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Carbon emissions of retail channels: The limits of available policy instruments to achieve absolute reductions

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Highlights

> Consumer choices of retail channel impact a product's carbon footprint.

> The consumer's last mile to the store substantially contributes to carbon emissions.

> Carbon emissions of retail channels will increase substantially.

> Viable policies fail to counteract this growth in carbon emissions.

> An absolute reduction in private demand for household goods is necessary.

Carbon emissions of retail channels: The limits of available policy instruments to achieve absolute reductions

Abstract

Buying the same product at the neighborhood store or at a shopping mall implies different carbon emissions. This paper quantifies carbon impacts of consumer choices of retail channel and shop location (where to buy), extending footprint assessments of product choices (what to buy). Carbon emissions of shopping situations are shown in the current situation, in a business-as-usual projection in 2020, and in policy scenarios with changed market shares of shopping situations.

The analysis covers the product categories: groceries, clothing, and electronics & computers, from the shopping situations: neighborhood store, town center, discount store, shopping mall, and mail order/online selling. Stages of the product life cycle which differ between shopping situations are examined: freight transport, warehousing, store operation, and the last mile of the consumers' trip to the store.

Carbon emissions of shopping situations amount to 2.7% of overall Austrian emissions in the base year. Dominant car use on the last mile substantially contributes to the overall footprint. In the business-as-usual scenario, carbon emissions from shopping situations increase by +33% until 2020, corresponding to 4.2% of the overall Austrian emissions target for 2020. Restricting shopping malls or supporting neighborhood stores could limit this increase to +25% and +20%, respectively. Facilitating online selling achieves no notable effects. The study

underlines that an absolute reduction in private demand for household goods is necessary, as available policy instruments aiming at shopping situations fail to compensate the steady growth in private consumption.

1 Introduction

Numerous studies show that product choices of private consumers contribute to negative impacts on the environment, especially concerning greenhouse gas (GHG) emissions (EEA 2012; Stern et al. 1997). In order to reduce the strain modern societies put on Earth's resources, not just efficiency gains but also absolute reductions in consumption are necessary. This call for absolute reductions relates to sufficiency goals in sustainable development, which promote reducing the overall level of consumption through self-limitation of private demand for material goods (Huber 1995, Sachs 1997). This paper uses the case of consumer choices of retail channel and shop location to illustrate the limited leverage of available policies for achieving absolute reductions unless overall consumption decreases.

In terms of environmental impacts of private consumption, common carbon footprint assessments are restricted to the prior stages of the product life cycle, namely extraction of raw materials, manufacturing and international logistics; and to the posterior stages of product use and disposal/recycling (BSI 2008; WRI/WBCSD 2010). Instead, this paper focuses on the intermediate stages which differ between retail channels (Mokhtarian 2004): freight transport from the national/regional distribution center to the retail store; warehousing and shop operation; and the last mile of the product, i.e. its transport from a specific store to the individual consumers' home, either by individual shopping trip or by delivery service. For example, buying the same product at the neighborhood store in contrast to buying it a shopping mall involves different GHG emissions, resulting from decentralized delivery logistics, shorter shopping trips by bicycle, and other factors.

Up to now, only few studies compared GHG emissions for freight transport and store operation between retail channels (e.g., Ademe 2005). The impact of the last mile has been investigated when comparing e-commerce to brick-and-mortar stores, but differentiation between traditional retailing channels has been underrepresented in previous research (Edwards, McKinnon, and Cullinane 2010; Farag et al. 2007; Weltevreden and van Rietbergen 2009; Wiese, Toporowski, and Zielke 2012). This paper analyzes consumers' choices of shopping situations, referring to retail channel and spatial location of stores (where to buy), complementary to the prevalent study of consumers' product choices (what to buy).

Shopping situations are of key importance for policy design. Channel and location connect to policy objectives regarding ecological and economic benefits as well as for enabling access to consumer goods for all members of society. Product policy emphasizes energy efficiency labeling, diversity in country of origin and seasonal scope, alongside other attributes (EEA 2012). Transport policy rarely associates shopping situations with last mile passenger and freight travel. Carbon assessments of shopping situations only compare traditional brick-and-mortar retailing channels with online selling as an upcoming, less carbon-intensive alternative (Cairns et al. 2008; Cao 2009; Cao, Zu, and Douma 2012; Lenz 2003; Rotem-Mindali and Salomon 2009). In contrast, our analysis of policy options draws on instruments targeting pricing and accessibility of retail stores, comprising spatial planning, fiscal policy and subsidies.

The aim of this paper is threefold: First, on the example of Austria, to quantify the carbon footprint of shopping situations. The footprint encompasses GHG emissions directly attributable to specific shopping situations, incurred in the intermediate stages of the product life cycle. Other stages such as manufacturing, product use and disposal are considered equal when comparing the same products across shopping situations. Thereby, we address a previous blind spot in life cycle assessment, the relevance of the location where a product is purchased.

Secondly, we project a business-as-usual, non policy case for 2020 reflecting an extrapolation of current market trends in the Austrian retailing sector. Thereby, we illustrate how the general growth in private consumption, in conjunction with shifts in the market shares of retailing channels, will lead to considerably higher GHG emissions from shopping situations in the near future.

Thirdly, we conduct three policy scenarios directed at restricting or advancing particular shopping situations: (i) restriction of shopping malls, (ii) support of neighborhood stores, and (iii) facilitation of online selling. Thereby, we show that interventions feasible within the current political framework fail to counteract the ongoing trends in the retailing sector, and thus cannot achieve the absolute reductions in emissions deemed necessary for remaining within our planet's ecological limits.

We apply a combination of methodological approaches: (i) a household survey on individual choices of shopping situations and private shopping mobility, (ii) a carbon footprint assessment of shopping situations and (iii) an economic model of consumption expenditure predicting shifts in the market shares of shopping situations due to policy interventions.

The remainder of the paper is structured as follows: Section 2 describes the basic framework, i.e. the product categories, shopping situations and region types which are relevant throughout the study, and outlines how our methodological approaches link to each other. Section 3 elaborates the applied methods in the household survey, the carbon footprint assessment and the economic model. Current and future carbon emissions from shopping situations, as well as the outcomes of the policy scenarios are presented in section 4. We discuss methodological caveats and conclude with an outlook for policy action and future research in section 5.

2 Present study

2.1 Study region and region types

The study region covers the agglomeration of Graz, comprising an urban core and its suburban surroundings, and the rural district of Hartberg, all located in the Province of Styria in Austria. Graz is the second-biggest city of Austria with 261,000 inhabitants living in an area of 127 km². The suburban surroundings of Graz include 143,000 persons on 1,100 km²; the rural district of Hartberg features a substantially lower residential density with 67,000 inhabitants on 960 km². Transport infrastructure is characterized by good access to all travel modes in Graz, a good road network and acceptable public transport in its suburban outskirts, and a general lack of alternatives to car use in rural Hartberg. Hartberg is further disadvantaged in terms of a hilly topography, which constrains bicycling on shopping trips. Most trends in the entire Austrian retailing sector as described in section 4.2 apply to the study region as well (CIMA 2004; GMA 2009; KMU Forschung Austria 2007; WKO 2006): Shopping malls accumulate in the urban periphery; grocery retailing consolidates towards fewer and bigger stores, operated by retail chains; and an increasing number of rural communities lack a local neighborhood store.

