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RESEARCH ARTICLE

Assessing the impact of structural change in sustainable consumption and lifestyles research

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Scientific evidence highlights the pivotal role for structural change in pursuit of the sustainability transformation. A particular challenge for research on structural aspects of sustainable consumption and lifestyles, however, is the assessment of their impact. Especially quantifying the impact of structural change remains a serious problem. While some forms of structural change can be quantified, like the rate of building renovations, changes in the energy mix at the production level, or trends in access to health care or education, the impact of other changes such as societal narratives about wellbeing, political campaigns on energy technologies or policies, or the abandonment of the growth paradigm defy easy quantification. This article aims to shed light on potential avenues for quantitatively assessing the impact of structural change drawing on insights gained by a group of international and interdisciplinary research consortia funded by the European Union in the area of sustainable consumption, citizenship, and lifestyles research. It delineates strengths and weaknesses of different approaches, foci and blindspots of associated data types. Thereby, it highlights fundamental decisions that need to be made in research designs, but also important aspects to consider in the interpretation of

results. Finally, the article highlights the particular challenges related to assessing the impact of deep political and ideational structures.

Keywords sustainable consumption • sustainable lifestyles • structural change • impact assessment • Quantitative Methods

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Introduction

Scientific evidence points not only to the urgent need to significantly and quickly reduce global carbon emissions (IPCC, 2022), but also highlights the pivotal role for structural change in pursuit of this reduction (Hirth et al, 2023). Indeed, reaching the goal of limiting global warming to anything close to the 1.5°C target of the Paris Climate Agreement will require a radical transformation of the structures shaping today's production and consumption systems, or, put differently, the structures that enable the lifestyles of today's consumer class (Lavelle and Fahy, 2021). A successful transformation will depend on system-wide structural change and, thereby, comprehensively impact individual and societal life (Gumbert et al, 2022; Koch and Hansen, 2023).

A particular challenge for research on structural aspects of sustainable consumption and lifestyles, however, is the assessment of their impact. Especially quantifying the impact of structural change remains a serious problem for sustainable consumption-oriented research. And yet if we want to make the case for the importance of pursuing structural change and draw political attention to this objective, being able to give some assessment of the likely impact of such change would be highly desirable. Politicians (and the media) tend to be more responsive to numbers or, at a minimum, ask for numbers to be able to support policy narratives. The focus on quantitative methods in applied sustainability research is frequently evident through the demand for 'solid' data derived from representative samples and replicable research designs, as well as reflected in discussions and policy efforts that prioritise directly measurable sustainability outcomes, such as metered energy use or tangible reductions in greenhouse gas emissions (Rau et al, 2018). Yet, to date, such 'directly measurable sustainability outcomes' tend to be mainly associated with individual behavioural change and neglect the question of structural change and thereby structures as an important determinant and limitation to behaviour. This potentially leads to the misperception that individual behaviour is the only or primary driver of change, or even to attributing the sole responsibility for change to the individual.

If we, researchers in the field of sustainable consumption and lifestyles, want decision-makers to shift their focus from the pursuit of individual behaviour change to structural change as a source of transformative momentum, our research needs to be able to show the mileage that can be gained with changes in economic, political, technological and societal structures. Furthermore, quantification of structural change is also a precondition for inclusion into climate and energy scenarios, which are

frequently used to evaluate the potential contribution of policy measures to reach climate goals. Importantly, an emphasis on the need for quantifying impacts at the structural level is in no way intended to dismiss the significance of structural change that cannot be quantified or of qualitative impact assessments, but to recognise the importance of numbers, which bear almost a magical significance in the policy arena.

And yet, measuring the impact of structural change, especially of deeper or more complex structures such as societal norms/narratives or changes in political or economic institutions, is extremely difficult. While some forms of structural change can be quantified, like the rate of building renovations, changes in the energy mix at the production level or trends in access to healthcare or education, the impact of other changes, such as societal narratives about wellbeing (that is, what it means to live a good life), political campaigns promoting energy technologies or a more differentiated evaluation of economic growth, defy easy quantification.

This article aims to shed light on potential avenues for quantitatively assessing the impact of structural change. In pursuit of this objective, it draws on insights gained by a group of international, interdisciplinary research consortia – all involving different social science perspectives in interaction with each other or with other disciplines such as industrial ecology – funded by the European Union in the area of sustainable consumption, citizenship and lifestyles research (see Appendix 1).[1] The six projects have pursued different aims with respect to structures, adopted different methodological approaches and assessed different forms of structures. EU 1.5° Lifestyles, for example, considers needs for structural change in the context of enabling a mainstreaming of lifestyle options, that is, household behaviours and routines, that would fit to the 1.5°C climate target. Likewise, Climate CAMPAIGNers aims to uncover the structural changes required to foster enduring and climate-friendly behavioural shifts in lifestyle-related decision-making in terms of actions, consumption patterns, as well as alignment with policies. ENCHANT considers structures in terms of their creation of boundaries for what households can realistically achieve in terms of reductions in electricity consumption. FULFILL investigates the role of structures in the pursuit of a transformation towards sufficiency-oriented lifestyles (lifestyles with a low greenhouse gas impact while maintaining individual and collective wellbeing). DIALOGUES considers the role of structures as an element of practices for inclusive energy citizenship, that is, practices that allow ordinary people to take a central role in the energy transition. EnergyPROSPECTS, finally, explores internal (agency) and external structures that impact the forms of citizen engagement towards a more just, democratic and sustainable energy system.

