



Sustainability and crisis: Shifting consumer preferences for food products under the influence of the COVID-19 pandemic in Germany

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ABSTRACT

This study analyses the dynamics of consumer sustainability preferences, and willingness-to-pay (WTP) for fresh tomatoes in Germany, under the influence of the external COVID-19 pandemic shock. Employing a hybrid latent variable model, we determine consumer behavior and attribute valuation, considering preference heterogeneity and attribute non-attendance (ANA). Our findings reveal significant shifts in consumer preferences and WTP before and after the pandemic-induced lockdown. While consumers revealed a higher mean WTP for sustainability attributes pre-lockdown, a decline in WTP, notably for organic quality, was observed during the lockdown, indicating increased price sensitivity during the situation of economic uncertainty. However, German origin retained high monetary valuation, emphasizing consumers' support for local produce during crises. The analysis of the ANA structures revealed that the processing strategies for the attributes changed during the lockdown, with increased attention being paid to product origin and packaging. This illustrates which attributes and thus cultivation systems are more and which are less resistant to crises and what policy implications can be derived from the results.

1. Introduction

In March 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic, leading many governments to enforce extended lockdowns to curb the spread of the virus. While these measures successfully contained infections, they inflicted significant damage on global economies and labor markets, impacting societies and economies worldwide (Chohan, 2020; Di Crosta et al., 2021). External shocks often disrupt traditional consumption patterns as people adjust their behaviors in response to changing circumstances (Larson and Shin, 2018). In Germany, the first COVID-19 lockdown was decided on March 16, 2020, and went into effect on March 22, 2020. It was associated with numerous restrictions on public life. It ended with the first easing of restrictions after seven weeks on May 4, 2020.

Studies on the impact of the COVID-19 pandemic have shown that consumer behavior is changing as a result of this shock (Sheth, 2020). Some authors argue that such external shocks can cause fundamental psychological changes in consumers (Tao et al., 2022). This study is uniquely positioned to analyze how significant disruptions in consumers' daily lives influence their willingness-to-pay (WTP) for

sustainability attributes, addressing a critical gap in the existing literature.

During the pandemic, lockdown measures, supply chain disruptions, and economic uncertainty led to shifts in consumer preferences towards essential goods, including food items. There was an increased demand for staple foods, shelf-stable products, and home-cooking ingredients, while preferences for luxury or non-essential items decreased (e.g. Eger et al., 2021). External shocks can heighten awareness of food supply vulnerabilities and sustainability concerns, prompting consumers to prioritize locally sourced, sustainable, and environmentally friendly food products. On the one hand, the pandemic highlighted vulnerabilities in global food supply chains (Deconinck et al., 2020), which may have led to greater interest in supporting local farmers and food producers or to greater consciousness of the environmental and social impacts of their food choices, changing preferences for organic, locally, and ethically produced goods (Brumă et al., 2022). At the same time, people's sensitivity to hygiene was elevated or requirements were mandated, which may have led to changes in preference structures for packaging types. In other words, consumer focus has shifted towards fulfilling fundamental necessities, such as basic food and hygiene

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products (Cannito et al., 2021; Di Crosta et al., 2021). On the other hand, external shocks can increase individuals' risk aversion and uncertainty about future income and employment prospects. During times of economic downturn or crisis, consumers may prioritize cost-saving measures and the most basic purchasing decisions.

This paper examines these complex relationships by analyzing consumer preferences for food products with different attributes and attribute levels. We use tomatoes in the experimental approach as they are associated with as few emotional controversies as possible, as might be the case with animal-based products or products from tropical regions. At the same time, they exemplify sustainability controversies that consumers are often unaware of. The tomato is a product that has different attributes, each of which have different impacts on the sustainability of the overall product. For example, conflicts of objectives can arise between the cultivation system and regionality or seasonality, or between different indicators such as CO₂ footprint, water consumption or pesticide use and organic cultivation. Tomatoes are considered the most popular vegetable in Germany (BLE, 2024) and are rarely influenced by dietary restrictions such as vegetarianism or others. It is available all year round, however, it has a specific season when grown outside of greenhouses in Germany.

In a complex system of potentially important indicators for sustainability, which have to be evaluated by the consumer alongside other attributes such as price or appearance, it is essential to account for heuristics applied by the consumer, such as attribute non-attendance (ANA). This concept frequently emerges in decisions regarding low-involvement items like food products, where consumers rely on habitual purchasing behaviors, deliberately omitting certain attributes during product evaluation (Beharrell and Denison, 1995). Recent literature demonstrates that considering ANA factors provides deeper insights into consumers' decision-making processes, while disregarding these heuristics may bias empirical estimates (e.g. Hensher, 2006; Richartz and Abdulai, 2022). We use a discrete choice experiment (DCE) to determine consumer preferences for tomatoes with different sustainability indicators and ANA patterns.

This paper is in an exceptional and unique position to present how preference structures and WTP change under the influence of the external shock of the global coronavirus pandemic. Thus, the primary aim of the paper is to analyze how consumer preferences for tomatoes with different sustainability attributes have changed due to the COVID-19 pandemic. To the best of our knowledge, our study is the first to analyze the effects of the external shock of the coronavirus pandemic on preferences as well as ANA structures. The findings are of particular importance, as they provide valuable information about people's behavior and attribute valuation during extreme situations. This study also contributes to scholarly knowledge, as it uses a hybrid latent variable model that allows us to jointly examine the response to the stated choice component and to attribute-processing questions.

The rest of the paper is structured as follows: Section two describes the econometric framework of the hybrid latent variable model. Section three explains the Survey Design, Data Description and Model Specification. In section four we present the empirical results and section five concludes.