The city of Graz, its suburban hinterland, and the district of Hartberg can be considered typical urban, suburban, and rural regions[1] regarding retail trade, transport options and settlement structure as compared to other Austrian regions. In 2005, 40.0% of Austrian households lived in urban regions, 23.6% lived in suburban regions and 36.4% lived in rural regions (Statistics Austria 2005). Results in section 4 relating to these three region types are scaled up proportionally to whole Austria.

Austria may serve as a typical example for Mid-European countries and the Alpine region in terms of gross domestic product per capita, consumption expenditures, residential density and topography. Austria's retailing structure however deviates to some degree from other European countries: In retail sales of groceries in the year

[1] We apply the Degree of Urbanization (DEGURBA) classification of Eurostat, which distinguishes densely populated areas (here: urban), intermediate density areas (here: suburban), and thinly populated areas (here: rural).

2009, Austria featured a higher share of small supermarkets (400-999 m² sales area) than the average across 20 European countries (EU: 28%, AT: 65%), and had correspondingly smaller shares of hypermarkets (>2,500 m²; EU: 35%, AT: 9%) and big box supermarkets (1,000-2,499 m²; EU: 23%, AT: 14%; Nielsen 2011). Austria's grocery retailing structure is comparable to countries which also hold many small supermarkets like Germany or Norway, but distinct to countries with few small supermarkets like Great Britain or Finland. Regarding electronics & computers retail in 2009, Austria closely resembled the dominance of superstores as in an average of ten Western European countries (GfK 2009). We suggest that transfer of our results to other western industrialized countries should be done specifically for each product category or country.

2.2 Product categories

Private consumption from retailing encompasses a multitude of products. The present study focuses on the product categories groceries, clothing, and electronics & computers instead of specific products (see Table 1). We assume specific products within the same product category to be homogenous and perfectly substitutable commodities from the consumer's point of view.

Product types are closely linked to the choice of shopping situations (Weltevreden 2007, Cao 2009, Rotem-Mindali and Weltevreden 2013). Differentiation by product may be done on a spectrum ranging from specific example products (e.g., yogurt and jeans in Ademe 2005) to generic product groups (e.g., non-daily goods in Farag et al. 2007). While the perspective on specific products allows better consideration of size, form and weight in calculating the freight transport footprint (Rotem-Mindali and Weltevreden 2013), product groups ensure comparability across regions, shopping situations, and customer routines, as well as robust upscaling to the entire national retailing sector. The product categories applied here are located in the middle of this spectrum, in order to address both aspects.

The product categories of groceries, clothing, and electronics & computers were selected to cover the main household expenditures for consumer goods purchased in retailing. Furthermore, groceries were included to consider products of everyday demand, whereas clothing and electronics & computers feature less frequent but more expensive purchases. These product categories were chosen because they differ regarding the shopping situations they are mostly bought in (as can be seen in Table 6). For example, groceries are mainly purchased at neighborhood stores and discount stores, while electronics & computers are frequently acquired at shopping malls and are sensitive to e-commerce. Finally, the product categories vary in how far they may be experienced and evaluated before purchase (Rotem-Mindali and Weltevreden 2013).

[insert Table 1 here]

2.3 Shopping situations

We abstract from specific retail stores to categories of shopping situations in order to support generalization of our findings. The definition of shopping situations (see Table 2; cf. BMLFUW 2008; KMU Forschung Austria 2007; Weltevreden and van Rietbergen 2009) attempts to capture the whole spectrum of retail channels for groceries, clothing, and electronics & computers, ranging from neighborhood stores to shopping malls and e-commerce. We apply the term shopping situation rather than the more common term retail channel in order to underline that our perspective goes beyond shop operation by including spatial location and transport accessibility of the retail store (Burnett 2008; Cao 2009; Cao, Zu and Douma 2012; Lenz 2003; Rotem-Mindali and Salomon 2009).

[insert Table 2 here]

Farmer's markets and farmhouse shops are excluded, since they are relevant for only 5% of grocery retailing in Austria (BMLFUW 2008). Television home shopping is subsumed under mail order and online selling, since it only plays a negligible role in Austrian retailing. Note that the household survey covers the market shares of all three product categories and five shopping situations listed here (see section 3.1), but in terms of complexity and data availability the subsequent analyses are limited to the dominant shopping situations within each product category.

When applying the criteria for shopping situations, as defined here, to the retail structure in the study region, discount stores could not be unambiguously distinguished from other shopping situations. In some remote areas, grocery discount stores at major roads have become the only decentral providers of basic supplies, taking over the role of small neighborhood stores which closed due to commuting or migration of the local population to cities. Besides, most big box discount stores for electronics & computers in urban and suburban Graz are integrated in shopping malls. The design of the present study required consistent criteria for discount stores regarding all investigated product categories. Future studies focusing on a single product category might need to reconsider the definition used here.

2.4 Study design

The study interlinks three methodological elements: (i) the household survey investigates consumer choices of shopping situations; (ii) the carbon footprint assessment accounts for GHG emissions; (iii) the economic model of consumption expenditure shows shifts in market shares in various policy scenarios. We employ a three-step approach:

First, the carbon footprint assessment calculates GHG emissions of shopping situations within product categories, drawing on market shares of shopping situations as well as on modal split and trip distances of shopping trips reported in the household survey. Additional data comes from company interviews and a literature review.

Second, projecting current market trends in the retailing sector, a non-policy, business-as-usual scenario for 2020 is developed; both economic model and carbon footprint assessment reflect this scenario. Using data from the Austrian household budget survey (note that this is a different dataset than the household survey conducted specifically in this study; see section 3.3), the economic model reports market shares of bundles of product category and shopping situation in 2020, measured in overall consumer expenditures in Euro. Thereof, we determine carbon emissions of shopping situations by using the GHG emission factors per Euro spent as determined in the prior step.

Third, policy scenarios for 2020 are conducted in the economic model. The model then reports changes in market shares of bundles of product category and shopping situation relative to the business-as-usual scenario. Based on these changes, we recalculate GHG emissions.

Both the economic model and carbon footprint assessment refer to the current situation, calibrated to the year 2004. The household survey was conducted six years later in 2010, therefore we apply only the relative distribution between product categories and shopping situations from the household survey to the absolute amounts of expenditures in the Austrian household budget survey 2004. In a similar vein, although company data was obtained in 2010, we assume that logistics and shop infrastructure of retailers, as well as derived carbon emissions have remained constant since 2004.

3 Method

3.1 Household survey

From July 2010 until January 2011, 690 standardized face-to-face interviews were carried out in the study region by 48 interviewers. Respondents received five Euro as a token of appreciation and were ensured anonymity. The obtained sample was biased towards younger and higher educated persons as well as urban citizens (see Table 3). As these demographic characteristics are related to the variables under investigation (choice of shopping situation and transport mode), differences in the distribution between sample and population were corrected by statistical weighting using census data from Statistics Austria (2004, 2005). The weighting proportionally overrates the underrepresented and underrates the overrepresented segments in the sample, so that the sample distribution for analysis equals the population distribution. All survey results reported in the remainder of the paper were computed using these statistical weights.