Although differing slightly in their objectives, together these projects have gathered insights into opportunities and challenges for quantifying structural change. Such knowledge is important both for future as well as for ongoing and concluded research projects. At best, the insights developed will help those designing new research projects to identify the most valuable methodological approaches for their objectives. Hopefully, they will also inspire researchers to increasingly take structural determinants of the sustainability of consumption and lifestyles into account. At a minimum, they can serve as a reminder of what a chosen approach necessarily neglects, and thus improve the interpretation of research results.

The article proceeds as follows. The next section lays out our understanding of 'structure' and 'structural change'. On the basis of qualitative and quantitative research, we provide examples of structures which sustainable consumption and lifestyles

research in general, and our various research projects in particular, suggest to be impactful for achieving a shift towards radically different lifestyles. The following section then details approaches and data types and sources used to quantify structural impacts in our projects, and associated opportunities and challenges. Finally, the article concludes with a short summary and outlook.

The many forms of structures in sustainable consumption and lifestyles research

Structure(s) and social change

Public and academic discourses frequently associate 'structure' with some notion of order, which results from constraints imposed on behavioural choice. Structures exist in the form of formal and informal, material and ideational institutions fostering patterned forms of activities (Hirth et al, 2023). Academic debates often have juxtaposed structure and agency, with Giddens' theory of structuration (1984) highlighting the duality of structure and agency resulting from interactions between both, as well as underlining the enabling and constraining role of structuration on human action. The contrast made between structure and agency, however, also helps to identify what may *not* be considered a 'structure', specifically personal choices and actions.

Structures will always reach beyond the individual, though individual agency influences them, because structures are inherently collectively constituted. Thus, structures are relatively stable phenomena, and yet they are changeable. Challenging the dichotomy between structure and agency, some scholars prefer to apply Actor Network Theory or the concept of configurations, highlighting the role of skills and knowledge and wider societal systems in the formation of sociotechnical landscapes (Rip and Kemp, 1998; Greenhalgh and Stones, 2010). Others apply social practice theory approaches, recognising how collectively held meanings, material arrangements and skills, competencies and capabilities inter-relate in 'mutable temporal structures' (Schatzki, 2019: 35). Such approaches can also be combined with transition theories, demonstrating, for example, how practices affect niche, regime and landscape levels – each exhibiting increased degrees of structuration (Keller et al, 2022). The literature on provisioning systems, in turn, analyses the interplay between individual and collective needs and the processes and institutions involved in meeting society's needs for essential goods and services (Fine et al, 2018; Kreinin et al, 2024).

These theoretical approaches underline the importance of structures, but also demonstrate the need to avoid an overly deterministic understanding of their role in societal change. People can destabilise practices, for instance, through collective action or grassroots innovations (Seyfang, 2007). Yet, the different approaches also acknowledge that the room for choice and individual change is more often than not limited. Many 'choices' take place in systems of provisioning before any individual 'choice' (Dubuisson-Quellier, 2013).

Structural change can be reactive or proactive. Reactive change may come about in response to changes in earth system dynamics and resource constraints or political or economic crises. Proactively, structural change may result from planning for more sustainable societies, specifically change in inter-related (or systems of) ideational and material institutions and processes that underpin all activities.

The question of how changes in structures may come about also relates to the possibility to distinguish between different types of structures. Specifically, one may differentiate between 'shallow' structures, such as specific regulations, which tend to be quite visible and the focus of political debates, and 'deep' structures that are broader and much less visible, indeed often taken for granted (Hirth et al, 2023). Changes in both types of structures will affect individuals, but changes in deep structures will do so in a much more fundamental and broader way. Moreover, intentional pursuits of structural change tend to focus on shallow structures.[2] Indeed, intentional deep structural change is difficult within existing power relations. Yet, these deep structures are extremely influential for achieving a transformation (Kreinin et al, 2024). While not all of our projects used the 'deep' and 'shallow' labels, many of them found deep structures, such as capitalism, societal understandings of wellbeing or market organisation to be particularly impactful for the sustainability of consumption and lifestyles.

As there has been significant progress in understanding behavioural change through quantitative methods, we shift the gaze to how structural aspects can be better quantified. Specifically, we explore how different structures may become visible or invisible in connection with different methodological approaches and data types. Taking a broad and multifaceted approach, we consider structures that are relevant for the sustainability of consumption and lifestyles to exist in all contexts and forms, ranging from political-economic to technological to societal structures (both formal, that is, codified, as well as informal), and from built infrastructures to natural/geographic conditions. From a different viewpoint, we also take into account that both ideational and material structures impact sustainable consumption (Fuchs et al, 2016). Ideational structures take the form of norms, values and narratives attributing meaning that underlie all evaluations of actors, situations and practices, and influence, for instance, to what extent people perceive actual or prescribed behaviours as 'good', 'normal', 'appropriate' or 'desirable'. Material structures, in turn, take the form of (distributions in) financial resources, access to technological resources, infrastructure, markets and the availability of natural resources (including sinks), all of which influence behavioural options and their effects.[3]

Structures in sustainable consumption and lifestyles research

Sustainable consumption and lifestyles research has considered a wide range of structures from different fields and levels. Indeed, it is not easy to get a good overview on structural dimensions of sustainable consumption and lifestyles given the breadth and diversity of what scholars have focused on under this heading.[4] Relevant structures exist at different levels, including global (for example, capitalism), national (for example, federal institutions and policies), subnational (for example, local contexts), and, depending on disciplinary perspective, even individual/household level (for example, psychological structures). They also are political, economic, societal and technological in nature, for instance.