2. Material and methods

2.1. Econometric framework

In the empirical analysis we follow Bello and Abdulai (2016) and Richartz and Abdulai (2022) by employing the framework proposed by Hess and Hensher (2013), where the link between the stated choice and the attribute-processing component in the model is made by a latent variable (LV) which relates to the unobserved respondent-specific importance measure for each attribute. The utility of alternative i for respondent n in choice scenario t is defined as $U_{int} = V_{int} + \varepsilon_{int}$. With J alternatives ($j = 1, \dots, J$), the probability of alternative i being chosen is

given by:

$$P_{int} = P(V_{int} + \varepsilon_{int} > V_{jnt} + \varepsilon_{jnt}, \forall j \neq i) \quad (1)$$

where V_{int} represents the deterministic and ε_{int} the random component of the utility. The deterministic component of utility is given by a function of observed attributes x and estimated parameters β , $V_{int} = f(x_{int}, \beta)$, where a linear in parameters specification is employed. To account for preference heterogeneity, a Mixed Multinomial Logit (MMNL) model is employed, where we accommodate random variation across respondents in β with a type I extreme value distribution for the remaining error term ε . We define

$$P_{int}(\Omega) = \int_{\beta} \frac{e^{V_{int}(\beta)}}{\sum_{j=1}^J e^{V_{jnt}(\beta)}} h(\beta|\Omega) d\beta \quad (2)$$

where $\beta \sim h(\beta|\Omega)$, with Ω being a vector of parameters to be estimated. Since we work with repeated choice data, we follow Hess and Hensher (2013) with the assumption of intra-respondent homogeneity so that the likelihood of the actual observed sequence of choices for respondent n is then given by:

$$L_n(\Omega) = \int_{\beta} \left[\prod_{t=1}^T P_{i^*nt}(\beta) \right] h(\beta|\Omega) d\beta \quad (3)$$

where i^*nt refers to the alternative chosen by respondent n in choice situation t .

In addition to capturing information on the choices, the study also provides data relating to respondents' attribute-processing strategies. The approach uses mutually exclusive, stated attribute rankings to determine the attribute non-attendance (ANA) indicators. The answers to information processing are treated as dependent variables that are a function of the true underlying processing strategies. We assume that for every attribute k , each respondent n has an underlying, latent rating of attribute importance. This underlying, unobserved rating is thus given by a latent variable:

$$\alpha_{nk} = \varphi_k z_n + \sigma_1 \eta_{nk}^1 \quad (4)$$

where z_n represents respondents' characteristics as well as answers to attitudinal questions relating to consumption, sustainability behavior or environmental aspects. η_{nk}^1 is a random term assumed to follow a standard normal distribution. The vector φ_k explains the effect of z_n on the latent variable α_{nk} .

To model the probability for the response to the ranking question (ANA-indicators), we make use of a rank exploded MNL model, where the probability to fall between specific thresholds is influenced by the latent variable α_{nk} . The mutually exclusive rankings for the K attributes are given by R_k , $k = 1, \dots, K$ where $1 \leq R_k \leq K$, $\forall k$. We specify:

$$\gamma_{nk} = \zeta_k + \tau_k \alpha_{nk}, \forall k \quad (5)$$

where ζ_1 is set to 0 for normalization purposes. The conditional probability is then given as:

$$v_{nr} = \sum_{k=1}^K \delta_{(R_k, r)} \gamma_{nk}, r = 1, \dots, K \quad (6)$$

where $\delta_{(R_k, r)}$ is equal to 1 if $R_k = r$, i.e., if attribute k has ranking r , and 0 otherwise. With ζ and τ grouping together the individual elements ζ_k and τ_k respectively, the probability for the response to the ranking question is specified as:

$$L_{Rn}(\zeta, \tau, \alpha_n) = \prod_{r=1}^{K-1} \frac{e^{v_{nr}}}{\sum_{s=r}^K e^{v_{ns}}} \quad (7)$$

To link the latent variable α_{nk} which explains the answers to the non-

attendance and ranking questions to the choice model, α_{nk} is used as shrinkage factors in the choice model component, thus allowing for a continuous measure of importance, i.e. using a latent variable scaling approach (Bello and Abdulai, 2016). We replace the parameter β_k in the choice model component by $e^{\beta_k \alpha_{nk}}$ by computing the attribute-specific scaling parameters $\lambda = (\lambda_1, \dots, \lambda_K)$. Two separate components to capture heterogeneity, α_{nk} and β_k , are used to allow for the absence of a strict relationship between attribute importance and sensitivities, thus capturing any unrelated random heterogeneity in β_k . Conditional on α_{nk} and β_k we specify:

$$P_{int}(\beta, \lambda | \alpha_n) = \frac{e^{\sum_{k=1}^K e^{\beta_k \alpha_{nk}} \beta_k x_{k,int}}}{\sum_{j=1}^J e^{\sum_{k=1}^K e^{\beta_k \alpha_{nk}} \beta_k x_{k,int}}} \quad (8)$$

where $x_{k,int}$ is the k th component in x_{int} . A positive estimate for λ_k here indicates that as the importance rating rises in value, so does the marginal sensitivity to attribute x_k (Bello and Abdulai, 2016). Thus, the values of the attribute-processing component $L_{Rn}(\zeta, \tau, \alpha_n)$ are jointly modeled with the likelihood of the observed choice sequence $P_{int}(\beta, \lambda | \alpha_n)$.

Model- and group-specific WTP values for the different product attributes X are calculated as the rate of change in the attribute coefficient β divided by the rate of change of the price parameter y_{ps} (marginal rate of substitution). This is given as

$$WTP = - \left(\frac{\partial U}{\partial x} \right) = - \frac{\beta_{as}}{y_{ps}} \quad (10)$$

For more information, the interested reader is referred to Hess and Hensher (2013), Bello and Abdulai (2016) and Richartz and Abdulai (2022).

