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The long-term effect of COVID-19 policy stringency on consumer food demand quantities in Switzerland

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ABSTRACT

This is the first study investigating the effect of COVID-19 policy stringency on consumer food demand for the years 2020 and 2021. In particular, we compared food demand in periods with strict COVID-19 policies to food demand in periods with less strict COVID-19 policies. For this purpose, we used Switzerland, which imposed two COVID-19 lockdowns, as a case study. To test this link, we applied fixed effects dummy variable regressions (as baseline estimates) and dose–response functions. To capture the stringency of Swiss COVID-19 policies, we relied on daily data from the Oxford COVID-19 Government Response Tracker. Food demand data at the product level came from the combined retail and consumer panel of the market research company Nielsen and covered meat, milk products, vegetables, and fruits. Empirical findings revealed that consumer demand for all food products was on average 2.5 times higher during the two lockdowns compared to periods without lockdowns. While we found no statistically significant differences in consumer food demand between the two lockdowns for milk products, vegetables, and fruits, the total food demand and the demand for meat was higher during the first lockdown. Increases in Swiss food demand were likely caused by the closing of restaurants (both lockdowns) and the closing of borders to neighboring countries (only the first lockdown), preventing shopping tourism. Against the background of potential future pandemics, our research provides important information for policymakers on the quantification of food demand changes in times of crisis.

1. Introduction

1.1. Background and aim of the study

After the first cases of the new coronavirus (SARS-CoV-2) were reported by the Wuhan Municipal Health Commission on December 30, 2019, the initially epidemic situation in China evolved very rapidly into a pandemic [1]. At the beginning of 2020, the outbreak of the COVID-19 pandemic had a sudden and drastic impact on private lives and the world of work. To contain the spread of the new coronavirus, over 100 governments decided to impose either a full or partial lockdown by the end of March 2020 [2]. The lockdown of an economy encompasses social distancing measures and the closing of restaurants and other non-essential businesses, which leads to substantial disruptions to individuals' behavioral routines. For instance, various studies have shown that the first COVID-19 lockdown in 2020 led to substantial changes in eating behavior and food demand [3–8]. Most of these studies focused on the first lockdown or the time shortly after and were based on cross-sectional data or repeated cross-sectional data. However, less is known about the long-term consequences of COVID-19 policies on consumer food demand. Furthermore, there is a lack of knowledge on how the stringency of COVID-19 policies influenced consumer food demand.

Against the background of potential future pandemics, it is of crucial importance for policymakers to be informed about the long-term consequences of COVID-19 policy stringency on food demand and consumption. Consequently, the aim of our study was to estimate the long-term effect of COVID-19 policy stringency on food demand. For this purpose, we used Switzerland as a case study. Similar to other European countries, the Swiss government imposed two lockdowns entailing a closing of borders to neighboring countries (first lockdown only) and closing of restaurants (both lockdowns).

To estimate the effect of COVID-19 policy stringency on consumer food demand quantities, we applied a dummy variable fixed effects regression and a dose–response function [9]. Consumers had no influence on the stringency and timing of the COVID-19 measures. Therefore, COVID-19 policies were given exogenously to consumers. To capture the stringency of Swiss COVID-19 policies, we relied on daily data from the

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Oxford COVID-19 Government Response Tracker (OxCGRT) compiled by Hale et al. [10]. For our analyses, we computed the monthly average value of the Stringency Index. Data on monthly consumer demand quantities were available for meat, milk products, vegetables, and fruits. Data came from the combined retail and consumer panel by the market research company Nielsen [11]. Our investigations focused on the years 2020 and 2021.

Our contribution to the literature investigating the effect of COVID-19 policy stringency on food consumption and demand is fourfold. First, the consumer data covering the years 2020 and 2021 allow us to provide empirical evidence on the long-term effects of COVID-19 policy stringency on consumer food demand. Second, owing to exogeneity of COVID-19 policies, we were able to estimate the unbiased effect of COVID-19 policy stringency on consumer food demand. Third, this is the first study applying a dose-response function estimating the effect of COVID-19 policy stringency on food demand. Fourth, we provide evidence on the heterogeneous effects of the two COVID-19 lockdowns on consumer food demand.

1.2. Related literature and hypotheses

A crisis such as the COVID-19 pandemic is an unexpected event that causes uncertainty and disrupts behavioral routines and consumption patterns [12]. In many countries, COVID-19 lockdowns inter alia entailed the closing of restaurants, bars, and coffee shops as well as borders to neighboring countries, preventing shopping tourism, all of which led to a shift in consumer demand for groceries [13–15]. Additionally, food panic buying, hoarding, and excessive stockpiling of food was observed during the first lockdown in 2020, causing food demand to temporarily increase [16]. For instance, results based on survey data from Russia indicated that people especially stockpiled large amounts of non-perishable food items [4]. In Germany, excessive purchases were observed not only for non-perishable foods but also, in smaller amounts, for fresh fruits and vegetables [17]. Against this background, we formulated our first hypothesis:

H1. Periods with strict Swiss COVID-19 policies resulted in higher consumer food demand than periods with less strict policies.