[insert Table 3 here]

Market shares of shopping situations refer to the distribution of consumption expenditures between shopping situations. Respondents were asked to divide their respective overall monthly expenses for groceries, clothing, and electronics & computers between shopping situations: Results are given in Table 6.

Data on frequency of shopping trips, transport mode choice and trip distance is necessary to determine GHG emissions on the last mile. Private shopping mobility was assessed separately for bundles of product category and shopping situation, e.g. for buying groceries at a neighborhood store, for buying clothing at a town center, and so forth. Comprehensively assessing all fifteen bundles (three product categories within five shopping situations) would have required considerable effort by the survey participants. In addition, some product categories are nearly unavailable in some shopping situations, e.g. groceries in online selling or electronics & computers in neighborhood stores. Therefore, to reduce respondent burden, similar to the approach of Rotem-Mindali and Salomon (2007, 2009), (i) seven bundles with substantial market shares were pre-selected, and (ii) in each interview, two out of these seven bundles were chosen randomly, provided they were actually used by the respondent. Consequently, sample sizes for mobility data are smaller than the overall sample, and vary between bundles of product category and shopping situation. The results in Tables 7 and 8 refer to brick-and-mortar shopping situations only, as "Mail order and online selling" was naturally excluded from the assessment of passenger shopping trips.

To estimate modal split, respondents divided 100% between car, public transportation, bicycling and walking, indicating how often they habitually use these travel modes to reach the specific shopping situation for buying the specific product category. We applied this format instead of recording actual trips in full-scale trip diaries (Richardson, Ampt, and Meyburg 1995) so to reduce respondent burden and to mitigate bias from irregular events, which could substantially increase variance in the small subsamples. Results on modal split are given in Table 7.

Regarding trip length, respondents estimated the two-way distance of their trips exclusively undertaken for shopping purposes depending on transport mode. However, besides such single-purpose trips, some shopping trips are combined with other activities in a multi-purpose tour (so called trip chaining), e.g. stopping for groceries on the trip home from work (Schwanen, Ettema, and Timmermans 2007). Extent and patterns of trip chaining are interlinked with shared responsibilities between household members and their respective daily schedules (Golob and McNally 1997; Martin 2006; Schwanen 2004). Therefore trip chaining is hard to assess with conventional survey methods apart from detailed activity diaries or GPS tracking, with all the difficulties in representative sampling this entails (Jia, Carling, and Hakansson 2013). Respondents named their preferred transport mode on trip chains involving shopping activities and estimated the additional trip distance to the store by deviating from a direct route. Survey responses on the frequency of shopping trips within trip chains showed questionable validity, so we referred to mobility surveys in the study region (Herry 2007; ZIS+P 2009) and assumed that 30% of all shopping trips in urban/suburban regions and 20% of all shopping trips in rural regions are undertaken as a part of trip chains. Results on trip distances are reported in Table 8.

Besides trip chaining, households might reduce their carbon emissions on the last mile by purchasing goods from several product categories at a single occasion and at the same shopping situation, e.g. buying both groceries and clothing during a visit at the shopping mall (Weltevreden and van Rietbergen 2009, Rotem-Mindali and Weltevreden 2013). GHG emissions of this shopping trip should be attributed accordingly to the purchased product categories. Yet, for lack of practical survey formats or secondary data, this aspect remains open for future studies.

3.2 Carbon footprint assessment

The partial product carbon footprint method applied here assesses the Global Warming Potential (GWP100a) along a product's life cycle following the IPCC2007 guidelines and the life cycle assessment approach (European Commission 2008; ÖNI 2005; Solomon et al. 2007). Global warming potential is expressed in CO_2 equivalents and thus equals the carbon footprint.

Carbon footprints of products often disregard transport and facilities needed for distribution, and in most cases ignore the last mile, the consumer's trip to the store, due to a lack of data, even though experts generally agree on its high relevance (Burger, Meixner, and Pöchtrager 2010). Hence, the partial product carbon footprint in this study explicitly sets its system boundary to include only freight transport from distribution center to retail outlet, storage, store operation and last mile, not the upstream GHG emissions. Stages of the product life cycle that do not vary between shopping situations, e.g. manufacturing, product use or disposal/recycling, are excluded from the analysis.

As the functional unit we use monetary units instead of quantity in kilograms, thus calculating the GHG emissions for the investigated life cycle stages per Euro product (excluding value added taxes), in order to enable linking with the economic model. Besides, consumer purchases in kilograms would be hard to measure in a household survey, as respondents can far more easily recall their spending than the combined weight of their shopping bags.

Operational data was obtained from retailing enterprises. Three out of 35 approached retailers agreed to provide data, two of them grocery chains and one clothing retailer. For the product category of electronics & computers, we used secondary data (Frauenhofer ISI et al. 2004; Weber et al. 2009). Table 4 summarizes the data sources for the three product categories and the four analyzed process steps. In order to convert data on energy use per m² sales area for clothing and electronics stores, we applied average sales per m² from KMU Forschung Austria (2007).

[insert Table 4 here]

Data on the last mile was obtained from the household survey by aggregating responses on frequency, transport mode choice and distances of shopping trips. The GWP100a of an average passenger car was assumed at 0.224 kg CO_2e per vehicle-kilometer based on the LCA database ecoinvent (Frischknecht and Jungbluth 2007;

this value also conforms to Carling, Hakansson, and Jia 2013) and information on the Austrian car fleet (Statistics Austria 2009).

Regarding online selling, Table 5 gives data sources for emissions related to electronic order, packaging, and parcel delivery. Multiple delivery attempts, ranging between 2% and 30% (Edwards, McKinnon, and Cullinane 2010), are considered in the emission factor by UPS (2010). Return shipments amount to 30% according to the information provided to us by a retailer, conforming to 25-30% of return shipments in de Koster (2002). Additional GHG emissions resulting from customer pick-up e.g. at a postal office after failed delivery were excluded for lack of data. However, the impact of customer pick-up seems negligibly small: An additional driving distance of one kilometer per parcel by the consumer would increase the carbon footprint per Euro product bought online by only 0.3%.

[insert Table 5 here]

Electricity use was converted into GWP100a using the ecoinvent data set “AT supply mix” (Frischknecht and Jungbluth 2007), adapted with the electricity mix for Austria in 2009 (Energie-Control Austria 2010). The heating energy mix of retailer storage and outlets was taken from Statistics Austria (2009, 2010b) and combined with specific emission factors from the ecoinvent database. The comprehensive emission factor related to tonne-kilometer for freight transport in ecoinvent was corrected using retailer data, resulting in a factor of 0.03287 liters of diesel per tonne-kilometer.

Table 9 summarizes the resulting emission factors for each of the investigated shopping situations applied to the process steps storage, store, distribution and last mile.

Due to a lack of data the study distinguishes between urban, suburban, and rural regions only for the consumer’s last mile to brick-and-mortar stores. However, retailer chains have few distribution centers all over Austria, which levels out differences in logistics between region types.