2.2. Survey design, Data Description and Model Specification

As stated above, key criteria for the product under examination included year-round availability and minimal self-sufficiency among consumers to ensure valid consumption data. To analyze seasonal and regional factors, as well as CO₂ emission, that may influence consumer choices, the product should be seasonally cultivated in Germany and regionally available for purchase during its growing season. According to data from the Federal Ministry of Food and Agriculture, tomatoes meet these requirements particularly well (BMEL, 2024). The choice of attributes was based on the goal of identifying possible conflicting objectives with regard to a perceived sustainable product. This is particularly important for a seasonal product that can be grown both in the field and in greenhouses, imported and packaged in different ways. Conflicting interests can arise for consumers, for example, if they want to minimize their carbon footprint when choosing a product and therefore opt for a regional product as they assume that transport has an impact on emissions. The consumer's perception therefore plays a major role in the consideration of various attributes. The study looks at preferences for sustainability indicators. Again, consumer perception plays a crucial role. Organic farming, for example, has the inherent potential to reduce CO₂ emissions (Scialabba and Müller-Lindenlauf, 2010). At the same time, transportation and the type of packaging can be perceived differently by consumers in terms of their impact on the environment (Magnier et al., 2016; Jürkenbeck et al., 2020; Kreier, 2022). Consequently, the product attributes to be considered in the DCE are defined as price per kilogram, CO₂ emissions in kilogram per kilogram of tomatoes, origin, cultivation structure and packaging type.

Table 1 describes all attributes and their respective levels. The attribute levels for cultivation structure, origin, type of packaging and price were derived from the existing range of products offered by the German food retailer REWE in March 2020. We use the retailer REWE to exclude prices from pure discount stores. The fact that this retailer is

Table 1

Attributes and attribute level in the choice experiments.

Attributes	Levels
Price/kg	1.69 €, 1.99 €, 3.89 €, 5.59 €
CO ₂ /kg tomatoes	0.6 kg, 2.4 kg, 5.8 kg, 9.3 kg
Origin	regional ^a , Germany, Mediterranean region
Cultivation structure	conventional, organic
Packaging type	unpacked, packed in carton, packed in plastic foil

^a Regional is defined as a radius of approx. 50 km.

represented throughout Germany and covers price ranges for tomato products from discounter prices to branded and organic products as well several types of packaging, ensures a representative product range profile. The levels of the attribute CO₂ emissions in kilograms, were derived from average values from the Institute for Energy and Environmental Research Heidelberg (Müller-Lindenlauf, 2012). CO₂ emissions are calculated along the entire production chain of a product. For food, CO₂ emissions therefore cover the entire value chain from the farm with all its inputs (feed, fertilizer, etc.) through processing and distribution to the end customer. Moreover, disposal of waste along the life cycle as well as transportation is taken into account. All greenhouse gas emissions such as methane (CH₄), nitrous oxide (N₂O) and carbon dioxide (CO₂) are recorded. These are then converted into so-called CO₂ equivalents according to their respective climate impact (Müller-Lindenlauf, 2012).

As in previous studies (Bechtold and Abdulai, 2014; Ouma et al., 2007) we decided to use a D-optimal design to reduce the number of choice tasks while guaranteeing a balanced design. The resulting generic choice sets were divided into three blocks. For more information on the widely documented development of choice experiments and experimental designs, we would like to refer the interested reader for example to Hensher et al. (2010, 2015). The design was generated using Stata®13. During the course of the experiment, each respondent was presented with six consecutive unlabeled choice scenarios. Each scenario also included a “no-buy” option.

Data collection was conducted from March to April 2020. The browser-based questionnaire was designed for both desktop computers and mobile devices. The questionnaire can be broken down into six sections. The first part of the questionnaire deals with social and political challenges of environmental problems and is employed to determine consumers' attitudes toward these specific issues. Attitudinal answers are thereby captured using Likert scales. The second part of the questionnaire examines respondents' personal environment-related behavior. The third and fourth parts explore respondents' general purchasing behavior and purchasing behavior with regards to tomato products, respectively. The implementation of the experiments follows in the fifth part. The questionnaire ended with socio-demographic information. In addition to the DCE, we also captured responses to questions on attribute processing strategies which can be linked to the answers of the DCE by using the aforementioned latent variable approach. Considering the fact that a hypothetical bias can be reduced using ex-ante hypothetical bias mitigation tools and that cheap talk scripts have been shown to work efficiently in online surveys, we implemented a cheap talk script before conducting the DCE (Bello and Abdulai, 2016; Howard et al., 2017; Lusk, 2003; Tonsor and Shupp, 2011). Right before the DCE, participants were asked about their understanding of the term and concept “regionality”. Ninety-two percent of respondents indicated that the product must originate from within a 50-km radius or at least from their own state.

Or dataset consists of 862 participants and is described by 66% women, a household size of 2.46 and an average age of 39 years. On average, 1.7 children live in 28% of the households. In the present data set, 30% of individuals have not yet completed vocational training, 23% have completed vocational training or are foremen, 19% have a bachelor's degree, and 28% have a master's degree or higher. The average

net household income is 3730.04 Euro. The respondents' postal codes are distributed across the entire German region. The descriptive statistics can be found in the Appendix in [Table A1](#).

Answers to attitudinal questions related to consumption and environmental issues as well as socioeconomic characteristics are included in the LV α_{nk} , thus represent z_n variables in our model. The variables used for our model specification in the LV approach and their definitions are presented in [Table A3](#).

