phases, as described for instance, in approaches like cohort biographies [3].

At a later age, lifestyles (arising out of the cumulativeness of many prior decisions) are to a large extent settled in particular material, social, and spatial organizational settings, which prove difficult (and costly) to change. Of course, dramatic changes in lifestyle patterns also occur at later ages, for example, through partner mobility (divorces). However, the salient point here is to emphasize that the high transaction costs of lifestyle changes are likely to be acceptable only in a relatively limited number of (dramatic) instances, leaving lifestyles "locked-in" to a surprising degree in decisions taken on early in the biography of a particular age cohort or generation.

From such a perspective, the freedom to choose or change a certain lifestyle is not unlimited, and is also age dependent. The degrees of freedom might indeed be largest in the early life phase, where a large number of critical and binding decisions are being made, limiting in turn possibilities for changes (at) later (ages). In our view, this is yet another line of argument for cohort or generation-specific approaches.

A similar illustration is provided by a comparison of housing of the elderly between cross-sectional (e.g., over family life cycle or over age) and longitudinal, or cohort-specific data. Cross-sectional data indicate that elderly couples or single-person households tend to live in smaller apartments than their younger counterparts (i.e., couples without children, or whose children no longer live with them in the same household, or singles). Is this pattern likely to persist in the future? Longitudinal data assembled within the socio-economic panel of Germany indicates that the residential mobility of the elderly is in fact small, as indicated by the persistence of square meter living space occupied in following a particular age cohort over time [42] (see Table 1). Once these age cohorts become the elderly of the future, the present differences in living space occupied are likely to have disappeared. In turn, such trends will have important implications not only for residential energy demand[4], but also for investments in the construction of private residences. Again, longitudinal data, which follow changing consumer preferences of particular age cohorts over time, can reveal patterns of demand structure changes (or perseverance) not apparent from traditional family life-cycle models or cross-sectional survey data.

SOME MORE DILEMMAS

From the perspective of this paper and the demographic trends of an aging society in industrialized countries, one might wonder about the impact of the emergence of a new, environmentally more conscious "green" generation in an aging society. Under the assumption that changing consumption preferences would primarily be driven by generational replacement dynamics, this process would take considerable time to noticeably affect the overall level of consumption in a society. Moreover, the quantitative effect would remain minimal given the projected "greying." Could distinctive differences

[4] For a discussion of residential energy use over the family life cycle see Schipper, et al., 1989 [40] and Gladhart et al., 1986 [10].

TABLE 1
Age and Cohort Effects in Living Space per Household

	Living space (square meter)					
Cohort	1984	1985	1986	1987	1988	Age
1934–1938					102.5	50–54
1933–1937				101.1		
1932–1936			100.5			
1931–1935		99.4				
1930–1934	101.6					
1929–1933					98.7	55–59
1928–1932				95.4		
1927–1931			95			
1926–1930		94.3				
1925–1929	93.7					
1924–1928					92.2	60–64
1923–1927				92.4		
1922–1926			91.4			
1921–1925		91.5				
1920–1924	90.5					
1919–1923					87.4	65–69
1918–1922				84.7		
1917–1921			82.4			
1916–1920		78.6				
1915–1919	80					
1914–1918					79.8	70–74
1913–1917				76.7		
1912–1916			76.1			
1911–1915		73.3				
1910–1914	75.2					
1909–1913					71.2	75–79
1908–1912				73.6		
1907–1911			74			
1906–1910		74.9				
1905–1909	72.7					
1904–1908					70.8	80+
1903–1907				71.1		
1902–1906			69.5			
1901–1905		70.7				
1900–1904	69.3					
Total	93.3	93.4	93.5	93.4	93.5	50+

in consumer behavior between younger and older generations become a source of potential social conflict over environmental issues? Under such a scenario the elderly would not only be accused of environmentally undesirable conspicuous consumption, but moreover of being the source of large intergenerational inequity with respect to the accumulation of environmental burdens[5] due to their past actions. All told, demographic trends indicate the importance of reexamining the assumption that older generations are indeed rather immutable in their preferences and consumer behavior, or alternatively whether "green behavior" would diffuse (at different rates and levels) across all generations.

[5] This in particular applies to long-lived environmentally harmful effluents such as radionuclides or greenhouse gases like CO_2. For a discussion of intergenerational equity issues in greenhouse gas emissions see Fujii, 1990 [7] and Grübler and Nakicenovic, 1994 [11].