3.3 Economic model of consumption expenditure

We employ a partial equilibrium model with special consideration of households’ demand of goods and services (Böhringer and Rutherford 2008; Lofgren, Harris, and Robinson 2002). These economic models are based on the theoretical equilibrium formulation of Arrow and Debreu (Shoven and Whalley 1992) and use empirical economic data (e.g., input-output tables, national accounts, micro-data) to solve numerically for equilibrium prices and quantities. They are well suited for the purpose of this study since they capture product and sectoral linkages and feedbacks in the economy. That is, policy instruments implemented on a specific economic activity (e.g. tax on consumption goods) have effects beyond that sector through linkages via supply and demand markets.

On the demand side the economic model considers seven different household types distinguished by income, consumption pattern and region type as well as 14 consumption commodities (listed in see Table 10). The consumption commodities comprise the product categories and their respective shopping situation; moreover, to represent market interactions within the whole economy, we include housing and rest of consumption goods (e.g., sports and leisure wares).

Methodologically each household-type receives its income via the supplies of the primary factors of production (capital and labor), the services of which may be sold or leased to firms, as well as transfers from the government (Babiker et al. 2001, Kulmer 2013). The household types maximize their utility by choosing among consumption goods and savings subjected to their budget constraint. In terms of consumption we use a nested structure to describe households' preferences (see Appendix): On top-level we differentiate between groceries, housing & housing provision and material goods. Material goods are specified by a tradeoff between electronic & computers and clothing. Each product category is differentiated by shopping situation. The elasticity of substitution describes the propensity of consumers to switch to other goods in response to changes in market prices (Panagariya and Duttagupta 2001). The elasticity represents both a households' preference for shopping situations and his mobility and transport costs.

Summarizing, consumer choices in this utility maximizing framework are based on product prices, disposable income and consumer preferences. Market shares expressed as households' expenditure share for each commodity result endogenously from the model.

The economic model is calibrated to data of the Austrian household budget survey of Statistics Austria (2005) and the household survey (see section 3.1) to account for market shares, consumer preferences and consumption possibilities. The Austrian household budget survey covers exhaustively all expenditures of private households for a representative sample of 8,400 households.

4 Results

4.1 Status Quo

Regarding market shares, the results displayed in Table 6 indicate that neighborhood stores and discount stores are the main competitors in grocery retail. A similar rivalry exists between shops in town centers and shopping malls regarding clothing. For the purchase of electronics & computers, shopping malls dominate the market; however, a considerable amount of electronics is bought online.

[insert Table 6 here]

The modal split for shopping trips reveals the car as the predominant travel mode regardless of product category and shopping situation, on single-purpose shopping trips as well as on multi-purpose tours (Table 7). Still, trips to neighborhood stores and to the town center are more often undertaken with other transport modes than the car compared to trips to shops in peripheral, less accessible locations (discount stores and shopping malls). The high percentage of walking in grocery shopping at the mall within a multi-purpose tour points to combined shopping activities, e.g.

when a person visits the mall by car originally to buy clothing, but also uses the opportunity to walk over to a grocery store in the same building complex.

Table 8 shows that trip distances for buying clothing or electronics & computers are generally longer as compared to buying groceries. It is noteworthy that the additional trip distance for reaching a store during a multi-purpose tour is substantially shorter than on single-purpose shopping trips. Trip lengths obviously depend on the local settlement structure and road network; for example, Carling, Hakansson, and Jia (2013) report trip lengths to shopping centers in a Swedish city of just 4-6 km.

[insert Tables 7 and 8 here]

The household survey provides market shares, frequency of shopping trips, modal split and trip distances separately for urban, suburban and rural regions. Both the carbon footprint assessment and the economic model of consumption expenditure apply this spatially differentiated data, however, for the sake of brevity, regional differences are not reported in detail.

Table 9 illustrates the carbon emission intensity of shopping situations. In the groceries category, neighborhood stores and discount stores feature similar CO_2 efficiency, while shopping malls perform poorly with GHG emissions per Euro net sales about four times higher. This disparity stems from significantly longer trip distances on the last mile at shopping malls and also from higher energy consumption per turnover in big stores. Contrastingly, regarding clothing and electronics & computers, the shopping mall's carbon footprint on the last mile is smaller than in groceries because of higher product prices and a lower trip frequency, resulting in a more favorable ratio of kg CO_2e to Euro. Results for urban, suburban and rural regions vary by circa 25% owing to longer distances from consumer homes to stores and stronger car-orientation in suburban and rural regions.

Regarding clothing, mail order and online selling performs best, as there are no emissions for store and distribution. Still, this shopping situation's last mile emissions are quite high due to multiple delivery attempts and return shipments. Again, last mile emissions vary between urban and rural locations. Note though that energy consumption data was provided by just a single clothing retailer, thus a cautious interpretation of the results is called for.

Electronics & computers show particularly low GHG emissions due to high spending and low frequency of visits. This product category reveals the sharpest contrast between urban and suburban areas to rural areas which feature hardly any retailing facilities and consequently long distances to stores. Online selling of electronics & computers is identified as the most emissions-saving shopping situation within all product categories and all regions.

[insert Table 9 here]

Total Austrian GHG emissions assignable to shopping situations in the investigated three product categories amount to 2,462 kt CO_2e, or 2.7% of the national GHG emissions of Austria in 2004 (Umweltbundesamt 2006). For this estimate, we multiplied the carbon footprint intensities per product sales value with the expenditures of Austrian private households, taking differences between region types, product categories and shopping situations into account, as given in the calibration of the economic model.

4.2 Scenario 0: Business-as-usual

The business-as-usual scenario for 2020 reflects current market trends in the retailing sector without policy intervention. All policy scenarios are compared to scenario 0.

For all product categories and shopping situations, a general growth in consumption expenditure by +1.5% per year is assumed (average annual growth rate for Austria in the last two decades, according to Eurostat). Relating to groceries we expect that the trend of increasing discount stores and shopping malls continues, whereas neighborhood stores are estimated to disappear in the long run (BMLFUW 2008; Nielsen 2010). For shopping malls however, we follow the increasing trend with diminishing returns in order to capture land-use boundaries as well as market saturation (KMU Forschung Austria 2009). Summarizing the growth rates within groceries are as follows: +10% for discount stores, +4% for shopping malls and -25% for neighborhood stores from 2004 until 2020.

Based on historical estimates (Statistics Austria 2010a, 2010b; Nielsen 2010) for clothing and electronics & computers, a substantial increase in online selling and shopping malls is assumed. Linear extrapolation of the historical trend (1980-2010) predicts an increase of +28% for shopping malls and +19% for online selling by 2020. As above, we also account for natural boundaries and market saturation regarding shopping malls. Due to lack of data, both clothing and electronics & computers are assumed to be affected to the same extent. These assumptions result in a substantial fall in town centers for clothing (-20%) as well as a decrease in discount stores and other shopping situations regarding electronics & computers. Table 10 shows consumption expenditures and carbon emissions in scenario 0.