3. Empirical results

3.1. Empirical results: complete sample

[Table A4](#) in the Appendix presents the maximum likelihood estimates of the hybrid latent variable model for the complete sample. For better readability, we refrain from presenting the whole table in this section of the manuscript. The results in the upper section of [Table A4](#) clearly demonstrate that preferences for most attributes are strongly influenced by the LV, suggesting that the estimates would have been biased without capturing consumers' preference heterogeneity. The coefficients show the economically rational expected signs, i.e., negative preferences for increasing prices as well as negative preferences for increasing CO₂ emissions. Interestingly, the attributes organic quality and CO₂ emission level seem to be particularly affected by the LV. This implies that consumer heterogeneity, i.e., personal characteristics, values or attitudes, have a much greater influence on preference structures and WTP of organic quality and CO₂ emission than on other attributes. At the same time, we identify the smallest influence on preferences by the LV for the attribute carton packaging. This implies that the preference structure in relation to this attribute can be assumed to be more homogeneous across all consumers. The complex, latent variable reflects the equally complex heterogeneous consumers. Roughly summarized, the manifestation of a higher latent variable corresponds to a group of people who tend to place less emphasis on environmental protection and sustainability interests in their everyday lives and consume more tomato products and vice versa. The β^l variables indicate that non-price attributes are increasingly excluded from the decision-making process at higher LV values. The β_0^l variables reveal that the cultivation structure and the carbon footprint are more strongly ignored than the price at the initial level, and that packaging and origin appear to be considerably more important to consumers. These estimates are in line with the corresponding participant responses, as indicated by the descriptive statistics in the dataset.

3.2. Empirical results: the COVID-19 shock

In [Tables A5 and A6](#) in the Appendix, we present the results before and after the severe consequences of the external COVID-19 shock. We define the first nationwide government-imposed lockdown as our threshold, given that the public had never experienced such an emergency scenario before. Consequently, we anticipate the strongest uncertainties and effects among the population. The first result that stands out is that the ANA of the price attribute is more strongly influenced by a changing LV during the lockdown. This suggests a generally increased price sensitivity of people in the upper spectrum of the LV. This could be explained by lower incomes and a generally lower focus on sustainability issues under the pressure and uncertainties of the pandemic situation. A further comparison of the ANA structures reveals that product origin, packaging and CO₂ emissions show the greatest differences. It can be observed that packaging and product origin receive more attention under lockdown conditions, while attention to CO₂ emissions decreases. The largest shifts can be observed for the latter two attributes. These results indicate that during the exceptional situation of the lockdown, consumers have primarily focused on the regionality of the supply chain and that the global problem of CO₂ emissions, which is more

difficult to grasp and play only a minor role in most people's everyday lives, has been pushed into the background when making purchase decisions. For a more intuitive interpretation of changing consumer preferences, we continue with presenting the WTP values of all three models in the following section.

3.3. Empirical results: willingness-to-pay

[Table 2, 3 and 4](#) show the WTP estimates for the tomato attributes and reveal how consumer sensitivity has changed under the shock situation. The mean WTP values provide valuable insights into consumer behavior. Consumers exhibited a modest WTP for organic quality compared to conventional ones, with a mean WTP of €0.96. Respondents revealed a negative WTP for additional CO₂ emissions of €-0.25, indicating sensitivity to environmental concerns and a preference for tomatoes with lower carbon footprints. Moreover, higher mean WTP values of €1.87 and €2.00 for German and regional origin tomatoes, respectively indicate a preference for locally sourced produce, likely driven by factors such as perceived freshness and support for local farmers (see [Table 3](#)).

Additionally, the slightly higher WTP for unpacked tomatoes compared to those packed in cardboard (€1.69 versus €1.48) may suggest a growing preference for minimal packaging and environmentally sustainable options among consumers. These findings underscore the importance of sustainable production practices and transparent labeling in meeting consumer demands and fostering a more environmentally conscious agricultural sector.

4. Discussion

Tomatoes are a staple food item in Germany, with consumption patterns influenced by factors such as seasonality, origin, cultivation methods, and packaging ([Latino et al., 2023](#)). Our results are in accordance with other studies that find that consumers are willing to pay price premiums for environmentally sustainable products ([Rizzo et al., 2023](#)), with environmental concern and products functional attributes being the two major determinants of consumer green purchase behavior ([Joshi and Rahman, 2015](#)). With regard to growing awareness of environmental impacts, German consumers reveal increased monetary valuation of attributes such as organic quality, regional origin, and more environmentally friendly packaging ([Groth et al., 2023](#)). On the other hand, higher prices for sustainable products have been found to constitute an effective barrier to consumption ([Vermeir and Verbeke, 2008](#)).

The disruptive event of the COVID-19 pandemic and the corresponding political handling (i.e. lockdowns) have led to changes in consumer behavior ([Seo and Hudson, 2023](#)) and food consumption patterns ([Efimov et al., 2020](#)). Our analysis of the pre- and post-lockdown periods due to the COVID-19 pandemic adds to this strand of literature by demonstrating and quantifying how consumer sensitivity has changed under the shock situation. The WTP estimates for tomatoes pre- and post-lockdown due to COVID-19 offer unique insights into shifting consumer preferences amidst the pandemic. Before the lockdown, consumers exhibited a higher mean WTP across most attributes compared to the post-lockdown period. This is in line with findings by [Grunert et al. \(2021\)](#) who analyzed differences in self-reported changes in food-related behaviors during the COVID-19 pandemic and identified increased awareness of prices, packaging, and attributes of food safety. Particularly noteworthy is the substantial decrease in mean WTP for organic quality, that indicates a potential shift in consumer priorities away from premium attributes towards more essential goods as economic uncertainties heightened during the pandemic. Similarly, [Grunert et al. \(2021\)](#) find that demand for expensive food decreased during the pandemic, while demand for inexpensive food increased.