TABLE 2
Age-Specific Car Ownership (COS) Rates, by Age Groups and Sex, 1982 and 1990
(Number of Cars per 1000 of Population)

	Females		Males		Total	
Age group[a]	1982	1990	1982	1990	1982	1990
Under 17	10.6	21.2	42.5	37.1	27.1	29.4
18-20	55.7	71.2	200.2	190.6	130.2	132.3
21-24	237.4	272.0	663.2	587.1	456.9	432.8
25-29	327.7	409.2	863.3	839.7	603.5	630.6
30-34	296.6	417.3	906.6	934.5	609.4	682.9
35-39	273.6	410.4	929.9	954.9	609.8	686.1
40-44	245.9	416.0	942.0	1012.7	603.8	720.5
45-49	204.5	399.5	973.9	1080.8	598.1	748.8
50-54	158.3	308.7	933.6	1096.3	549.0	710.1
55-59	132.1	218.7	848.5	1008.2	446.2	614.8
60+	47.5	100.4	473.2	712.6	205.0	337.9

[a] Age at beginning of the year.

Another lifestyle aspect deals with migration. How would the aspirations and consumer preferences of a young immigrant, coming from a background with low levels of material affluence and consumption, compare to postmaterialistic values and ultimately to the consumer behavior of the "green generation" in his or her country of destination? Again this aspect points to the need to consider heterogeneity in lifestyle patterns, which lends itself to the analysis from a generational perspective.

Not only does the emergence of "green" consumer behavior take time, but also the behavior itself takes time, as can be testified by anyone participating in one of the elaborate garbage separation and material recycling schemes put in place in a number of European cities. In fact, much of the subjective impression of the decline in free time is related to a "compression" of active work careers, due to longer education and earlier retirement. Thus, although indeed the amount of free time, measured over the entire population or over a person's lifetime, has been increasing, gains during the active work career have been much less significant [1]. This is yet another illustration of the importance of considering heterogeneity and differentiation of expressions (and constraints) of social behavior. Compression of time during active life can be one contributing factor stimulating material consumption. Conversely, changes in lifestyle can be contingent on changes in time budgets, including inter alia alternative models of the distribution of free time over one's lifetime. Perhaps transport modal choices are the best illustration of the critical importance both time and time constraints play in consumer decisions.

An Illustration: the Demographics of Car Ownership

DATA

The following illustration of cohort dynamics is based on data (Table 2) on mid-year stocks of private-owned passenger cars in the Federal Republic of Germany (FRG) by age groups and sex of the owner, for the period 1982 to 1990 [23][6]. Some interpolations were required to calculate age specific rates (by single years of age) of what we will call

[6] The data also include preliminary de-registered cars, but do not contain cars of owners with unknown age and cars of corporate ownership (firm cars). The latter accounts for approximately 10% of all cars. Note also that this kind of disaggregated data has not been generated before 1981.

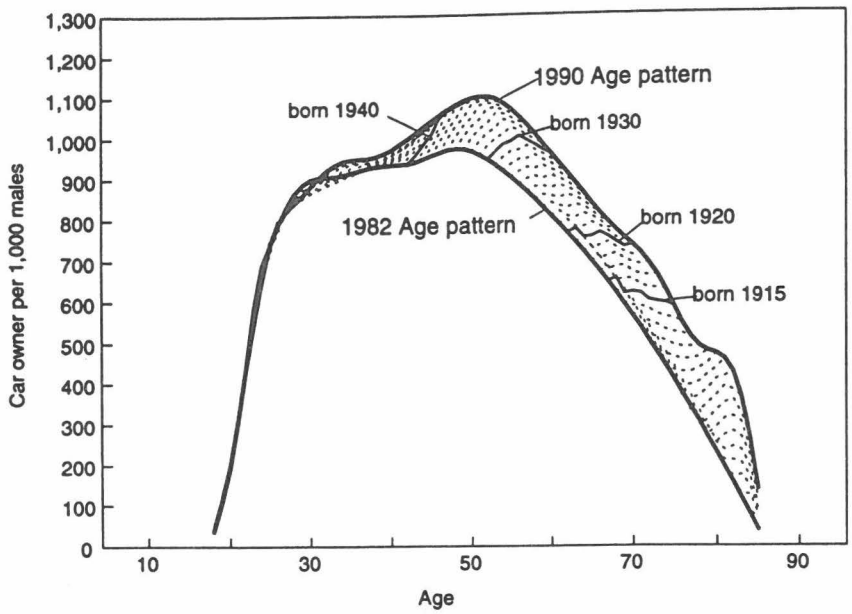

Fig. 4. Germany: Age-specific COS rates for males, for 1982 and 1990 and selected cohorts.

car ownership (COS).[7] It is important to emphasize that this variable is perhaps not the most useful lifestyle indicator, as it measures ownership rather than actual car usage. In the absence of appropriate data, however, we assume the COS variable to be congruent with actual car usage.

The (period) age patterns of COS for the period 1982 to 1990 show a very high overall level for males and a significantly lower level for females (Figures 4 and 5). Although changes in age-specific COS rates for the period under consideration appear to be minor for males, and are concentrated in the age groups beyond 45, for females the magnitude of increase between 1982 and 1990 is significantly higher and, at the same time, is more evenly distributed across the age intervals. Smaller increases for males may result from their much higher level of COS: In 1990 males in the age group 40 to 59 even owned, on average, more than one car per male, whereas the highest COS rate for women did not exceed 0.42 cars per woman.