[insert Table 10 here]

Carbon emissions from the investigated shopping situations amount to 3,276 kt CO_2e in 2020, corresponding to an increase of carbon emissions by +33% from 2004 until 2020 or 4.2% of the overall national emissions target for Austria in 2020 (Umweltbundesamt 2007).

4.3 Policy analysis

In scenario 0, carbon emissions rise substantially until 2020. Thus, the policy analysis looks into options to counteract this growth. The policy scenarios 1, 2, and 3 show options for intervention by targeting shopping malls, neighborhood stores, and online selling. In the policy scenarios, the impacts of policy instruments are added as an external shock to the business-as-usual scenario 0, thereby alleviating or exacerbating ongoing general trends in retailing. Policy instruments initiate changes of prices and market shares in the targeted shopping situation, which the economic model translates into adjustments in the other shopping situations, resulting in a new distribution of market shares, which is then scaled up to revised carbon emissions.

In the following scenarios, policy instruments are applied with a stringency that seems barely acceptable within the current political framework and stakeholder interests in Austria. In that, we aim to illustrate the leverage available to Austrian policymakers, if they were to confront carbon emissions attributable to shopping situations. Design of scenarios and the assumed impacts on the targeted shopping situation were derived in an expert workshop with participants from public administration, research, retail business, and environmental NGOs, drawing on the participants' expertise in assessing these policies in comparable contexts as well as in estimating the room for maneuver in the retailing sector. The following policy scenarios are compared:

Scenario 1: Reduction of shopping malls. In this scenario we assume that regulatory policy leads to a decline of 15% in the market share of shopping malls (regardless of product category). This fall represents restrictions on the construction of new shopping malls, introduction of a parking site tax, or similar measures.

Scenario 2: Supporting neighborhood stores. Through fostering neighborhood stores in rural regions, so to counteract lack of local supply from migration of residents and firms to central regions, we assume an increase in the market share of neighborhood stores by 25%.

Scenario 3: Facilitation of online selling. In order to stimulate online selling we assume an increase of 30% in the market share of online selling, reflecting measures such as introducing new, secure terms of payment and delivery.

Scenarios 1, 2, and 3 serve to illustrate the sensitivity of various shopping situations to policy intervention. They show how changes in a single shopping situation drive the entire retailing sector, while the actual impacts of the proposed policy instruments may depend on socio-economic background factors, practical implementation, etc.

4.3.1 Economic impacts: Market shares and consumption

Figure 1 illustrates the impacts of the policy scenarios on the market share for each product and shopping situation. Overall findings show that scenario 1, the reduction of shopping malls, affects household's consumption the strongest, while the impacts of scenario 2, supporting neighborhood stores, are the smallest.

[insert Figure 1 here]

Figure 1. Changes of market share of product categories and shopping situations relative to scenario 0 (in %, reference year 2020)

The decline in the market share of shopping malls in scenario 1 implies a considerable rise in the respective price by 4.4%. As illustrated in Figure 1 regarding clothing and electronics & computers, this favors online selling substantially (up to 38% in case of electronics & computers). In terms of groceries we find a uniform distribution of the lost market share of shopping malls to other shopping situations, not least as the absolute expenditures for groceries purchased at shopping malls are comparably small.

The rise in the market share of neighborhood stores in scenario 2 is met by a respective fall in the price by 12%. Since neighborhood stores are only relevant for the consumption of groceries, this product category is mainly affected; while the equilibrium framework also derives indirect feedback effects on other product categories, these are negligible[2]. For groceries we find that other shopping situations are affected equally. Neighborhood stores in rural regions benefit most, since they already have their highest market share in these regions, and since discount stores or shopping malls as a substitute are scarce and hardly accessible (for regional details see Table A.2 in the Appendix).

As expected, the online selling scenario 3 has the strongest impact on electronics & computers. Figure 1 illustrates a substantial fall in market shares of other shopping situations in electronics & computers, with shopping malls facing the biggest loss.

[2] This traces back to the applied elasticity of substitution between groceries and all other products (see Table A.1 in the Appendix).

Regarding clothing, effects on other shopping situations are minor, because the absolute expenditures for clothing shifted to online selling are comparably small. In terms of regional impacts, rural regions experience the strongest increase, at the expense of urban and suburban regions (see Table A.2).

Summarizing, we find that the direct economic impacts of the policy scenarios on consumption behavior and hence market shares are quite strong depending on the response of prices, substitution possibilities and preferences. Contrastingly, indirect impacts and feedback effects on the remaining household consumption, i.e. the commodities "housing and housing provision" and "rest of consumption", are rather modest and vary between -2% and +2% (see Table A.2).

4.3.2 Environmental impacts: CO_2 emissions

The resulting changes in market shares also affect CO_2 emissions considerably, because the policy scenarios aim to promote less carbon-intensive shopping situations and hence consumption patterns. Figure 1 illustrates the changes in CO_2 emissions by shopping situation and scenario. However, although emissions are lower than in scenario 0, they still rise in all policy scenarios substantially compared to the reference year 2004.

In particular, in scenario 2, which shows the highest reduction potential compared to scenario 0, carbon emissions still add up to 2,947 kt CO_2e in 2020, relating to an increase by +20% from 2004 until 2020.

The impact of the general, underlying growth in retailing is most visible in scenario 3. Carbon emissions from shopping situations in this scenario add up to 3,270 kt CO_2e in 2020, which reflects an increase by +32% from 2004 until 2020. This increase is only marginally lower than the increase by +33% in scenario 0, where no policy action would be taken.

Finally, carbon emissions from shopping situations in scenario 1 add up to 3,154 kt CO_2e in 2020, which relates to an increase by +25% from 2004 until 2020.

5 Conclusions

Carbon emissions assignable to shopping situations amount to 2.7% of overall Austrian emissions in 2004 when considering passenger transport, freight transport, and warehouse as well as retail store operation. Dominant car use on the last mile substantially contributes to the overall footprint: For example, up to three quarters of the CO_2e emissions caused by shopping in suburban and rural shopping malls originate from private shopping trips. At first sight, the share of 2.7% seems too small to justify societal effort in this field, instead of prioritizing sectors more problematic for Austria's carbon balance. However, zooming in on shopping situations enables us to highlight the interrelations between retail channels, logistics and the customer's last mile, thus showing specific leverage for policy intervention. The intrinsic connection of shopping situations with growth in consumer demand further underlines their relevance for the overarching topic of absolute reductions.

Projecting market trends in retailing in conjunction with a general growth in consumption shows an increase of emissions by +33% until 2020. None of the studied policy options may compensate this autonomous growth, thereby failing to achieve absolute reductions in emissions. Encouraging neighborhood stores or restricting shopping malls could slightly counteract the increase to +20% and +25%, respectively. Facilitation of online selling achieves no notable effects. Introducing these policy options more severely, with stronger effects on prices and market shares, might force a turnaround in greenhouse gas emissions, but would exceed public acceptability and democratic support, thereby rendering their implementation improbable.