In addition, WTP values for regional origin tomatoes experienced a slight decrease post-lockdown. However, it is also crucial to highlight

Table 2

Willingness-to-pay, complete sample.

Mean	WTP_ORGANIC	WTP_CO ₂	WTP_GER	WTP_REGIO	WTP_CARTON	WTP_LOOSE
	0.96	−0.25	1.87	2.00	1.48	1.69
Standard deviation	0.43	0.15	0.52	0.69	0.57	0.55
KI upper bound	0.97	0.25	1.85	2.02	1.50	2.09
KI lower bound	0.95	−0.25	1.89	1.98	1.46	1.83
Max Value	3.31	−0.06	4.21	5.37	4.42	4.33
Min Value	0.30	−1.14	0.92	0.82	0.55	0.72

Table 3

Willingness-to-pay, pre-lockdown.

Mean	WTP_ORGANIC	WTP_CO ₂	WTP_GER	WTP_REGIO	WTP_CARTON	WTP_LOOSE
	1.62	−0.39	2.24	2.72	2.14	2.30
Standard deviation	1.06	0.34	0.77	1.25	1.13	1.09
KI upper bound	1.58	−0.38	2.27	2.76	2.18	2.34
KI lower bound	1.66	−0.40	2.21	2.68	2.10	2.26
Max Value	8.61	−0.05	6.03	9.62	8.81	8.39
Min Value	0.33	−3.02	0.94	0.86	0.58	0.71

Table 4

Willingness-to-pay, post-lockdown.

Mean	WTP_ORGANIC	WTP_CO ₂	WTP_GER	WTP_REGIO	WTP_CARTON	WTP_LOOSE
	0.89	−0.23	2.37	2.44	1.88	1.92
Standard deviation	0.47	0.15	0.71	0.89	0.73	0.49
KI upper bound	0.92	−0.22	2.41	2.49	1.92	1.95
KI lower bound	0.86	−0.24	2.33	2.39	1.84	1.89
Max Value	2.85	−0.04	4.86	5.70	4.60	3.54
Min Value	0.19	−0.93	1.01	0.87	0.62	0.93

the relative importance of attributes, particularly in the context of shifting consumer preferences during times of crisis. While the mean WTP value decreased slightly, it is important to emphasize that the attribute retained its significance relative to other factors. Additionally, WTP for German origin tomatoes increased post-lockdown, indicating even stronger preferences for domestically sourced produce compared to pre-lockdown levels. This result is in line with the literature on tomato preferences in Germany, where locally produced tomatoes often receive a high preference ranking, even if it has been shown that these preferences often result from incorrect assumptions about the sustainability of agricultural products (Groth et al., 2023; Meyerding et al., 2019). Our findings suggest that despite increased overall price sensitivity, consumers maintained strong preferences for locally and regionally sourced produce, indicating a reaffirmed commitment to supporting local economies and ensuring food security under uncertainty. Similarly, other scholars reported increased interest in local food as a result of vulnerable food supply chains and changed purchase behavior (e.g. Thilmany et al., 2021; Vecchi et al., 2022; Cappelli and Cini, 2020). In general, the literature suggests that consumers are willing to pay for packaging that they perceive as sustainable (Herrmann et al., 2022). However, we observe that WTP for the product packaging, relative to plastic packaging, also decreased. Two reasons could explain the decline. Firstly, it could be that the reduced WTP is simply an expression of increased price sensitivity during the crisis. Secondly, it is also conceivable that people have developed increased preferences for plastic packaging due to uncertainties regarding the hygiene situation. The relative stability of preferences for plastic-free packaging compared

to the preference for organic products, amidst changing economic conditions, may indicate an underlying shift towards more sustainable consumption patterns (with regards to packaging) that are likely to persist beyond the crisis.

5. Conclusion

This study shed more light on the complex dynamics of consumer preferences and willingness-to-pay (WTP) for tomatoes in Germany, particularly in the context of sustainability concerns and the unprecedented external shock of the COVID-19 pandemic.

We used a hybrid latent variable model, that provides valuable insights into consumer behavior and attribute valuation. The model accounts for preference heterogeneity and attribute non-attendance (ANA), offering a deeper understanding of consumers' decision-making processes. The results reveal significant shifts in consumer preferences and WTP pre- and post-lockdown due to the COVID-19 pandemic. Before the lockdown, consumers exhibited higher mean WTP values for the more sustainable levels across all attributes, suggesting a willingness to pay premiums for desired attributes. During the lockdown, a decline in WTP was recorded for all attributes except German origin, which indicates an overall increase in price sensitivity during the exceptional pandemic situation. The most notable decline in WTP was observed for the organic quality attribute, possibly indicating a shift towards more essential goods in times of economic uncertainty. The decline in WTP for organic quality was almost 50%, which indicates that preferences for this quality are the least pronounced or consolidated among the

population under such extreme conditions.

While the mean WTP for regionally grown tomatoes decreased slightly post-lockdown, overall, the origin attributes received the highest monetary valuation compared to all of the other attributes. This underscores consumers' reaffirmed commitment to supporting local economies and ensuring food security under uncertainty. In addition, the analysis of ANA structures revealed that the lockdown led to changes in attribute processing strategies, in particular that product origin and packaging received more attention under lockdown conditions, while attention to CO₂ emissions decreases. This aspect is of particular importance as it suggests that the reduced WTP of the packaging levels compared to the plastic packaging may reflect uncertainties regarding hygiene and virus spread. Hence, it is apparent that the COVID-19 shock has reduced the WTP for sustainability in relation to fresh vegetables.