Political structures considered, for instance, range from broader institutional set-ups to specific regulations (for example, Grosjean et al, 2016; Campos et al, 2020). They relate to questions of de jure and de facto political control, considering both state and non-state actors. In this context, projects have explored the role of vested interests, of institutions for citizen participation and justice in political partaking. Moreover, research has focused on the impact of specific policies, but also overall

characteristics of regulatory frameworks, in particular the stringency and coherence of the regulatory framework. Importantly, a number of our projects found political structures to be particularly impactful. In EU 1.5° Lifestyles, for instance, experts ranked the power of vested interests and the stringency and coherence of the regulatory framework among the top three influential structures for the sustainability of lifestyles. Similarly, the PESTEL analysis (see the section on 'Qualitative analysis') conducted in EnergyPROSPECTS identified the political factor as the most important one, both independently and in terms of its influence on the overall system of factors.

Societal structures explored in sustainable consumption and lifestyles research include both formal and informal institutions and range from more stable ones, such as long-term cultural traditions, to more fluent structures, such as dominant narratives (for example, Jackson and Smith, 2018; Keil and Kreinin, 2022). They include broad and often subtle expectations and norms about what is proper and what not, about phases and institutions in life such as childhood or marriage, for instance, but also social structures in terms of income distributions or socioeconomic welfare provisions. Indeed, inequity in terms of ownership of and access to resources was identified as a highly impactful material structure by DIALOGUES and EU 1.5° Lifestyles. Similarly, surveys conducted in FULFILL highlighted the role of economic disadvantages mirrored in deprivation. On the ideational side, narratives and understandings of, for example, 'a good life' or 'justice' were found to be particularly impactful by a number of our projects, including DIALOGUES, EnergyPROSPECTS and EU 1.5° Lifestyles. FULFILL and DIALOGUES also highlighted the influence of gender roles on behavioural choices in energy use. Similarly, both the access to specific relevant information (for example, on product characteristics), but also the provisioning of education and skill development were identified as highly relevant in several of the projects. In this context, ENCHANT explored the effect of information about the effects of one's own behavioural choices versus comparative information about the behaviour of other people in similar situations.[5] At the aggregate level, societal influences also impact the overall acceptability of specific technological innovations, and thus the likelihood of their diffusion. Yet, it is also clear that the provision of information is often not sufficient for inducing change. In DIALOGUES, citizens recruited for 'energy forums' were found to have sufficient information for bringing about change, suggesting that overcoming the information deficit gap is not sufficient and other factors, including structural barriers (for example, time limitations for engagement in energy-related activities), must be taken into account.

Economic structures considered relevant for the sustainability of consumption and lifestyles focus on markets and prices, in particular (for example, Antal and van den Bergh, 2013; Dorninger et al, 2021). The existence of economic (dis)incentives for greener or fairer consumption choices has long drawn attention, of course. Not surprisingly, experimental designs in some of our projects, such as CAMPAIGNers, found economic incentives to be influential for lifestyle choices. In other projects, such as EU 1.5° Lifestyles and EnergyPROSPECTS, expert rankings identified the internalisation of ecological and social costs in general as a crucial step for the sustainability transformation. Similarly, some of our projects, especially ENCHANT, underlined the role of energy markets highlighting differences between countries.[6] Others stressed investment opportunities. Finally, the EE-MRIO analysis in EU 1.5° Lifestyles was able to model expected changes in price levels as well as consider

economic rebound effects, arising from the saving potential of certain low carbon lifestyle options.

Relevant material and technological structures range from the existence of specific technologies or availability and accessibility of energy or resource efficient products and services to broader questions of infrastructure (for example, Birch, 2016; Ruhrort, 2020). The latter includes built mobility infrastructure, infrastructure for energy sources, distribution and provisioning, as well as the characteristics and distribution of existing building stock. Accordingly, regulatory standards for buildings, cars or appliances move into focus, highlighting the link between technological and political structures. Most of our projects assessed the role of the overall energy mix and/or the availability of electricity from renewable sources. ENCHANT also explicitly explored the role of the existing building stock in terms of dwelling types and sizes, and DIALOGUES underlined the importance of space (and time) for citizen dialogue and action around the energy transition.

As the link between technology and regulatory standards already shows, structures often exist in the interface between the various sectors. A politico-economic structure that is very relevant for sustainable consumption and lifestyles research is the growth paradigm. Indeed, experts identified it as the most impactful structure in EU 1.5° Lifestyles. Structures at the interface between social, economic and technological factors are asymmetries in the availability of means of investment, for instance, that also impact house ownership and formal control over relevant technological equipment. Focusing on energy citizenship, both EnergyPROSPECTS and DIALOGUES highlighted structures at the interface between energy provisioning and citizens' political control, that is, focusing on empowerment at the interface between the political, the societal and the technological realm.