Indications for further changes in both level and age patterns of COS can already be derived from the period data, because the observed patterns show significant changes in the period 1982 to 1990.[8] Obviously, the penetration of car ownership seems to be far from stable. The period patterns alone, however, do not reveal clear indications about possible trends of changes. For deeper insights into the dynamics of COS changes, spline-interpolated COS rates for single-year age groups have been rearranged along cohort lines. Figures 4 and 5 show, together with the period observations for 1982 and 1990, selected cohort trends, suggesting not only that further changes in age-specific COS

[7] We used mid-year population estimates for the former FRG for the years 1982 to 1990. The calculated central COS rates for males, females, and both sexes combined (total) have been spline-interpolated into single-year age groups. We assumed car ownership beyond the age of 82 as being negligible, and therefore rates for all ages over 85 have been set to zero.

[8] For a discussion of car density and possible trends of the number of cars in Germany, see Möller, 1990 [27].

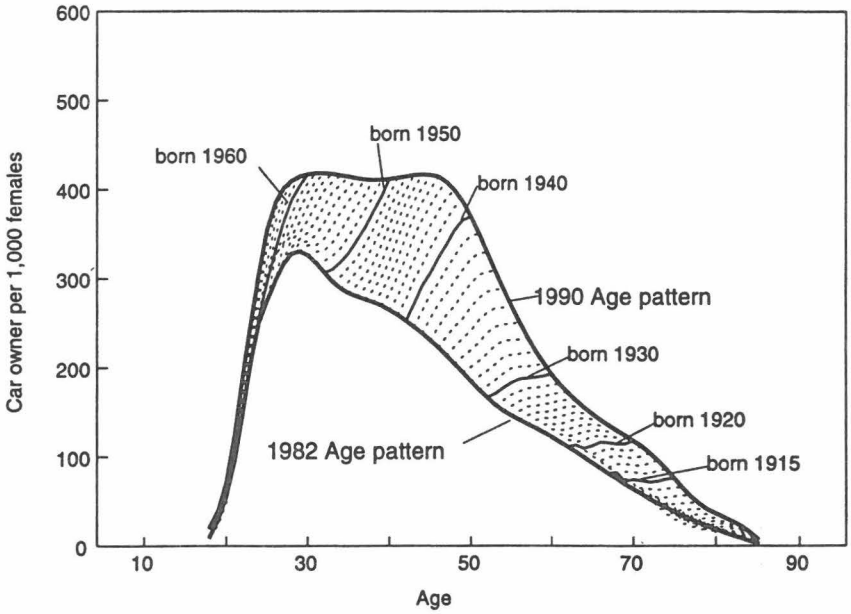

Fig. 5. Germany: Age-specific COS rates for females, for 1982 and 1990 and selected cohorts.

patterns are likely to occur, but also some possible trends. For example, it seems obvious for today's male and female cohorts to have higher COS rates when they become older compared to their predecessors (see male cohorts 1915 and 1920, and female cohorts 1915 to 1930). It seems also likely, especially for females, that certain cohorts will further increase the maximum level of COS, arriving at rates not observed so far. This can easily be assumed, for instance, for the 1940 male cohort, and for female cohorts born between 1960 and 1940.

TRENDS

In order to estimate further cohort trends of COS, a simple combination of logistic functions were used to model complete cohort age patterns (see Appendix 2). Figures 6 and 7 show modelled COS trends for selected cohorts. For both males and females there is a tendency toward higher COS rates for the elderly, but this is much more pronounced for women. There is also some evidence for rather different trends regarding the cohort-specific maximum level of COS for males and females, respectively. Although for some male cohorts, even a further increase of COS seems to be likely (for those born around 1940), for cohorts born after 1950 lower maximum COS rates of about 940 per 1000 can be assumed (see Figure 6). The possible decrease for the younger cohorts, however, is related to much more uncertainty, as they are far from showing stable trends. Furthermore, a possible reduction of COS for younger male cohorts should relate to female cohort trends. Although for older cohorts even an increase in female car usage probably resulted in increased male car ownership, with changed female attitudes toward self-determination and economic independence this might have already changed for younger cohorts. For women, the modelled cohort trends strongly suggest further increases in COS for almost all cohorts, thus raising the maximum COS level for them (Figure 7). We arrived at about 520 per 1000 females as an upper limit.