Regarding absolute reductions and sufficiency goals, the case of shopping situations demonstrates that traditional policies are insufficient for reaching Austria's emission targets as long as they focus on mere shifts between shopping situations instead of addressing the underlying growth in consumption. More progressive steps need to be taken aiming at an absolute reduction in private demand for household goods – ideally as interplay between stringent policy actions on the one hand and a societal change towards sufficient consumer lifestyles on the other hand, wherein consumers restrain their spending and value immaterial or shared goods (Kleinhückelkotten 2005).

In regard to the specific case of shopping choices, the following directions for future research also point to potential angles for policy: Shopping, in particular buying convenience goods, is embedded in everyday activity schedules (Schwanen, Ettema, and Timmermans 2007) and often combined with return trips from the workplace. Analyzing trip chaining based on trip diary observations of all household members could provide better estimates how multi-purpose trips reduce carbon emissions on the last mile. Additionally, such an analysis could point out conditions how to encourage consumers to further combine household activities to multi-purpose tours, consequently attaining absolute reductions in their travel mileage.

Our approach focused on the availability and accessibility of shopping situations. However, policies affecting the transport system as a whole (e.g., improvement of public transport, increase of fuel prices) influence shopping trips, too. Policy combinations targeting multiple shopping situations simultaneously might be more effective due to synergies and closing of loopholes. Compact settlement structures may decrease shopping trip distances through higher residential and store density and better accessibility for public transport. Linking our methodological approach with travel demand models would allow assessing the effects of such general policies, but also implies a broader scope of feedback effects and less clear interpretation of scenario results.

Shopping situations refer not only to the location where a product is bought, but also where information on available products is provided. Consumers might obtain product information in a brick-and-mortar store but buy online or vice versa (Farag et al. 2007; Hjorthol 2009). Consumers might also undertake several trips to different retailers just to gain product advice and to compare product options, so that the internet complements traditional in-store shopping (Cao, Zu, and Douma 2012). A closer look into consumers' information search activities might attenuate the carbon advantage of mail order and online selling over the other shopping situations. Furthermore, policies targeting the preceding product search might be effective to direct subsequent store choice.

Finally, the scenarios for the retailing sector presented here are limited to the year 2020 because of the large uncertainties involved. Judging from Austrian consumption in the previous decades, we would expect an ongoing consumption growth beyond 2020, and thus an aggravation of GHG emissions from shopping situations. However, we are aware that some policy measures might unfold their full effect within a longer timeframe beyond 2020. Moreover, the relation between shopping situations and GHG emissions may improve through endogenous technological change, e.g. if new cooling technologies decrease energy demand for warehouse refrigeration, if private shopping trip distances change due to settlement dynamics, or if vehicle-specific emission factors decline because of more efficient car engines.

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Appendix

Generally, as stated in many economic textbooks the constant elasticity of substitution (CES) utility function is defined as:

Equation A.1: $C(x,y) = (\alpha * X^{\varrho} + (1- \alpha) * Y^{\varrho})^{1/\varrho}$,

where:

- α represents the share parameter of consumption good x (the share of good x on overall consumption)
- ϱ describes the elasticity of substitution between x and y in consumption behavior

As mentioned in Section 3.3, for the purpose of this research we use a nested CES structure to describe households' preferences for each region *i* (urban, suburban, rural). Figure A.1. illustrates the multi-level nested CES function for region i:

[insert Figure A.1 here]

Figure 1: Nesting structure of household preferences

With:

- ϱ_i^{GHM} : Substitution elasticity between groceries, housing & housing provision and the material bundle
- ϱ_i^{EEC} : Substitution elasticity within the material bundle between electronic equipment and clothing

- $\varrho_i^{Cs,r}$: Substitution elasticity within clothing between the respective shopping situations s,r
- $\varrho_i^{Gs,r}$: Substitution elasticity within groceries between the respective shopping situations s,r
- $\varrho_i^{EEs,r}$: Substitution elasticity within electronic & computers between the respective shopping situations s,r

For further details regarding the whole model structure see Kulmer et al. (2014) as well as Kulmer (2013).

In model calibration, elasticities of demand play a substantial role. Empirically estimated elasticities of substitution are scarce within the literature, in particular considering different shopping situations. The applied elasticities of demand between shopping situations, as illustrated in Table 6, are derived according to the following assumptions: (i) groceries are an essential good and thus can hardly be substituted with other product categories; (ii) electronics & computers and the rest of consumption goods are characterized as luxury goods and have a high substitution possibility; (iii) clothing and housing are goods for daily needs and thus have a lower substitution possibility. Furthermore, we assume that households in urban regions have higher substitution possibilities due to better shopping options, lower transport costs and higher wages (Cao 2009).

[insert Table A.1 here]

[insert Table A.2 here]

Table

Table 1: Investigated product categories

Product category	**Groceries**	**Clothing**	**Electronics & computers**
COICOP classes[1]	01, 02.1	03	09.1
Example products	dairy products, bread, meat, fruit, vegetables	clothes, shoes, sportswear	TV sets, cameras, computers, phones
Average monthly household expenditures and share of total expenditures (corrected for household size, Statistics Austria 2005)	226 Euro/Month 13.9%	89 Euro/Month 5.5%	31 Euro/Month 1.9%
Personal demand (Heinritz, Klein, and Popp 2003)	short-term, everyday, spontaneous	mid-term, occasional, planned	

[1] "Classification of Individual Consumption Expenditures by Purpose", used by the United Nations Statistics Division and Eurostat.

Expenditures refer to the year 2004.

Table 2: Investigated shopping situations

Shopping situation	Neighborhood store	Town center	Discount store	Shopping mall	Mail order and online selling
Description	Local provider for basic necessities	Downtown shopping street with a wide variety of businesses	Supermarket, big box warehouse	Building complex with multiple shops under an anchor store or an umbrella brand name	Catalogue selling, delivery service
Typical sales area	<250 m²	up to 400 m²	500-1,000 m², sometimes more	overall >2,500 m²	n/a
Location and accessibility	Decentral, in residential areas or village centers	Inner city, often in pedestrian areas	At main roads and traffic arteries	Urban periphery, connected to motorways, extensive parking area	n/a

Table 3: Distribution of demographic characteristics in the unweighted household survey sample

	Gender	Age (years)				Education			Region type		
	Female	**18-34**	**35-49**	**50-64**	**65-89**	**Comp.**	**Sec.**	**High**	**Urban**	**Suburb.**	**Rural**
N (unweighted sample)	363	194	219	158	119	257	285	148	358	154	178
% (unweighted sample)	52.6	28.1	31.7	22.9	17.2	37.2	41.3	21.4	51.9	22.3	25.8
% (weighted sample, equal to population, Statistics Austria 2004, 2005)	52.8	30.4	28.5	21.7	19.4	63.2	25.6	11.2	40.0	23.6	36.4

Comp.= Compulsory or vocational education; Sec.= Secondary school (with or without school leaving exam); High=Higher education (university-level); Suburb.=Suburban

Table 4: Data sources for the carbon footprint assessment for three product categories and four process steps