Even though many countries imposed a second COVID-19 lockdown beginning in the fourth quarter of 2020 [18], from a scientific perspective, less is known about the consequences of this lockdown on food demand and consumption. Food panic buying behavior was only reported in newspaper articles for a few countries such as France [19], and the UK [20]. While the closing of restaurants, bars, and coffee shops likely caused a shift in consumer food demand toward groceries, Swiss people seemed to have adapted to the pandemic situation, and therefore, food panic buying was not observed during the second lockdown [21]. Furthermore, borders to neighboring countries remained open so that shopping tourism was possible. Consequently, we tested our second hypothesis:

H2. The first Swiss lockdown caused a stronger increase in food demand than the second Swiss lockdown.

2. Databases and methods

2.1. Databases

To measure the stringency of Swiss COVID-19 policies, we used data from the OxCGRT compiled by Hale et al. [10]. The OxCGRT data cover the following four policy indices ranging from 0 (nonexistent) to 100 (very stringent): (1) Government Response Index, (2) Containment and Health Index, (3) Stringency Index, and (4) Economic Support Index. The four OxCGRT indices are based on publicly available information on 21 sub-indicators (and three retired sub-indicators) related to governmental responses to the COVID-19 pandemic. The governmental policy responses have been tracked since January 1, 2020. Data are available for more than 180 countries. The four policy indices more or less captured the same information. Therefore, for our empirical analyses, we used the Stringency Index, which is calculated according the following equation:

$$Stringency\ Index = \frac{1}{k}\sum_{j=1}^{k} I_j \tag{1}$$

The Stringency Index is based on $k = 9$ component indicators: (i) school closings, (ii) workplace closings, (iii) cancellations of public events, (iv) restrictions on gathering sizes, (v) closures of public transport, (vi) stay-at-home requirements, (vii) restrictions on internal movement, (viii) restrictions on international travel, and (ix) public information campaigns. In this context, I_j represents the sub-index score. Consequently, the Stringency index is computed as the simple average of its $k = 9$ component indicators. Data were available on a daily basis. For our analyses, we computed the monthly average value of the Stringency Index.

In Fig. 1, we show the development of the average monthly Stringency Index values (blue solid line) and the timing of the two lockdowns in Switzerland. Red vertical dashed lines refer to the beginning and end of the first lockdown; green vertical dashed lines refer to the beginning and end of the second lockdown. In general, both Swiss lockdowns entailed a closing of non-essential businesses, restaurants, bars, and clubs.

In Switzerland in January 2020, the value of the Stringency Index was zero, and in February 2020, the average Stringency Index value was 2.5. With the beginning of the first lockdown on March 13, 2020, the stringency of Swiss COVID-19 policies increased rapidly, reaching its maximum in April 2020 (average Stringency Index value = 72.5) (see Fig. 1). The first lockdown ended on June 15, 2020 with the opening of the borders and the abolishment of restrictions on admission for EU/EFTA states and the UK. Between June 2020 (average Stringency Index value = 44.4) and October 2020 (average Stringency Index value = 33.4), the COVID-19 policy stringency weakened. In November 2020, the COVID-19 policy stringency increased again, before the second lockdown was announced on December 22, 2020. With the opening of the indoor areas of restaurants, the second lockdown ended on May 31, 2021. Afterwards, the COVID-19 policies were substantially relaxed (for a more detailed history of Swiss COVID-19 policies [22]). The highest stringency of COVID-19 policies was observed during the two lockdowns. During the first lockdown, the average Stringency Index value was 57, whereas during the second lockdown, the average value was 58.

Monthly consumer food demand quantities at the product level stem from the combined retail and consumer panel of the market research company Nielsen [11]. The retail panel entails all products scanned at the checkout of Swiss retailers. The consumer panel covers the purchased quantities and expenses of 4000 Swiss households from German and French speaking cantons, whereby purchasing data of each household member were aggregated. The consumer panel entails purchases from various sales channels, such as traditional retailers, direct sales at farms, butcheries, and bakeries. Within the (global) combined retail and consumer panel, sales channels not included in the retailer panel were estimated through the consumer panel. A linkage with household income data is not possible. Therefore, the combined retail and consumer panel provides monthly data at the product level. Data are only available at the national level and not at the regional level (i.e., Kanton). The following four basic food product categories are covered by the combined retail and consumer panel: meat, milk products, vegetables, and fruits. Detailed information on the covered product groups and the number of products per product group are presented in Table A1 in the Appendix.

The consumer demand quantities used for our empirical analyses refer to the years 2020 and 2021. The descriptive statistics of the variables used are presented in Table 1.