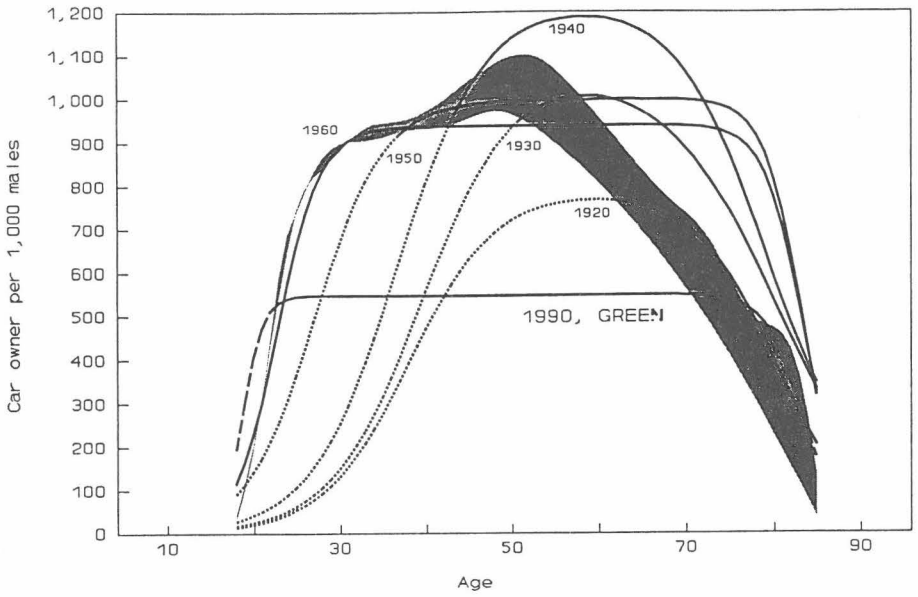

Fig. 6. Scenario cohort trends for males.

Based on these sets of possible cohort trends, three difference scenarios have been estimated for future car ownership in post-unification Germany. It has to be noted that we assumed the age-specific COS rates to be similar for East and West Germany, although the estimation of the age patterns and levels of COS was based on data for West Germany only. The rapid catch-up in East Germany after unification regarding number and density

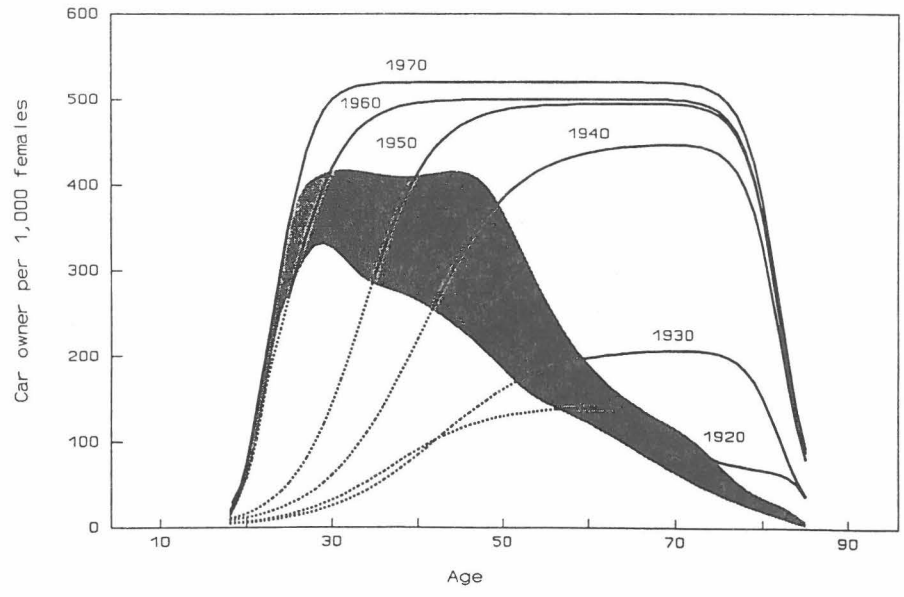

Fig. 7. Scenario cohort trends for females.

of private cars might serve a confirmation of this hypothesis [43]. Latest data [42] indicate that as of January 1993 66.2% of all households in East Germany owned a car, compared to 73.9% in West Germany. Differences in ownership rates of other consumer durables had also practically disappeared by 1993. The only noticeable difference was in single-person households (including the elderly), which seems to confirm the cohort perspective of car ownership changes adopted here.

BENCHMARK scenario: Constant 1990 age-specific COS rates.
TREND scenario: Further cohort dynamics, as described above, have been assumed for all cohorts born before 1960 (males) and 1970 (females). The saturation level for male COS rates was assumed to decline from 1220 for the cohort 1940 to 940 for the 1960 born. For females, an increase was assumed from about 450 for the cohort 1940 to about 520 for those females born before 1970. For all younger cohorts, the COS patterns have been set constant to the 1960 (males) and 1970 (females) cohorts.
GREEN scenario: Based on the TREND scenario, a dramatic reduction in cohort males COS have been assumed, starting with those born 1970 and reaching its lowest level of 550 cars per 1000 male population for the cohort 1990. All cohorts born after 1990 are assumed to remain on that level. For females, no reduction in COS for the GREEN scenario has been assumed.