The study's findings resulted in both theoretical and practical implications. From a theoretical point of view, our results provide insight into consumer behavior changes as a result of an external shock. During times of economic downturn or crisis, consumers may prioritize cost-saving measures and the most basic purchasing decisions. By analyzing the extent to which an extreme event and a corresponding policy measure affects the consumers' WTP for sustainability attributes, we add to the literature by quantifying the shock to consumers and shed light on its impact on sustainability. From a managerial perspective, the study's findings further have implications for the agricultural and nutritional sector. Organic production methods, which are a set goal in both German and European agricultural policy, appear less resilient than other areas of sustainability with regard to certainty in the event of shocks or disaster situations. Political support and the promotion of incentives relating to organic production methods therefore seem to be more crucial (Durham and Mizik, 2021) compared to other areas of sustainability like eco-friendly packaging solutions or regionality, as consumers are less likely to limit their WTP in these areas. The reasons for this are likely to be manifold, particularly in the context of the coronavirus pandemic, which presents potentially unique circumstances. Events of global significance like these underscore the critical need to promote and support regional or national supply chains, thereby mitigating conditions of significant economic dependence. In this regard, consumer education is an important element. As the literature indicates, firstly, consumers overestimate and underestimate the sustainability effects of certain measures and thus attributes (Groth et al.,

2023), and secondly, the provision of information can change these assessments and thus also preferences and WTP (Nitzko et al., 2024; Richartz and Abdulai, 2022). Targeted educational campaigns could help to bridge the knowledge gaps in consumers regarding the sustainability effects of their diet (Cianni et al., 2024). Effective consumer information can therefore guide consumers towards more sustainable diets and make a major contribution to improving the valuation and WTP of important sustainability factors and thus to improving the resilience of the related supply chains in the event of external shocks.

Of course, this study has some limitations that can be addressed in future research work. First, and as a direct consequence of the survey design and sample structure, the results cannot be generalized to consumption patterns under uncertainty nor are they representative to the entire population in Germany. It is likely that the magnitude and the direction of effects is context specific, and future research may focus on different food products, target different countries or world regions. Another limitation is that we do not measure actual behavior in our study. While this holds true for hypothetical market behavior in general and has been addressed by cheap talk script, other product-specific factors could influence the results and the estimated WTP could differ depending on chosen attributes and levels. Future research should thus try to include measures of actual buying behavior during the Covid pandemic that could validate our findings, e.g., by using scanner data of the *Gesellschaft für Konsumforschung* (GfK) in the same time frame, explore other categories of food products, identify long-term consumer preferences post-pandemic, and target regional differences by conducting comparative studies between countries or world regions.

CRediT authorship contribution statement

Christoph Richartz: Writing – original draft, Software, Methodology, Formal analysis. **Sascha Stark:** Writing – review & editing, Supervision, Project administration, Conceptualization. **Matthias Kühlen:** Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Table A1
Descriptive statistics

Variable	Description	Sample	Percentage
No. participants	Number of participants	862	100
Age	Mean age	39.5	
Marital status			
	Single	199	23.3
	Relationship	249	29.2
	Married	359	42.0
	Divorced	40	4.6
	Widowed	6	0.7
Household size	Mean household size	2.5	
Children in Household	Mean number of children in household	1.75	
HH 1 Child	Number of households with one child	118	
HH 2 Children	Number of households with two children	80	
HH 3 Children	Number of households with three children	30	
HH 4 Children	Number of households with four children	8	
HH 5 Children	Number of households with five children	2	
Education			
Berufsreife	Occupational maturity	11	1.3
Mittlere Reife	Intermediate school-leaving certificate	52	6.0

(continued on next page)

Table A1 (continued)

Variable	Description	Sample	Percentage
Fachhochschulreife	Technical matriculation standard	75	8.8
Allgemeine Hochschulreife	General matriculation standard	109	12.7
Berufsausbildung	Vocational training	144	16.8
Meister, Fachwirt	Foreman	63	7.4
Bachelor	Bachelor	161	18.8
Master, Staatsexamen, Diplom	Master, state examination, diploma	228	26.6
Promotion	PhD	14	1.6
Occupational Categories	White collar	513	59.5
	Blue collar	12	1.4
	Civil servant	73	8.5
	Self employed	46	5.3
	Student	143	16.6
	At home	13	1.6
	Unemployed	11	1.3
	Unable to work	13	1.5
	Retired	26	3.0
	Other	12	1.4
	Mean net household income	3704 €	
	Median net household income	3450 €	
Political orientation	CDU/CSU	141	17.0
	SPD	97	11.7
	FDP	41	5.0
	Die Linke	73	8.8
	Bündnis 90/Die Grünen	303	36.7
	AFD	31	3.8
	Others	140	17.0

Table A2**z_n** Variable Definitions

z _n Variable	Definition
age_64_more	1 if respondent is 64 years or older, 0 otherwise
female	1 if respondent is female, 0 if respondent is male
highEducation	1 if respondent has university degree or master craftsman, 0 otherwise
incMoreAv	1 if respondent has an above-average income, 0 otherwise
haveChildren	1 if respondent has children, 0 otherwise
greenvote	1 if respondent is a green party voter, 0 otherwise
better_tech	Factor Variable ¹ , individuals seek to contribute to environmental protection primarily through the use of modern, more energy-efficient electrical appliances or lighting
less_energy	Factor Variable ¹ , individuals try to contribute to environmental protection by saving electricity, heating or consuming less water
priority_environment	Factor Variable ¹ , describes the conviction that the protection of the environment must be prioritized over one's own standard of living or the economy
sus_daily_routine	Factor Variable ¹ , individuals try to contribute to environmental protection by using environmentally friendly detergents or washing and care products as well as environmentally friendly clothing
tomatoes_week	Consumption of tomato products per week 1 = never; 2 = on one day; 3 = on two days; 4 = on three days 5 = on four days; 6 = on five days; 7 = on six or more days
veggie	1 if respondent is a vegetarian or vegan, 0 otherwise

¹ The variables and questions upon which the factor is based can be found in Appendix, [Table A3](#).