Finally, climate and geographical contexts provide a relevant structure as well. They tend to be less in focus in research exploring political, economic or societal strategies for change. Yet, they set an important context for energy consumption. Among our projects, ENCHANT used the availability of relevant data to explore how such climate and geographical contexts interact with energy savings efforts, showing their combined strong influence on the energy consumption of people living in these dwellings. Interestingly, this combined influence also identifies a space for change, including structural changes (for example, by upgrading the insulation standard of the building stock), changes in behaviour and their joint consideration.[7]

In sum, studies of sustainable consumption and lifestyles in general, and the six projects drawn on here in particular, consider a large variety of structures and assess their role with respect to different outcomes, for example, 1.5°C or low carbon lifestyles, sufficiency-oriented lifestyles or the energy transition.

Among the six projects, approaches and research objectives differ slightly in terms of the concrete element of a sustainability transformation that is in focus (see Appendix 1). Yet, they all have in common that they recognise and try to assess the impact of phenomena and dynamics beyond the individual and behavioural level. Such a focus on the structural dimension also serves as a reminder of the risk of 'privatising' the implementation of the sustainability of consumption and lifestyles by making it the sole responsibility of individuals or households. To date, measures and recommendations typically address changes in decision-making or everyday behaviours and provide skills and knowledge to do so, while structural change such

as providing public transport and efficient buildings (changing infrastructure) or menu offers (available options) would likely be more effective for fostering radical, in the sense of transformative, change.

Assessing the impact of structures: approaches and data

In recent years, there has been a growing emphasis on the role of structures in sustainable consumption research. In these efforts, a focus on qualitative methods has predominated. However, there is currently a noticeable shift towards the adoption of quantitative methods in these assessments. It is probably no surprise that the six projects on which this article draws all included quantitative elements and were funded by the EU within close temporal proximity. They show that a range of different approaches exist that allow approaching a quantification of the impact of structures on the sustainability of consumption and lifestyles. They also highlight that the different approaches all have strengths and weaknesses relating to their focus and especially the data types used. In the following, we describe the various approaches and discuss these strengths and weaknesses.

Input-output analysis

Input-output (IO) analysis, or more specifically environmentally-extended input-output analysis (EE-IOA), is a method frequently used in sustainable consumption research, from an industrial ecology or ecological economics perspective, to calculate per capita, country or regional emissions. In our set of projects, both EU 1.5° Lifestyles and FULFILL worked with this method (Tukker and Dietzenbacher, 2013; Stadler et al, 2018).[8] Today, most EE-IOA analyses draw on assessments of economic activities across and between regions to arrive at environmentally extended multi-regional input-output (EE-MRIO) analyses. In other words, these analyses track resource flows between countries and sectors with the help of financial data, thereby capturing both consumption within a country but also trade between regions. In order to calculate the implications of socioeconomic developments for greenhouse gas emissions, EE-MRIO analyses combine these data on economic activities with territorial emission accounts,[9] with emissions being then assigned to the different production sectors. While traditionally, EE-MRIO has been used to calculate current emissions, such analyses can be expanded by adjusting the relevant supply and use tables according to IPCC (or other) scenarios, thus allowing the projection of future developments. In the case of EU 1.5° Lifestyles, for instance, the supply and use tables in EXIOBASE 3 were adjusted in line with the IPCC's SSP1-RCP1.9[10] scenario (Cap et al, 2024). In terms of assessing the sustainability of consumption, EE-MRIO has both strengths and weaknesses, which become particularly clear when comparing it to other approaches like life-cycle assessment (LCA), that is, the assessment of the impacts of a specific product, from the extraction of primary resources, to production, distribution, consumption and final waste (Serenella et al, 2020; Suski et al, 2021). A particular strength of EE-MRIO is that it can more easily attribute environmental impacts to upstream economic drivers, while providing a comprehensive assessment of activities within a country or region, whereas LCA tends to focus on a selection of products and services. In addition, EE-MRIO captures impacts from trade. On the downside, EE-MRIO tends not to account for differences in the production

characteristics of similar products, something which LCA can more easily do, in comparing the impacts of two different cars, for example. Moreover and related to this aspect, getting a detailed view of what changes in a given product would mean in terms of changes in overall environmental impacts is difficult, as the level of resolution of the input-output tables tends not to be that high. Finally, EE-MRIO just like LCA is vulnerable to poor data quality and the analyses depend on a considerable amount of assumptions being made regarding the relevant interactions and dynamics, of course.