Applying the unchanged 1990 COS rates (BENCHMARK) to a population projection will reveal those potential effects that are due to demographic changes, namely changes in size and the age and sex composition of the population. The TREND scenario serves as a conventional wisdom approach, as it assumes simply the continuation of observed trends, though derived from cohort dynamics. The GREEN scenario, on the contrary, tries to assess implications of a reduction in COS due to several potential reasons, such as growing environmental awareness, green taxes (emission taxes), increased car pooling, and so on.

All three COS scenarios have been combined with a recent official population projection for Germany [45]. According to it, the German population will decline by 12% or almost 10 million people within the next 4 decades until the year 2030. At the same time, the population in Germany will continue to age, for example, the percentage of the elderly (aged 60 and older) is expected to rise from 20.4% (1990) to about 34.9% in 2030 or, in other words, the total number of the elderly will increase from 16.3 million in 1990 to 24.4 million in 2030. Changes are also expected with respect to the sex ratio of the elderly: The 1990 ratio of 168 women to 100 men will decrease to 126 to 100 in 2030.

The three scenarios imply rather diverse trends for the total number of privately owned passenger cars in Germany (Table 3). For the BENCHMARK scenario, only a little increase in the number of cars (about 1.4 million) is to be expected for the next decade, and even a decrease thereafter. In 2030, the total number of cars will be about 4 million cars less than around 1990, due to the drop in total population by about 10 million people.

Assuming further changes in the age patterns of COS as explained above (TREND scenario), the number of cars in Germany will increase, but more so in the mid-term than in the long run. Around the year 2010, about 41.4 million cars have been estimated, and about 37.6 million in 2030. As for the GREEN scenario, the total number of cars will rise at almost the same path as for the TREND scenario until 2010, but then decreases from about 40 million (2010) to about 33.3 million (2030).

TABLE 3
Projected Number of Private Cars by Scenarios, 1990–2030 (in 1000)

Year	Scenario		
	BENCHMARK	TREND	GREEN
1990[a]	34,628	34,628	34,628
2000	35,956	40,206	40,045
2010	35,449	41,076	39,982
2020	33,570	40,055	37,250
2030	30,487	37,560	33,263

[a] The 1990 figure for cars in Germany, though a result of our estimation procedure, is very close to that given by SHELL (1991) [43], amounting to about 35.3 million cars (30.7 for West Germany and 4.6 million for East Germany).

TABLE 4
Projected Car Density by Scenarios, 1990–2030 (Cars per 1000 of Population Aged 18 to 85)

Year	Scenario		
	BENCHMARK	TREND	GREEN
1990	546	546	546
2000	552	617	615
2010	553	641	624
2020	545	650	605
2030	534	657	582

TABLE 5
Sex Ratio of Car Ownership by Scenarios, 1990–2030 (Percentage of Female Car Owners)

Year	BENCHMARK (%)	TREND (%)	GREEN (%)
1990	25.9	25.9	25.9
2000	25.2	30.7	30.8
2010	24.5	33.6	34.5
2020	23.9	35.4	38.0
2030	23.7	36.1	40.7

The car density (number of cars per 1000 population in the age group 18 to 85) will rise for all three scenarios until the year 2010 (Table 4). In the long run, however, car density varies widely according to the different scenarios. For the BENCHMARK scenario, it will even drop below the current level (1990), mainly due to a decrease in the size of the population. The TREND scenario shows a continued increase well beyond 2010, resulting in 657 cars per 1000 population. As expected, under the GREEN scenario the car density will decrease in the long run, but is found well above the initial figure of 1990. This has to be seen against the background of a declining population, which led to the conclusion that the assumed cohort dynamics for the GREEN scenario will overcompensate the population decline.

Except for the BENCHMARK scenario, there is a dominant tendency toward a further feminization of the driving (car-owning) population (Table 5). The increase in female COS for both the TREND and the GREEN scenario is significant. Although the underlying assumptions for the two scenarios are quite different, the level of feminization for both of them is not very different, rising from one out of four (1990) to more than one out of three (TREND) and even four out of ten (GREEN).

TABLE 6
Age Structure of Private Car Owners by Scenarios, 1990–2030 (in 1000)

	Private cars owned by people in age group		
		60+	
Scenario, year	18–59	Cars	As percentage of total
BENCHMARK			
1990	29,323	5,305	15.3
2000	29,014	6,942	19.3
2010	28,247	7,202	20.3
2020	25,750	7,819	23.3
2030	21,702	8,786	28.8
TREND			
1990	29,323	5,305	15.3
2000	30,904	9,302	23.1
2010	29,379	11,698	28.5
2020	26,986	13,068	32.6
2030	22,703	14,857	39.6
GREEN			
1990	29,323	5,305	15.3
2000	30,743	9,302	23.2
2010	28,284	11,698	29.3
2020	24,182	13,068	35.1
2030	18,406	14,857	44.7