Table A3**Factor variables**

Factor Variable	Elements
better_tech	1. Efforts in individual's everyday life: Purchase of energy-efficient appliances. Likert scale: 1 = never to 7 = always.
	2. Efforts in individual's everyday life: Purchase of energy-efficient light sources. Likert scale: 1 = never to 7 = always.
less_energy	1. Efforts in individual's everyday life: Keep consumption of electricity and water low. Likert scale: 1 = never to 7 = always.
	2. Efforts in individual's everyday life: Reduce heating and keep heating costs low. Likert scale: 1 = never to 7 = always.
priority_environment	1. There are natural limits to growth that our industrialized world has reached or already exceeded. Likert scale: 1 = strongly disagree to 7 = strongly agree.
	2. We can only solve our environmental problems by fundamentally changing the way we manage our economy and our way of life. Likert scale: 1 = strongly disagree to 7 = strongly agree.
	3. In order to preserve our natural basis of life, we must all be prepared to reduce our standard of living. Likert scale: 1 = strongly disagree to 7 = strongly agree.
	4. Environmental protection should be a priority for Germany even if economic growth could be impaired as a result. Likert scale: 1 = strongly disagree to 7 = strongly agree.
sus_daily_routine	1. Efforts in individual's everyday life: Purchase of environmentally friendly detergents. Likert scale: 1 = never to 7 = always.
	2. Efforts in individual's everyday life: Purchase of environmentally friendly personal care products. Likert scale: 1 = never to 7 = always.
	3. Efforts in individual's everyday life: Purchase of environmentally friendly clothing. Likert scale: 1 = never to 7 = always.

Table A4
Maximum Likelihood Estimates, Complete Sample

Name	Est.	Rob. Std err	t-test
ASC_NOBUY_LV	1.05***	0.244	4.3
ASC_NOBUY_REF	-1.00***	0.326	-3.06
$\lambda_{_}$ ORGANIC_LV	-0.31***	0.12	-2.58
$\beta_{_}$ ORGANIC_REF	0.425***	0.0449	9.45
$\lambda_{_}$ CO ₂ perKG_LV	-0.538***	0.183	-2.95
$\beta_{_}$ CO ₂ perKG_REF	-0.102***	0.0205	-4.97
$\lambda_{_}$ Germany_LV	0.0282	0.0594	0.474
$\beta_{_}$ Germany_REF	0.925***	0.0983	9.41
$\lambda_{_}$ Regional_LV	-0.191*	0.0721	-2.65
$\beta_{_}$ Regional_REF	0.685***	0.0784	8.74
$\lambda_{_}$ Carton_pck_LV	-0.075**	0.0755	-0.994
$\beta_{_}$ Carton_pck_REF	0.808***	0.0852	9.48
$\lambda_{_}$ Unpacked_LV	0.621	0.0744	8.35
$\beta_{_}$ Unpacked_REF	-0.563***	0.0388	-14.5
$\lambda_{_}$ Price_LV	-0.109***	0.0577	-1.9
$\beta_{_}$ Price_REF	0.948***	0.102	9.33
$\beta^I_{_}$ ana_cultivation	0.161***	0.0176	9.13
$\beta^I_{_}$ ana_CO ₂	0.209***	0.0237	8.83
$\beta^I_{_}$ ana_origin	0.14***	0.0154	9.08
$\beta^I_{_}$ ana_packaging	0.131***	0.0149	8.83
$\beta^I_{_}$ ana_price	-0.704***	0.0703	-10
$\beta^I_{0_}$ ana_cultivation	0.103***	0.0131	7.87
$\beta^I_{0_}$ ana_CO ₂	0.572***	0.0643	8.9
$\beta^I_{0_}$ ana_origin	-0.289***	0.0308	-9.39
$\beta^I_{0_}$ ana_packaging	0.103***	0.0131	7.87
$\beta^I_{0_}$ ana_price (normalized to zero)	0	-	-
$\phi_{_}$ age_64_more	-0.507***	0.0944	-5.38
$\phi_{_}$ female	-0.0764***	0.00175	-43.7
$\phi_{_}$ high education	0.085***	0.00148	57.4
$\phi_{_}$ incMoreAv	-0.178***	0.00212	-83.9
$\phi_{_}$ children	-0.00135	0.00223	-0.604
$\phi_{_}$ greenvote	-0.278***	0.00247	-113
$\phi_{_}$ better_tech	0.00951***	0.00079	12
$\phi_{_}$ less_energy	-0.0249***	0.00085	-29.3
$\phi_{_}$ priority_environment	-0.0441***	0.00058	-76.1
$\phi_{_}$ sus_daily_routine	0.00044***	5.28E-06	83.3
$\phi_{_}$ tomatoes_week	0.162***	0.00135	120
$\phi_{_}$ veggie	-0.543***	0.00536	-101
Respondents	738		
Observations	4428		
LL(0)	-36014.17		
LL	-36086.17		
Parameters	46		