In terms of assessing the impact of structural change, EE-MRIO can consider a range of more specific structural changes. The SSP1-RCP1.9 scenario used in EU 1.5° Lifestyles, for instance, already includes assumptions regarding changes in the energy mix. Other structural changes can be addressed via additional changes made to supply and use tables. Examples include policies incentivising a shift to e-mobility, towards vegetarian or vegan diets, or reductions in flying. Importantly, however, assumptions regarding the proportion of the population implementing a resulting shift will need to be made to adjust the data in the supply and use tables accordingly. In this context, a regulatory ban of a product or service (that is, a 100 per cent adoption rate) is much easier to implement in the data than policies relying on economic incentives or the provision of information to consumers via (better) labels and certification systems. For relevant assumptions regarding the impact of economic incentives, it is possible to rely on data on the relevant price elasticities for products and services, (only) to the extent that they exist. For relevant assumption on the impact of improved information systems, some information may be drawn from past instances of change, within limits of generalisability, of course. Particularly difficult for EE-MRIO, however, is the quantification of the impact of changes in broader societal and political structures. Changes in consumption behaviour resulting from changes in narratives about the good life, for instance, could in principle be implemented in the supply and use tables, but would require assumptions about the size of associated changes in a lot of economic sectors, and the question is what the basis for these assumptions could be. Likewise, changes in broader politico-economic structures, such as in the dominance of the growth paradigm or the power of vested interests, would require many assumptions to be made first, for which no clear data basis exists. Also, it is important to note that EE-MRIO cannot differentiate between causes of change. In the case of degrowth, for instance, it is not possible to differentiate between degrowth caused by economic crisis or by a demise of the growth paradigm in political, economic and societal thinking, which would have rather different long-term consequences. Still, while EE-MRIO struggles with quantifying the impact of change in broader, especially societal and political structures, it does offer interesting opportunities in the context of more specific forms of structural change.

(Quantitative) survey analysis

Another frequently used method in sustainable consumption and lifestyles research is the statistical analysis of survey data. FULFILL, for instance, applied surveys to estimate carbon footprints and the state of wellbeing in a first round, with a second round of surveys looking into the stability of lifestyles characterised by the footprint and wellbeing as well as the acceptability of policy instruments. Similarly, ENCHANT, DIALOGUES, CAMPAIGNers and EnergyPROSPECTS conducted surveys. Surveys, in turn, may draw on qualitative data from preceding interviews, workshops

and observational research and seek to substantiate the findings at a representative scale. The strength of survey-based approaches is that they offer the opportunity to compare across different countries, regions, domains or settings as questions can, to a large degree, be standardised (with all the costs this comes with, for example, the need to simplify and categorise experiences people have). Surveys are often able to deliver data that is compatible with official statistics, so that assessments can be made if conclusions drawn based on a sample of respondents matches the population of, for example, a country or city. Furthermore, depending on the survey design, they can also deliver input for other methods such as modelling or experimental designs. Challenges for survey-based research exist in getting as representative a sample as possible and in operationalising complex dynamics in a methodologically sound set of questions and indicators. A further challenge is to design them in such a way that they do not act as an 'intervention', that is, suggest a certain normative understanding of what is right or wrong. This is particularly important in the context of sustainability-related research, as the relevant topics are becoming increasingly politicised in public discourse and because understandings of how change takes place tend to be overly individualised and moralistic. Survey questions such as 'Do you turn off the lights when not in use?' are not only derisory in terms of energy saving potentials, they are also moralistic and shade the need for structural change rather than individual micro actions.

In terms of assessing the impact of structural change, surveys can provide large-scale insights (at relatively low costs) into the relevant target groups' perceptions and evaluations of a given problem, solution, dynamic, and so on. Thus, one can also try to get at deeper ideational structures, such as imaginaries. Limits exist in so far as surveys tend to rely on existing scales that have been tested in the literature. Yet not all scales are able to move beyond individual dynamics to consider broader dynamics. Validating new scales to capture more structural aspects of change is essential. In addition, surveys can only capture what the respondents are willing and able to provide in terms of information. To the extent that surveys go beyond 'empirical facts' such as age or income, the information provided by respondents has to be considered subjective or 'perception-dependent'. A well-known example in the sustainable consumption context is the attitude behaviour gap, the overreporting of the consideration of sustainability criteria in consumption decisions, for instance (Carrington et al, 2014). In a similar manner, data may have a low validity if respondents are asked to provide information on aspects they are not very familiar with in everyday life, such as energy consumption in physical units or technology configurations. In EnergyPROSPECTS, for instance, this was notable in a question related to practising 'energy sharing', for which the positive answers were way too high compared to the availability of such exchange systems. Also, the broader and more abstract, in terms of being removed from individuals' everyday thoughts and actions, the information sought is, the more unreliable survey answers are likely to be. It probably makes little sense to include questions about the impact of changes in the power of vested interests on the sustainability of consumption and lifestyles in a survey. However, questions that aim to uncover objective forms of wellbeing can be treated in a survey, for example, by asking people if certain human needs are being satisfied in their everyday lives. Changes over time in everyday life can also be part of questions related to structural change, for instance, to support assessment of the impact of specific context conditions (such as the energy crisis of 2021–2023) or to consider the range of rebound effects. In sum, surveys are helpful in getting at perception-dependent and some types of

perception-independent data. In this context, they allow a quantified approximation of the impact of changes in ideational structures, or expected reactions to changes in specific politico-economic and technological structures. They are more challenging and have been less used so far, however, when it comes to broader change, especially in the political realm. An interesting challenge for the future is therefore to design surveys that capture people's view of broader system changes and their role in these. In DIALOGUES, questions were asked quite directly about who should be most responsible for change in the energy transition, for example.