There is a significant tendency toward an increase of older car owners for all scenarios (Table 6). Starting with 15.3% of car owners aged 60 years and older in 1990, this percentage is expected to rise to about 29% (BENCHMARK), 40% (TREND) or even 45% (GREEN) until 2030. The rapid aging of the car-owning population is due to two facts. First, the subset of the population ages as the total population shifts its age structure toward the higher age groups, though not necessarily at the same path and speed. The pure effect of demographic aging can be seen in the BENCHMARK scenario, which shows almost a doubling of the percentage of older drivers. For the TREND and GREEN scenarios, the assumed "aging" of age-specific COS profiles/patterns adds to the demographic effect, increasing the aging of the car-owning population even more. One can summarize this example as follows:

- The number of cars in Germany is likely to increase. This can be derived from upward trends of cohort COS for many contemporary generations, especially pronounced for females. A clear tendency toward a rising stock of private cars is limited to the mid-term period until 2000/2010. After 2010, a decline can be expected for demographic reasons. The car density, however, is likely to increase further.
- For reasons of comparison, some results of a recent projection regarding private cars [43] should be mentioned. The Shell Low scenario[9], with a total number of cars in 2010 of about 41 million, arrives at almost the same level as our results, for both the TREND and the GREEN scenario. The SHELL High scenario[10] comes up with almost 46 million cars in 2010, or more than 10 million cars more than

[9] This more pessimistic scenario is originally labeled "European Community as block."
[10] Originally labelled as "European Community under Change."

in 1990. With a car density of almost 700 cars per 1000 population, this could challenge traffic and transport enormously. Interpreting this number within the framework of age- and sex-specific COS, this would mean either a much higher level of female COS, a continuing tendency to have more than just one car for males, or both. Because the Shell scenarios are essentially based on the main characteristics of the existing stock of cars—like its age structure—and its past trends, those results are not easy to compare with the approach presented here, relying on behavioral trends along cohort lines of car owners.

- Major changes in the age composition of car owners are most likely, resulting from cohort trends not easily visible from period observations alone. The underlying behavioral changes are especially pronounced for persons aged 60 and over, thus reflecting expected major shifts in attitudes among the elderly. These behavioral changes of the elderly toward prolonged car ownership—and extended car usage in older ages—in combination with the general demographic trend of population aging is the main reason for a mid-term increase in the number of cars in Germany, despite the fact of a shrinking population. Besides the implication a rising stock of cars most likely will have, the aging of the driving population is another issue of considerable relevance. Because driving habits and risks of a car accident are also age specific, existing safety standards and traffic regulations may be challenged.[11]
- Even if one assumes a rather dramatic drop in male COS as in the GREEN scenario, the total number of private cars is likely to increase further in the medium run, and will decline only modestly in the long run. If behavioral changes are solely bound to cohorts, as in this illustration, then the penetration of changed attitudes, carried by successive cohorts, takes a long time. This indicates that desirable changes—the drop of COS for all younger generations—can be compensated by changes at the other end of the age span, namely the assumed "stay-active-longer" life style of the elderly.

Dealing with Heterogeneity: A Research Agenda

The preceding discussion was aimed at supporting our argument on the importance (and possible interest) of a perspective of generational heterogeneity in social behavior. As no single indicator (or model) will be able to capture phenomena of social change in an uncontestable way, however, complementary angles of description *and* analysis are required. The inclusion of cohort effects and generational dynamics (as argued for in this paper) constitutes, in our viewpoint, a further important step—yet only a complementary one—toward a more thorough understanding of social change.

With respect to empirical indicators, comprehensive coverage of a wide array of expressions of social change are required. This should include attitudes and perceptions, activities, their possible constraints and information about the social (even the physical) context in which values, perceptions, and consumer choices and actions evolve. These hitherto often separate areas of investigation have to be linked together so that they become more relevant for the study of the social dimension of global change. Measures of various demographic characteristics, along with other socioeconomic variables are particularly useful for linking these diverse domains together.

In addition, from the perspective of energy demand and environmental impact analysis, the focus of surveys would have to be enlarged to cover not only consumer

[11] For a discussion of the demographics of car accidents see Rallu (1990) [33]. A comprehensive overview about elderly drivers is given in Malfetti (1985) [25]. See also O'Neil (1992) [30].

decisions but also subsequent *usage patterns* of artifacts. This is because usage patterns can have more influence on the overall efficiency for delivering a particular service demand than the characteristics of the up-front technological chain [28]. For instance, per passenger-kilometer traveled, usage choices (how, and what kind of a car is driven, or even not driven at all if the trip[12] is covered by walking and bicycling instead) can matter more than the fuel economy of the car, and/or the efficiency of the petroleum supply chain including extraction, transport, refining, and distribution.