Table A5
Maximum Likelihood Estimates, Pre-Lockdown

Name	Est.	Rob. Std err	t-test
ASC_NOBUY_LV	1.04***	0.0579	18
ASC_NOBUY_REF	-0.494***	0.0909	-5.43
$\lambda_{_}$ ORGANIC_LV	-0.268***	0.0808	-3.32
$\beta_{_}$ ORGANIC_REF	0.51***	0.0584	8.73
$\lambda_{_}$ CO ₂ perKG_LV	-0.471***	0.103	-4.57
$\beta_{_}$ CO ₂ perKG_REF	-0.104***	0.0134	-7.76
$\lambda_{_}$ Germany_LV	0.0545	0.0562	0.968
$\beta_{_}$ Germany_REF	0.879***	0.0715	12.3
$\lambda_{_}$ Regional_LV	-0.0599	0.0454	-1.32
$\beta_{_}$ Regional_REF	0.996***	0.0747	13.3
$\lambda_{_}$ Carton_pck_LV	-0.182**	0.0669	-2.72
$\beta_{_}$ Carton_pck_REF	0.738***	0.0719	10.3
$\lambda_{_}$ Unpacked_LV	-0.0852	0.0628	-1.36
$\beta_{_}$ Unpacked_REF	0.828***	0.0693	12
$\lambda_{_}$ Price_LV	0.541***	0.0409	13.2
$\beta_{_}$ Price_REF	-0.428***	0.0241	-17.7
$\beta^I_{_}$ ana_cultivation	0.164***	0.0196	8.34
$\beta^I_{_}$ ana_CO ₂	0.239***	0.0289	8.28
$\beta^I_{_}$ ana_origin	0.151***	0.0178	8.47
$\beta^I_{_}$ ana_packaging	0.157***	0.0196	8.04

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Table A5 (continued)

Name	Est.	Rob. Std err	t-test
$\beta^I_{ana_price}$	-0.745***	0.077	-9.69
$\beta^I_{0_ana_cultivation}$	0.15***	0.0185	8.1
$\beta^I_{0_ana_CO_2}$	0.733***	0.0715	10.3
$\beta^I_{0_ana_origin}$	-0.38***	0.0368	-10.3
$\beta^I_{0_ana_packaging}$	-0.241***	0.0267	-9.04
$\beta^I_{0_ana_price}$ (normalized to zero)	0	-	-
$\phi_{age_64_more}$	-0.628***	0.117	-5.39
ϕ_{female}	-0.0932	0.0623	-1.5
$\phi_{high_education}$	0.0355	0.0549	0.646
$\phi_{incMoreAv}$	-0.408***	0.057	-7.15
$\phi_{children}$	0.0179	0.0604	0.297
$\phi_{greenvote}$	-0.404***	0.0576	-7.01
ϕ_{better_tech}	0.0076	0.0357	0.213
ϕ_{less_energy}	-0.0121	0.0247	-0.492
$\phi_{priority_environment}$	-0.0567**	0.0201	-2.82
$\phi_{sus_daily_routine}$	0.000585*	0.000293	2
$\phi_{tomatoes_week}$	0.238***	0.0245	9.72
ϕ_{veggie}	-0.552***	0.0643	-8.59
Respondents	569		
Observations	3414		
LL(0)	-35837.44		
LL	-28039.84		
Parameters	46		

Table A6

Maximum Likelihood Estimates, Post-Lockdown

Name	Est.	Rob. Std err	t-test
ASC_NOBUY_LV	0.731	1.47	0.498
ASC_NOBUY_REF	-0.979*	0.513	-1.91E+00
$\lambda_{ORGANIC_LV}$	-0.275	0.612	-0.449
$\beta_{ORGANIC_REF}$	0.43***	0.113	3.81
$\lambda_{CO_2perKG_LV}$	-0.336**	0.166	-2.03E+00
$\beta_{CO_2perKG_REF}$	-0.0954*	0.0514	-1.86E+00
$\lambda_{Germany_LV}$	0.0941	0.281	0.335
$\beta_{Germany_REF}$	0.899***	0.13	6.94
$\lambda_{Regional_LV}$	-0.0866	0.0938	-0.923
$\beta_{Regional_REF}$	0.892***	0.139	6.42
$\lambda_{Carton_pck_LV}$	-0.0513	0.147	-0.35
$\beta_{Carton_pck_REF}$	0.73***	0.159	4.6
$\lambda_{Unpacked_LV}$	0.0492	0.194	0.254
$\beta_{Unpacked_REF}$	0.781***	0.131	5.97
λ_{Price_LV}	0.437	0.792	0.551
β_{Price_REF}	-0.514***	0.103	-4.98
$\beta^I_{ana_cultivation}$	0.233***	0.0248	9.39
$\beta^I_{ana_CO_2}$	0.199***	0.0231	8.63E+00
$\beta^I_{ana_origin}$	0.165***	0.0262	6.31
$\beta^I_{ana_packaging}$	0.114*	0.0589	1.94E+00
$\beta^I_{ana_price}$	-0.959***	0.0505	-19
$\beta^I_{0_ana_cultivation}$	0.122	0.34	3.59E-01
$\beta^I_{0_ana_CO_2}$	0.883	1.73	0.512
$\beta^I_{0_ana_origin}$	-0.526	0.906	-0.58
$\beta^I_{0_ana_packaging}$	-0.153	0.235	-0.653
$\beta^I_{0_ana_price}$ (normalized to zero)	0	-	-
$\phi_{age_64_more}$	-0.363	0.737	-4.93E-01
ϕ_{female}	0.173	0.561	0.308
$\phi_{high_education}$	0.235	0.391	0.601
$\phi_{incMoreAv}$	0.296	0.337	8.77E-01
$\phi_{children}$	0.161	0.564	0.286
$\phi_{greenvote}$	-0.0825	0.0667	-1.24E+00
ϕ_{better_tech}	-0.00405	0.051	-0.0795
ϕ_{less_energy}	-0.0473	0.344	-0.138
$\phi_{priority_environment}$	-0.0656	0.07	-0.938
$\phi_{sus_daily_routine}$	-0.000149	0.001	-0.149
$\phi_{tomatoes_week}$	0.0966	0.366	0.264
ϕ_{veggie}	-0.638	0.774	-0.825
Respondents	169		
Observations	1014		
LL(0)	-10602.72		
LL	-7967.84		
Parameters	46		

Data availability

Data will be made available on request.

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