Qualitative analysis

A related approach to assessing the impact of structures is to first gather qualitative information on experiences with structural enablers and constraints and then add a quantification method on top. The first step can be done in interviews (which, however, tends to limit the number of responses), focus groups or via digital reporting, for instance, but also textual analysis. In a second step, then, such qualitative results can be transformed into quantitative data via a range of methods. Qualitative data can form the basis for questions in subsequent quantitative surveys, for instance, thus allowing for the assessment of whether results are statistically valid. Alternatively, the Delphi Method drawing on experts' knowledge in a structured way may be used to produce a ranking of impactful factors. One particular approach in this context is PESTEL analysis, initially a management tool aimed at collecting the Political, Economic, Social, Technological, Environmental and Legal contextual factors that are impacting the observed phenomenon, in combination with DEMATEL and AHP.[11] Here, experts provide a pairwise assessment of factors identified via the qualitative methods, which allows a ranking of the six PESTEL factors and their main subfactors with regard to their specific/direct impact on a given phenomenon as well as on the whole system of factors impacting it (see Appendix 2). Among our projects, EnergyPROSPECTS adopted such an approach to shed light on the relative importance of the structural factors that impact energy citizenship. Via the PESTEL analysis in combination with DEMATEL and AHP methods, it was able to rank the importance of the 25 factors and 96 subfactors identified for the EU-level via textual analysis, both in isolation and with regard to the whole system of factors.[12] Importantly, the quantitative results gained via this method are based on (consistent) expert assessments and, as such, they cannot claim any representativity or objectivity. They, and similar approaches used to achieve a ranking of the importance of factors, also do just that, and provide a ranking that in the best cases highlights if factors are causes or consequences and how these factors interact with each other. This is different from the type of quantitative results provided by modelling or statistical analyses, of course.

Big data analysis

The impact of structures and structural change on the sustainability of consumption and lifestyles can also be assessed via statistical analysis of existing datasets focusing on socio-material factors. Such datasets tend to focus at the macro-level (Rapsikevičius et al, 2022), but can under certain conditions be combined with micro- and meso-level data. The advantage of relying on such datasets tends to be that the data exist

in longer time series thus allowing also temporal comparison of developments. At the same time, they have a limited ability to provide insights into dynamics at the household levels. They also suffer from vulnerability to a lack of/bad data. Specifically, research relying on existing datasets has to make the best use of existing variables and their operationalisation, which often do not capture exactly what one wants to look at. GDP per capita is a prime example of this situation. While its shortcomings in terms of actual assessments of quality of life have been known for decades (Fuchs et al, 2020), it is still widely used even in sustainability research due to data availability.

When it comes to assessing structural change, such statistical analyses often allow the integration of demographic, economic, political, technological and geographic structural aspects. Yet, they tend not to be able to capture the role of ideational change, and struggle with differences in normative conditions and associated reactions, for instance, in terms of the societal acceptance of a given technology or policy. More fundamentally, statistical analysis of such big datasets can only approximate the impact of existing structures or future trends already visible in today's (and yesterday's) data. It cannot assess the impact a change in fundamental political conditions would have, for instance, unless one or more of the units of analysis already exhibit these conditions. The impact of a specific policy, for example, an energy tax, on the sustainability of consumption and lifestyles, for example, can only be quantified if one of the countries/regions/cities in a given dataset already has implemented it (and the statistical analysis can control for the influence of all other potentially intervening factors). When it comes to specific structures, such a situation in which it already exists somewhere in the dataset is quite probable. When it comes to broader political change, however, this is often not the case. While the power of vested interests, for example, may differ between democracies in the world, there is no case where such power does not exist. Existing indices of democracy, sometimes, attempt to assess this dimension along with many other indicators of democratic quality, but the level of detail and reliability of data tends to be low. The situation is even more stark when it comes to a structure such as the growth paradigm.

Experimental analysis

Qualitative as well as quantitative survey and socio-material data-based analyses can also be combined with experimental approaches. Among our projects, ENCHANT and CAMPAIGNers included experimental elements that rolled out 'interventions' or 'challenges' to participants and recorded and analysed responses. For instance, ENCHANT rolled out a large online electricity saving campaign to 2,500 households and experimentally varied the interventions provided (for example, communicating social norms, giving feedback about changes in one's own behaviour over time, asking for a commitment, framing electricity saving as an individual or collective task, or inviting to a competition). In a complex randomised control trial design it could be tested which interventions worked best in which sociotechnical context. CAMPAIGNers developed an app to engage citizens in sustainable lifestyle challenges and asked its users to comment on the reasons for or against adopting sustainable behaviours, as well as the barriers and enablers they encountered along the way. The advantage of such an approach is the ability to get direct feedback on different constellations (for example, the provision of incentives) on a broad geographic scale and to provide input for modelling behaviour shifts over time. On the downside, it

depends on self-selection in so far as those adopting a challenge are more likely to answer, and, of course, the answers may suffer from the same kind of bias in terms of perceptions of one's own action as well as inclinations to answer in a 'socially appropriate way' to surveys in general. Moreover, reliance on digital devices, by itself, still leads to a higher likelihood to reach certain groups in society than others. DIALOGUES, in turn, had an experimental element allowing citizens to experiment with different forms of citizen engagement. To that end, researchers partnered with local associations and citizen groups to host a series of forums or 'citizen action labs' where citizens tested with different forms of engagement in the energy transition, with surveys capturing a before and after picture.

In general, then, all approaches have strengths and weaknesses, and focus on some structures more than on others. The selection of approaches and of data sources and forms are inherently intertwined, of course. Table 1 provides an overview of potentials and constraints of assessing the impact of structures from the perspective of the use of certain data types and sources.