	Distribution (fuel use / tkm per € net sales)	**Storage** (energy use per € net sales)	**Store** (energy use per € net sales)	**Last Mile** (vehicle-kilometers per € net purchase)
Groceries	Data provided by retailer	Data provided by retailer	Data provided by retailer	Household survey
Clothing	Data provided by retailer	Data provided by retailer	Data provided by retailer (energy use per m²) and KMU 2007 (sales per m²)	Household survey
Electronics & computers	Assuming same as for clothing	Weber et al. 2009	Frauenhofer ISI et al. 2004 (energy use per m²) and KMU 2007 (sales per m²)	Household survey

Table 5: Data sources for the last mile of online selling

	Value	Source
Net value per order	116 €	Household survey
Electricity use per order (assuming 1 MB data transfer)	0.0125 kWh	Taylor and Koomey 2008
Corrugated cardboard per parcel (assuming a parcel size of 40x40x40 cm and a cardboard weight of 530 g per m²)	0.51 kg	Own assumption
Emissions per parcel delivery	2.18 kg CO_2	UPS 2010

Table 6: Market shares of shopping situations within each product category

	N	Neighb. [%]	Town [%]	Disc. [%]	Mall [%]	Online [%]	Other [%]
Groceries	686	45.8	4.8	41.1	7.4	0.1	0.9
Clothing	685	3.3	40.5	5.4	42.9	6.5	1.4
Electronics & computers	607	6.1	10.3	10.5	59.2	12.4	1.5

Neighb.=Neighborhood store; Town=Town center; Disc.=Discount store; Mall=Shopping mall; Online=Mail order and online selling

Market shares refer to the year 2010.

Table 7: Modal split of private shopping trips

Product category	Shopping situation	N	Private motor vehicle [%]	Public transport [%]	Bicycle [%]	Walking [%]
Single-purpose shopping trips						
Groceries	Neighb.	250	46.2	7.2	16.5	29.9
	Disc.	244	62.8	7.2	14.0	15.6
	Mall	37	64.3	11.6	3.8	18.9
Clothing	Town	227	42.6	27.9	13.6	15.4
	Mall	235	69.3	17.2	8.7	4.8
Electronics & computers	Disc.	46	68.5	6.8	10.7	14.0
	Mall	169	71.3	20.3	6.6	1.5
Shopping trips within a multi-purpose tour						
Groceries	Neighb.	207	48.4	12.1	15.6	23.8
	Disc.	204	60.3	8.1	13.8	16.6
	Mall	33	40.7	10.4	1.5	47.4
Clothing	Town	153	36.7	14.6	11.8	36.8
	Mall	178	68.2	9.2	7.8	14.5
Electronics & computers	Disc.	25	51.0	15.0	11.5	22.5
	Mall	114	62.6	13.2	2.6	21.6

Neighb.=Neighborhood store; Town=Town center; Disc.=Discount store; Mall=Shopping mall
Difference to 100% corresponds to other transport modes.
Modal split refers to the year 2010.

Table 8: Trip distance of private shopping trips

Product category	Shopping situation	Private motor vehicle		Public transport		Bicycle		Walking	
		N	[km]	N	[km]	N	[km]	N	[km]
Single-purpose shopping trips									
Groceries	Neighb.	121	6.94	16	9.74	39	2.64	72	1.94
	Disc.	158	9.80	18	8.44	30	2.90	36	1.34
	Mall	26	15.58	3	n/a	1	n/a	5	1.14
Clothing	Town	96	19.22	65	14.88	33	5.22	32	4.60
	Mall	173	24.80	38	17.18	19	5.84	6	4.18
Electronics & computers	Disc.	30	24.22	3	n/a	7	7.26	6	1.48
	Mall	126	25.18	31	10.82	11	6.64	1	n/a
Shopping trips within a multi-purpose tour									
Groceries	Neighb.	82	0.94	11	1.59	26	0.79	49	.57
	Disc.	93	1.11	10	1.11	22	0.27	33	0.50
	Mall	10	1.49	3	n/a	1	n/a	16	0.55
Clothing	Town	41	2.07	13	2.17	16	1.37	53	0.55
	Mall	84	2.20	10	0.71	10	0.81	26	0.80
Electronics & computers	Disc.	11	1.41	1	n/a	3	n/a	6	0.42
	Mall	50	1.87	13	0.86	2	n/a	25	0.14

Single-purpose trips: Two-way distance of trips exclusively undertaken for the purpose of shopping. Trips within a multi-purpose tour: Additional distance for reaching the store deviating from a direct route.

Neighb.=Neighborhood store; Town=Town center; Disc.=Discount store; Mall=Shopping mall

n/a = sub-sample N<5

Trip distances refer to the year 2010.

Table 9: Carbon emission intensity of the different shopping situations in kg CO_2 equivalents per 1,000 Euro of product net sales value, rounded

	Retail			Last Mile			Total		
Shopping situations	Storage	Distribution	Store	urban	suburban	rural	urban	suburban	rural
Groceries									
Neighborhood store or town center	6	13	47	6	34	29	95	161	308
Discount store	6	13	32	22	37	45	97	148	283
Shopping mall	6	9	90	200	236	301	405	510	1,011
Clothing									
Neighborhood store or town center	2	7	41	6	20	19	68	118	229
Shopping mall	2	7	23	13	20	49	82	114	221
Mail order and online selling	2	0	0	65	65	65	67	68	136
Electronics & computers									
Discount store	3	7	16	18	19	115	141	168	328
Shopping mall	3	7	16	26	13	140	167	193	379
Mail order and online selling	3	0	0	28	28	28	31	35	70

Storage= total energy demand of storage including lighting, cooling, heating.

Distribution=transport from the regional distribution center to the point of sale in vehicle-km.

Store=energy demand for heating, cooling, lighting and electric devices within the store.

Last mile= person-kilometer from the shopping situation to the home of the consumer, multiplied with the specific emissions factor of the means of transport. For mail order and online selling, the last mile refers to delivery transport to the customer's home.

Carbon footprint refers to the year 2010 (underlying data sources partly from earlier years, see section 3.2).

Table 10: Annual consumption expenditure and carbon emissions in scenario 0 (reference year 2020)

	Urban		**Suburban**		**Rural**		**Total**	
	[Mio. €]	[kt CO_2e]	[Mio. €]	[kt CO_2e]	[Mio. €]	[kt CO_2e]	[Mio. €]	[kt CO_2e]
groceries in neighborhood store	2,757	198	1,742	173	3,475	330	7,974	701
groceries in discount store	3,674	269	2,719	239	3,280	317	9,673	825
groceries in shopping mall	882	268	291	99	383	155	1,556	522
groceries in all other shopping situations	1,104	165	634	103	1,442	252	3,180	520
clothing in town centre	988	55	217	15	773	53	1,978	123
clothing in shopping mall	1,552	71	1,323	70	1,696	138	4,571	279
clothing in online	291	19	235	16	90	6	616	41
clothing in all other shopping situations	1,093	61	151	9	200	14	1,444	84
electronics & computers in discount store	11	0	25	1	28	4	64	5
electronics & computers in shopping mall	843	45	397	16	493	82	1,733	143
electronics & computers in online	235	7	126	4	103	3	464	14
electronics & computers in all other shopping situations	23	1	36	1	121	14	180	16
housing and housing provision	14,944	n/a	10,153	n/a	14,925	n/a	40,022	n/a
rest of consumption goods	25,959	n/a	16,328	n/a	23,897	n/a	66,184	n/a
Total	**54,355**	**1,161**	**34,376**	**746**	**50,907**	**1,369**	**139,638**	**3,276**