Thus, existing data sets and surveys concentrating on areas as diverse as public beliefs and attitudes, time budgets, consumer expenditures, socio-demographic panels, traffic surveys, etc., have to be combined together, and especially maintained over a sufficiently long period to allow study and documentation of processes of change. The examples shown in this paper, or identified in the literature, indicate that in individual fields longitudinal data already exist, yet up to now were designed primarily to respond to the particular needs of specialized fields of study. A necessary precondition for linking different surveys and panel data would be to better harmonize and standardize basic socio-demographic variables in various surveys. In the meantime, "selective sampling" (e.g., concentrating on the early phases of cohort biographies, in which the degrees of freedom in the decision space of individuals are largest) could be performed to identify possible value changes and newly emerging lifestyle patterns, not yet apparent at the aggregate level.

The ultimate modeling agenda should aim to link values and perceptions to physical expressions of social behavior with its subsequent impacts. We also maintain that such models should explicitly include a cohort perspective, perhaps with special emphasis on transitional periods such as formation of an independent household, or at retirement. Such transitional periods may be considered as "opportunity" windows to change existing lifestyle patterns. Below we discuss some (nonexhaustive) points for consideration in future analysis and modeling of social change phenomena.

1. Changes in behavioral "targets" versus changes in timing of behavior. Models need to be both dynamic and cohort specific in order to differentiate between "changing targets" as opposed to changing "timing" of targeted decisions. Such a differentiation becomes especially clear when in retrospect one analyzes whether people have changed their consumer choices rather than just the timing of their decisions. A hierarchy of phenomena could include: (1) action versus nonaction (or adoption decision versus nonadoption), (2) frequency and intensity of actions, (3) timing of decisions/actions.
2. Who are the actors? Apart from distinguishing different categories of consumer decisions [individual, within family, within particular (formal or informal) social groups, or at the level of firms or companies, etc.], care must also be given to differentiate "unintended" from planned decisions, and voluntary versus contingent type of actions.[13]
3. What are the differences between attitudes and perceptions and actual behavior? Here models should attempt to identify the significance of such differences, identify reasons for them, and how these in turn influence consumer decisions.

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[12] Detailed traffic surveys in Europe indicate that up to 50 percent of all trips (most of them by car) cover distances of less than 3 km (Socialdata, 1984 [46]; Sammer, 1990 [39]).

[13] Consider for instance the case of an unplanned child, or of an inheritance as examples of *unintended* decisions, or emigration of children (together with their parents) as an example of contingent action.

4. Do consumer choices depend on infrastructural support; and what are the relationships between values and consumer preferences and the organizational/institutional structure of ownership of consumer products? Here models should differentiate between a topology of consumer decisions as affected by different (degrees of) infrastructural requirements (independence from support infrastructures[14] versus strong dependence, or intermediary states). In addition, different organizational/institutional settings for ownership (e.g., buy versus lease models of consumer products) should be differentiated, and the influence of value systems on such ownership preferences be investigated.
5. Differentiation of decision types into nonrecurrent[15] and recurrent decisions. This differentiation is similar to those proposed in consumer-products diffusion research between first purchase and repeat purchases [24]. Recurrent events can be further decomposed into sequences of singular events (e.g., the purchase of the first, second car, etc.) and linked together via transitional probabilities. "Event chains" can serve to derive a topology of changes, considering for instance: (temporary or permanent) interruption of event sequences, slow-down or acceleration of frequency of sequential events, or changes in the characteristics of the event or item involved.
6. How to deal with limited data? Under the assumption that cohort trends are more stable than period trend typologies, various cohort-specific life cycles may be constructed. This would be a good way to combine cohort-specific approaches with life-cycle analysis. Such a typology may also provide initial models in case of limited data availability, for example, only cross-sectional data or limited longitudinal data on cohort specific behavior.
7. Finally on our "shopping list," we would like to see models addressing explicit interactions between different agents of (consumer) decisions. Again, the reference example is taken from demography, where it is known as the "two-sex problem".[16] The two-sex problem arises when male and female populations are treated separately in modeling and projections, which is normally the case. Considering their interactions requires a different design of data sampling. In short, consider the actors rather than statistical proxy variables. Interactions between actors in the context of consumer decisions could be modeled, for example, via different probabilities depending on types of relationship, types of decisions, and kind of interactions between actors.

Conclusions

Why do we think the cohort or generational perspective outlined in this paper is important? First, it is an important concept for dealing with heterogeneity in consumer behavior, enlarging traditional models, in order to observe, model, and discuss possible explanations of different "populations" within a population. Second, it can enlarge more traditional approaches leading to more differentiated perspectives and enlarging methodological pluralism, which we consider of particular importance in the study of social change. Third, the approach can also provide hints on the dynamics (and possible

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[14] In economic theory referred to as *network externalities*. The utility of adoption of a consumer product can depend on the quality of the available support infrastructure (e.g., electricity for a CD-player, a road network for an automobile, or standards for video-recording equipment enabling one to share video cassettes.

[15] The most classical human "singularity" being of course mortality.