As the discussion and table show, there is not one perfect approach or data type and source for assessing the impact of structures and structural change on the sustainability of consumption and lifestyles. Ideally, research projects combine and integrate different approaches in order to be able to draw on their respective strengths while reducing individual weaknesses, and indeed all of our projects combined qualitative and quantitative approaches or included experimental interventions. It is important to note, however, that a real integration of methods also can run into challenges of its own, as different types of macro-, meso- or micro-level data tend to defy simple approaches to translation and integration. At a minimum, then, such an integration of approaches costs time and resources.

Conclusion

An increasing share of sustainable consumption and lifestyle research recognises the key role of structures in terms of shaping lifestyles as well as enabling and constraining the possibilities for lifestyle change. Structural change is a precondition for a transformation towards 1.5°C, low-carbon or sufficiency-oriented lifestyles as well as for sociopolitical outcomes considered important for a successful sustainability transformation, such as energy citizenship. The six European research consortia, on which this article draws, all paid attention to the role of structures, even if they did so in pursuit of slightly different research objectives (see Appendix 1).

Most importantly, the six projects all contained an element of quantification in their analyses. To date, much of quantitative empirical sustainable consumption research overemphasises the individual, behavioural dimension, while at the same time bemoaning the limited amount of observed change. Given what we know about the important role of structures, the resulting findings are at best incomplete. Accordingly, it is important to make the impact of structures visible and to be able to communicate about this impact more effectively in political and public communication. The six projects, therefore, explored the structural dimension in their quantitative elements as well. In pursuit of this aim, they gathered insights on the strengths and weaknesses of a diverse set of methods and data types. Understanding these strengths and weaknesses is helpful both for the design of future research projects (see Table 2) as well as the interpretation of results from current and previous projects.

Table 1: Data types' potentials and constraints for assessing structures

	Material flows (financial or other material flows combined with, for example, emission accounts)	**Quantitative survey data**	**Qualitative data from interviews, dialogues, Delphis or labs**	**Datasets combining economic, demographic, infrastructural, geographic (non-survey) data**
Assessment possibilities	• Impact of assumed changes in material flows resulting from political, economic, technological or societal change on carbon footprints	• Perceptions of influence of ideational and material structural change • Can assess impact of change over time if conducted in waves • Combination with exp. designs to test causal influence possible	• In-depth data on perceptions on influence of ideational and material structural change • Can assess impact of change over time if conducted in waves • Combination with quantification methods (for example, PESTEL) possible	• Influence of material, demographic, geographic structural change • Assesses structures via predefined proxies
Strengths	• Breadth of assessment (all economic activity) • Attribution of environmental impacts to upstream economic drivers • Perception-independent assessment of diverse possibilities of structural change • Potential for estimating time dynamics	• Large-scale insights into target group perceptions • Comparability across domains and groups • Representativeness possible • Deeper ideational structures/ potential scenarios if combined with experimental design • Can be linked with modelling/ upscaling estimations	• In-depth insights in reasonings and understandings • Direct feedback on different constellations possible • Enables focus on selected (incl. difficult-to-reach) groups • Can allow collecting of best practices • If combined with quantification method: ranking possible	• Breadth of assessment: can assess combined effect of differences in specific political, socioeconomic, technological and geographic structures • Data often available across time and regions
Weaknesses	• Limits to product level analysis • Assumptions necessary for immediate size of impact • Causes of change neglected • Cannot access acceptability implications of change • Neglects power dynamics • Vulnerable to poor quality/blind spots of data • Model structure implies a certain structural representation	• Simplification and categorisation of interviewees' experiences • Depends on willingness to answer (selection bias) • Perception-dependent* • Snapshot if not repeated • Does not uncover deeper understandings and meanings • Perspective of researcher shapes input and thus output of questionnaire	• Limits to generalisability • Depends on willingness to participate (selection bias) • Perception-dependent • Snapshot if not repeated • Focus limited to selected issues • With quantification: ranking depends on panel size; constraints for assessing combinations/contradictory effects of factors	• Ideational structures difficult to assess • Cannot access acceptability of change • Neglects power dynamics • Difficulty to disentangle concrete causal relationships • Vulnerable to poor quality/ blind spots of existing data

Note: * Low data validity when respondent not familiar with issue, or issue associated with strong emotions or societal norms.

As the discussion in the previous section showed, there is no one single method that can be considered universally applicable or perfect in all situations. All methods provide certain opportunities and are associated with certain challenges. They all are good at turning a spotlight on the impact of some structures and have blind spots when it comes to other structures. Next to the more detailed discussion of the opportunities and challenges associated with the different methods, however, a couple of general points arise from our projects' joint learnings on methods for assessing the impact of structural change. First, all methods struggle in particular with the assessment of the impact of changes in deep structures, be they societal in nature, such as understandings of a good life, political, such as power asymmetries in political systems, or economic in terms of the role of markets in organising systems of consumption and provisioning. The methods also have difficulty capturing disruptive, systemic change. All the methods described are to a certain degree rooted in the status quo. Moreover, they are better equipped to look back than look forward, if the future is not just a step-wise change from the existing trajectory. With respect to these aspects, further methodological development is clearly needed. Second, the differentiation between perception-dependent and perception-independent approaches is decisive. Research has highlighted the significant role played by ideational structures and their impact on the sustainability of consumption and lifestyles, both directly in terms of consumption behaviour as well as indirectly via their influence on legitimacy evaluations of policies or technological innovations, for instance. At the same time, the