Table A.1: Elasticities of demand in the economic model

Elasticity of substitution in demand	Rural	Suburban	Urban
Between all product categories, except groceries (clothing, electronics & computers, housing, rest of consumption goods)	4	4	5
Within groceries between shopping situations	3	5	5
Within clothing between shopping situations	5	6	6
Within electronics & computers between shopping situations	7	6	8
Between groceries and all other product categories	0.05	0.05	0.05

Table A.2: Relative changes in market shares and carbon emissions in scenarios 1, 2, and 3, by region type (reference year 2020)

	Scenario 1			Scenario 2			Scenario 3		
	Urban	**Suburban**	**Rural**	**Urban**	**Suburban**	**Rural**	**Urban**	**Suburban**	**Rural**
groceries in neighborhood store	+1.27%	+0.99%	+0.86%	25.88%	25.36%	23.34%	+0.03%	+0.05%	+0.17%
groceries in discount store	+1.31%	+1.05%	+0.89%	-26.44%	-26.69%	-27.94%	+0.03%	+0.03%	+0.17%
groceries in shopping mall	-12.40%	-12.58%	-12.78%	-23.31%	-23.43%	-24.96%	+0.03%	+0.03%	+0.17%
groceries in all other shopping situations	+1.27%	+0.97%	+0.85%	-27.86%	-28.19%	-29.33%	+0.03%	+0.04%	+0.17%
clothing in town centre	+2.91%	+4.05%	+3.59%	+1.69%	+1.85%	+1.46%	-0.43%	-0.66%	-0.08%
clothing in shopping mall	-15.70%	-14.91%	-15.29%	+1.68%	+1.83%	+1.47%	-0.85%	-1.07%	-0.46%
clothing in online	+3.81%	+4.78%	+4.37%	+1.68%	+1.84%	+1.46%	+24.63%	+24.19%	+25.10%
clothing in all other shopping situations	-1.32%	+0.30%	-0.07%	+1.70%	+1.89%	+1.49%	+-0.17%	-0.54%	+0.10%
electronics & computers in discount store	+9.64%	+9.31%	+8.92%	+1.68%	+1.84%	+1.45%	-3.20%	-3.16%	-2.76%
electronics & computers in shopping mall	-18.39%	-18.69%	-18.83%	+1.67%	+1.83%	+1.47%	-3.80%	-3.80%	-3.28%
electronics & computers in online	+11.55%	+11.02%	+10.80%	+1.67%	+1.81%	+1.45%	+36.27%	+36.08%	+36.94%
electronics & computers in all other shopping situations	+9.81%	+9.36%	+9.01%	+1.68%	+1.84%	+1.44%	-3.33%	-3.45%	-2.92%
housing and housing provision	+0.85%	+0.80%	+0.69%	+1.69%	+1.84%	+1.48%	-0.26%	-0.26%	-0.11%
rest of consumption goods	+0.88%	+0.83%	+0.72%	+1.67%	+1.83%	+1.47%	-0.26%	-0.27%	-0.12%

Figure1
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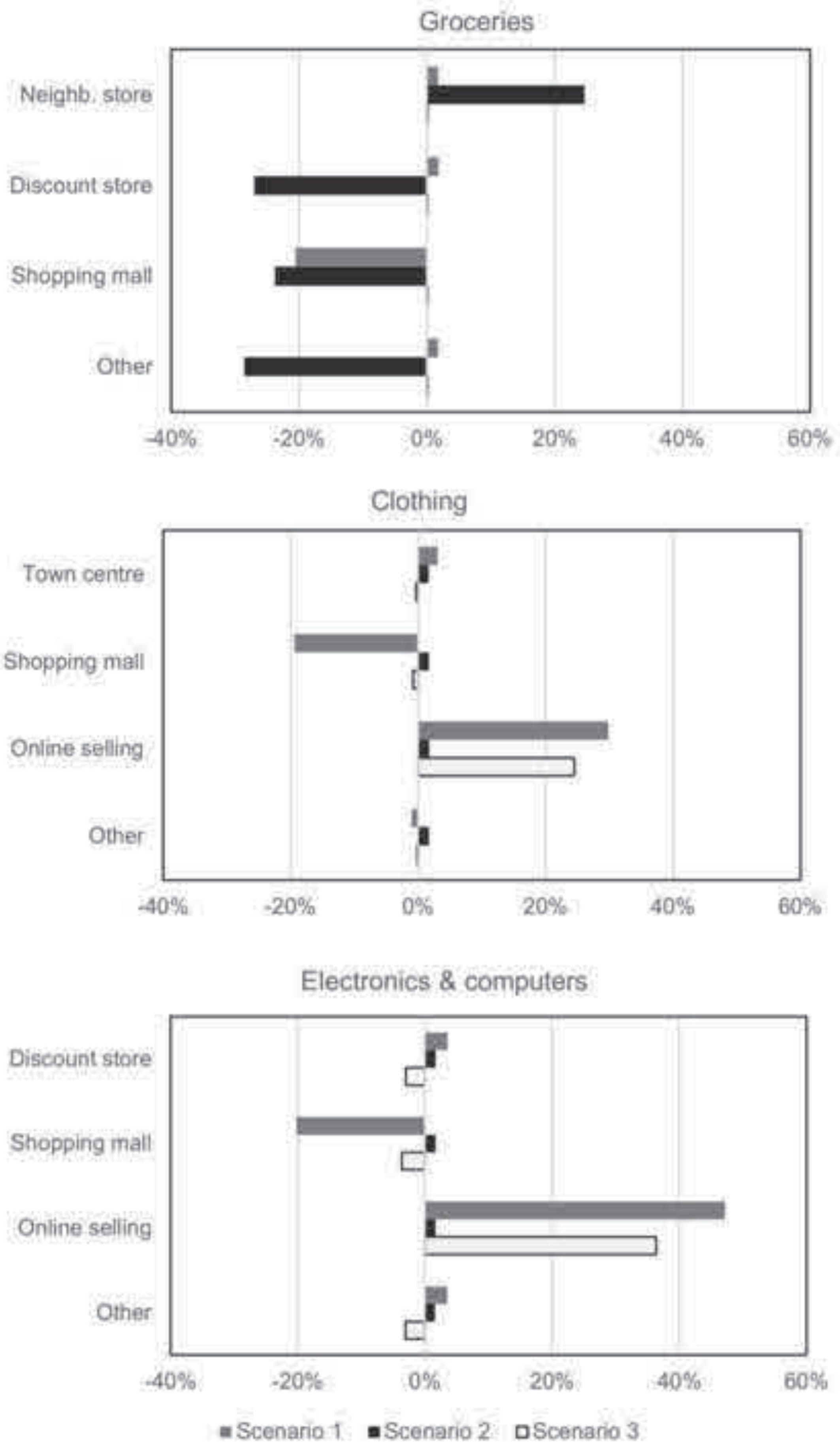

FigureA1
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