[16] Compare Pollak, 1986 [31]; van Imhoff, 1992 [48].

constraints) of the diffusion of "green" behaviors and consumption patterns. If indeed cohort-specific behavior patterns show greater stability than aggregate period-specific data, it may also be easier to anticipate future changes, or to look into more detail into "critical periods" of a cohort biography in which various generational "consumption paths" are being formed. As such, it can also direct data sampling and modeling toward the areas most critical for causing change and identifying trends that may not be visible yet at the aggregate level.

The cohort approach is one (out of other important ones) working hypothesis to capture phenomena of social change. In addition, it will be also important to consider differences and dispersion within particular cohorts. However, one general problematic remains. How does such an "atomized" approach capture the possible reconfiguration of the identified groups? It would be naive to assume that people hold extensively to "their" generation. However, such a problematic is also inherent in more traditional approaches, for instance in household surveys, where people also move between categories. Longitudinal panel surveys following the evolution of particular groups and a more careful look at "transitionals" are possible research strategies.

Even if the "atomistic" approach advocated here can release some problems (e.g., sweeping generalities) domains of uncertainty remain. In making forecasts (or rather: likely scenarios of possible futures), life cycle, income, and cohort-specific analysis all combined will still entail inevitable elements of assumptions, and require permanent adjustments. This adaptive perspective is important as not all of the future may be deducible from the past. But it may enable us to differentiate what changes are either rooted in the past or influenced by it from those that come as genuine "surprises," for which human history provides many plentiful examples.

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APPENDIX 1
Age, Period, and Cohort in Demographic Analyses

Age, period, and cohort are key concepts in demographic analyses.[a] Demographic events, such as birth, marriage, divorce, moving from one place of residence to another (migration), and ultimately death are characterized by three measures:

Period – The exact date of occurence of the event (measured in terms of calendar years);
Cohort – the exact date of occurrence of the event-origin, that is the time when the specific group of individuals under risk came into existence (represented by the year of birth);
Age – the seniority of time elapsed since the occurrence of the event-origin (measured in years).

Because of their considerable explanatory power, age, period, and cohort variables[b] are often used as proxies for underlying causal relationships of the events under study.

The *age variable* often is a proxy for physiological states, the amount of exposure to certain influences (as social norms or environmental hazards), or stages in the life cycle. Most demographic events show some typical age patterns, even across countries and cultures. Human fertility, for instance, not only is physiologically limited to the age span of approximately 15 to 50 years, but also shows a well-known age distribution. The force of mortality also follows a common age pattern, from relatively high mortality in the first days and months of life, through an all-time low around the age of 10, and a geometrically increasing mortality for later age groups. This suggests that physiological factors have significant influence. For other demographic events, as migration and (first) marriage, characteristic age patterns can be found, too. Regularities in demographic age patterns are widely used in so-called "indirect techniques" for dealing with incomplete or defective data [52].

The *period variable* can be used as a proxy for all sorts of contemporaneous influences that induce changes to all age groups (or cohorts) in a similar way during a certain period of time. True period effect should, therefore, work irrespective of former experiences of the cohort (actors). Period effects are assumed by demo-economic models, linking the level of say, fertility or (first) marriage during a given period of time to gross national product (GNP), individual income, business cycles, labor force participation, and so on. Period effects are easily identified when the underlying causes are catastrophic or extraordinary events, such as wars, epidemics, and famines.

The *cohort variable* can be taken as a proxy for influences of the past that determine the response or behavior of cohorts in the present. The underlying assumption is that earlier events, experienced by the members of a cohort, leave an imprint (either physiological or behavioral) on the members of that cohort. In other words, lifetime experiences are regarded as important driving forces for cohort response or behavior at later stages of life. One example for the relevance of the cohort variable is the fact that the first 15 years of life determine – at least partially – the health of the cohort for its whole lifetime [4, 5, 50]. Related examples are the exposure of groups of people to mining at the coal-face and their subsequent morbidity and mortality patterns.

Obviously, these three measures are interrelated. A strong period effect, like a war or a famine, might also result in cohort effect for certain cohorts.

[a] For a comprehensive discussion see Hobcraft and Gilks (1981) [13]; Hobcraft, Menken, and Preston (1982) [14]; Willekens and Baydar (1984) [51].

[b] Note that there is a linear relationship between the three measures; Age = Period – Cohort.

APPENDIX 2
Modelling the Cohort Trends

Logistic functions have been chosen for modelling future cohort trends of COS. This function type is assumed to represent the observed cohort trends reasonably, and allows one to operate with saturation levels for COS in particular. In brief, the age-specific cohort COS rates – COS(x) – are represented by a combination of two logistic functions:

$$COS(x) = LOG1(x) - LOG2(x)$$

The first function (LOG1) represents the steady increase of COS with age until a certain upper limit (saturation level) is achieved, and the second function (LOG2) is modelling the reverse trend at older ages, when car ownership decreases. The combination of the two logistic functions is assumed to represent cohort car ownership over the life cycle.

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