Table 2: Key decisions when assessing structures

Type of structure and dynamic infocus	**Methodological opportunities**	**Examples**
Breadth of structures		
Shallow structures	Mostly accessible via various methods; with perception-dependent methods vulnerable to attitude-action gap; with perception-independent methods dependent on existence of data or assumptions (for example, uptake of technology, price elasticities)	Specific policy, technology; sectoral approach
Deep structures	Extremely difficult to assess via existing methodological approaches; (only) to some extent accessible via EE-MRIO if scenarios used include relevant assumptions	Politico-economic and societal foundations (for example, capitalism); cross-sectoral approach
Role of perceptions		
Perception- dependent	Accessible at different levels of depth by surveys and interviews, with and without experimental forms	Ideational structures: individual and collective ideas/narratives/ imaginaries, emotions
Perception- independent	Accessible via statistical analysis of existing data-sets (including input-output tables)	Material structures: financial/ economic conditions and flows, energy resources and use, demographic conditions, technological infrastructure, geographic conditions

influence of broader underlying material structures, such as income distributions or technological infrastructures, is not to be underestimated. As a consequence, research needs to pay particular attention to respective choices and associated blind spots (associated with those choices), and strive to integrate approaches, where possible.

Summing up, this article was motivated by the need to focus on the structural dimension in the pursuit of radically sustainable consumption, and the associated need to consider and develop methods for quantifying the impact of structural change. In acknowledging the strengths and weaknesses of different methods and highlighting the associated opportunities for including a structural dimension in analyses, it becomes evident that further methodological development is urgently needed. While the six research projects on which this article draws highlight the importance of broader political and societal structures, in particular, all of the methods discussed here struggle with quantifying the impact of a change in these structures. Certain methods allow a ranking of the relevant structures and their impact by experts, and this provides important insights. In the future, however, it would be helpful if such structural change could be also better incorporated in statistical analyses and other quantitative models. In other words, there are still clear limits to what form of structures and associated potential impacts of structural change research currently is able to see and assess, and this needs to be taken into account in the interpretation of any results.

Focusing on to what extent and how we can quantify the impact of which structures, does not mean that structural change that we do not know how to quantify is not relevant or should be ignored. As pointed out earlier, while assessing the impact of changes in deep structures is particularly difficult and we may not have approaches to measure it at hand for a while, at least, these structures are especially influential for societies' chances to overcome entrenched sustainability. Still, any contribution we can make to make the impact of structural change better understood also in numbers is likely to be helpful in political discourse and research agendas.

Notes

[1] The projects applied a variety of definitions with regard to the sustainability aspects studied, but mostly emphasised the environmental dimension and especially climate change, due to the need to limit scope and the priorities of the funder.

[2] The question of intention also relates to the speed of change. Intentional pursuits of change often aim at a targeted and well-paced change. Structural change can also occur incrementally and unnoticed, or happen like a tsunami, being forced, for instance, by an external crisis.

[3] It is important to acknowledge that the ideational/material distinction is made for analytical purposes. In reality, most structures have an ideational and a material dimension (as exemplified by a practice theoretic perspective on the links between technologies and skills and know-how), even if one is more dominant.

[4] See Hirth et al (2023) for a systematic assessment of the field and suggestions for ordering it.

[5] Social comparison may result from concerns about social status and belonging, but can also be used as an anchor or reassurance for decisions in unknown or unfamiliar contexts.

[6] Hourly spot prices, spot-price contracts and smart meters in households in Norway correlate with considerable influence of electricity prices compared to Romania or Germany, where household electricity prices are set monthly level.

[7] In a cold climate and poorly insulated houses reducing indoor temperature from 22 to 20 degrees makes a much bigger difference than in temperate climates and/or well-insulated houses.

[8] In order to conduct input-output analyses, EE-IOA employs specific datasets of input-output tables, of which EXIOBASE is an example (www.exiobase.eu).

[9] They can also be combined with resource accounts like land use.

[10] The Shared Socio-Economic Pathways (SSP) scenarios are underlying the IPCC's calculations of greenhouse gas emission trajectories in combination with different sets of climate policies. They model different assumptions about global socioeconomic developments such as population growth, urbanisation and economic growth and accompanying changes in economic, social, technological and environmental policies. The SSP1 'Sustainability' scenario assumes a gradual shift towards the pursuit of social wellbeing within planetary boundaries. Representative Concentration Pathways (RCP) are climate change scenarios that the IPCC used to project greenhouse gas concentrations. In the 6th IPCC Assessment Report, they have been combined with SSP scenarios. SSP1-RCP1.9 is a scenario entailing assumptions regarding socioeconomic developments and climate action that would limit global warming to below 1.5°C.

[11] While the Analytic Hierarchy Process (AHP) method is interested in the direct importance/weight of independent factors, the DEcision MAking Trial and Evaluation Laboratory (DEMATEL) method investigates the influence that factors have on each other within the system and the extent to which the factors are influencing the whole system.

[12] Comparing the AHP and DEMATEL outputs allows the highlighting of differences in the ranking of the PESTEL factors. Such differences provide a joint result on – in this case – the relevance and function of the PESTEL factors for citizen engagement towards a just, democratic and sustainable energy system at the European level.

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Conflict of interest

The authors declare that there is no conflict of interest.

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