Fig. 2 shows the monthly development of the consumer food demand

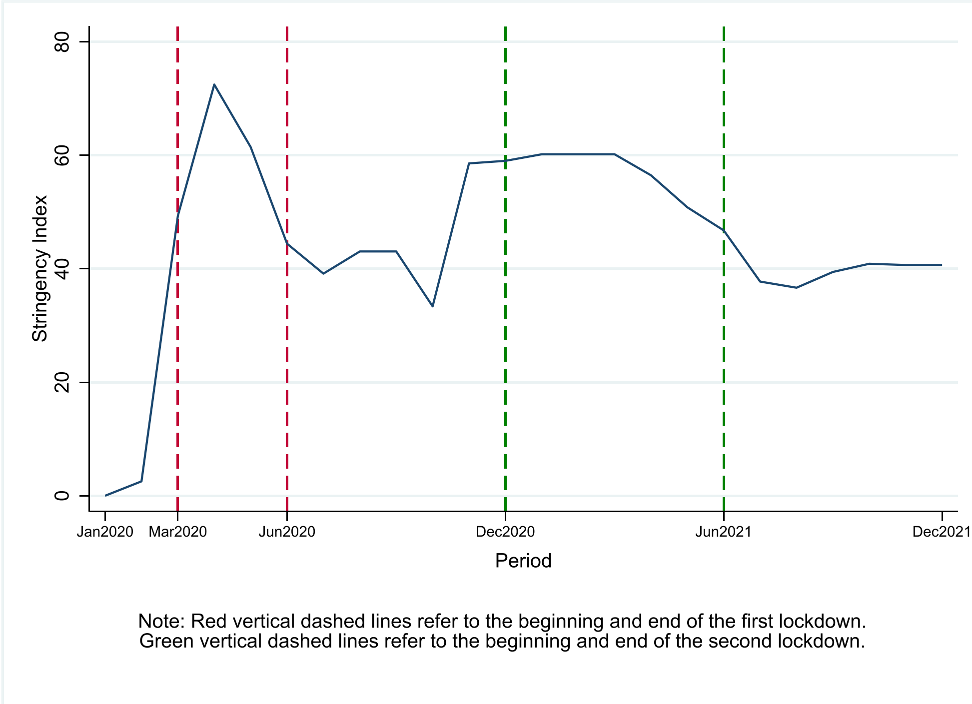

Fig. 1. Development of the Stringency Index value and timing of the two lockdowns in Switzerland (Hale et al., 2021; Swiss Tourism Federation, 2022).

Table 1
Descriptive statistics of variables used for the years 2020 and 2021.

Stringency of Swiss COVID-19 Policies					
Variable	Mean	Std. Dev.	Min.	Max.	*N*
Stringency Index (continuous)	44.9	16.8	0.0	72.5	24
Consumer Data					
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	***N***
Demand quantity: All product categories (in tonnes)	643.9	1,514.3	0.0	23,803.8	4.389
Demand quantity: Meat (in tonnes)	254.9	391.3	0.2	2,365.5	1,439
Demand quantity: Milk products (in tonnes)	1270.6	2,887.9	8.8	23,803.8	816
Demand quantity: Vegetables (in tonnes)	602.0	856.1	0.0	6,930.1	1.152
Demand quantity: Fruits (in tonnes)	770.2	1,286.4	0.0	9,572.2	982

Note: The number of observations for the variable Stringency Index ($N = 24$) reflects 24 months (i.e., 2020–2021). The total number of observations for the consumer data reflect the demand quantity results by multiplying the total number of products in a product category (Table A1 in the Appendix) by 24 months. For instance, in the milk products category, the total number of observation ($N = 1152$) results from multiplying 48 products by 24 months.

quantities for (a) all product categories (i.e., the aggregate of consumer demand for meat, milk product, vegetables, and fruits), and (b) individual product categories (i.e., meat, milk products, vegetables, and fruits), each in 1000 tonnes for the years 2020 and 2021. The red vertical dashed lines refer to the beginning and end of the first lockdown, and the green vertical dashed lines refer to the beginning and end of the second lockdown.

2.2. Methods

2.2.1. Exogeneity of COVID-19 policies

Our aim was to estimate the unbiased effect of Swiss COVID-19 policy stringency on consumer food demand quantities. The COVID-19 pandemic can be considered a natural experiment because it occurred naturally (i.e., a force of nature) and was imposed exogenously on societies [23–25]. This implies that societies had no influence on the occurrence of the pandemic. The corresponding policies aiming at containing the spread of the coronavirus were considered a response to this natural event. In this context, COVID-19 policies represent the intervention and were likewise given exogenously to individuals/consumers. Consequently, we argue that owing to exogeneity of COVID-19 policies, we are able to estimate the unbiased effect of COVID-19 policy stringency on consumer food demand [26]. Against this background, we assumed that observed changes in consumer food demand quantities were caused by COVID-19 policy stringency (i.e., exogeneity and unconfoundedness).

In this context, we must emphasize that we did not perform a pre–post analysis by estimating the differences in demand quantities before and after the outbreak of COVID-19. In such a setting, food demand affected by COVID-19 policies would represent the treatment unit (i.e., food demand in 2020 and 2021), whereas food demand not affected by COVID-19 policies would represent the control unit (i.e., food demand in 2019). However, data on policy stringency was not available for the years before the outbreak of COVID-19. Moreover, as indicated in Fig. 1, the value of the Stringency Index was zero in January 2020. This implies that only the food demand in January 2020 was not affected by COVID-19 policies, whereas food demand from February 2020 to December 2021 was affected by different levels of policy

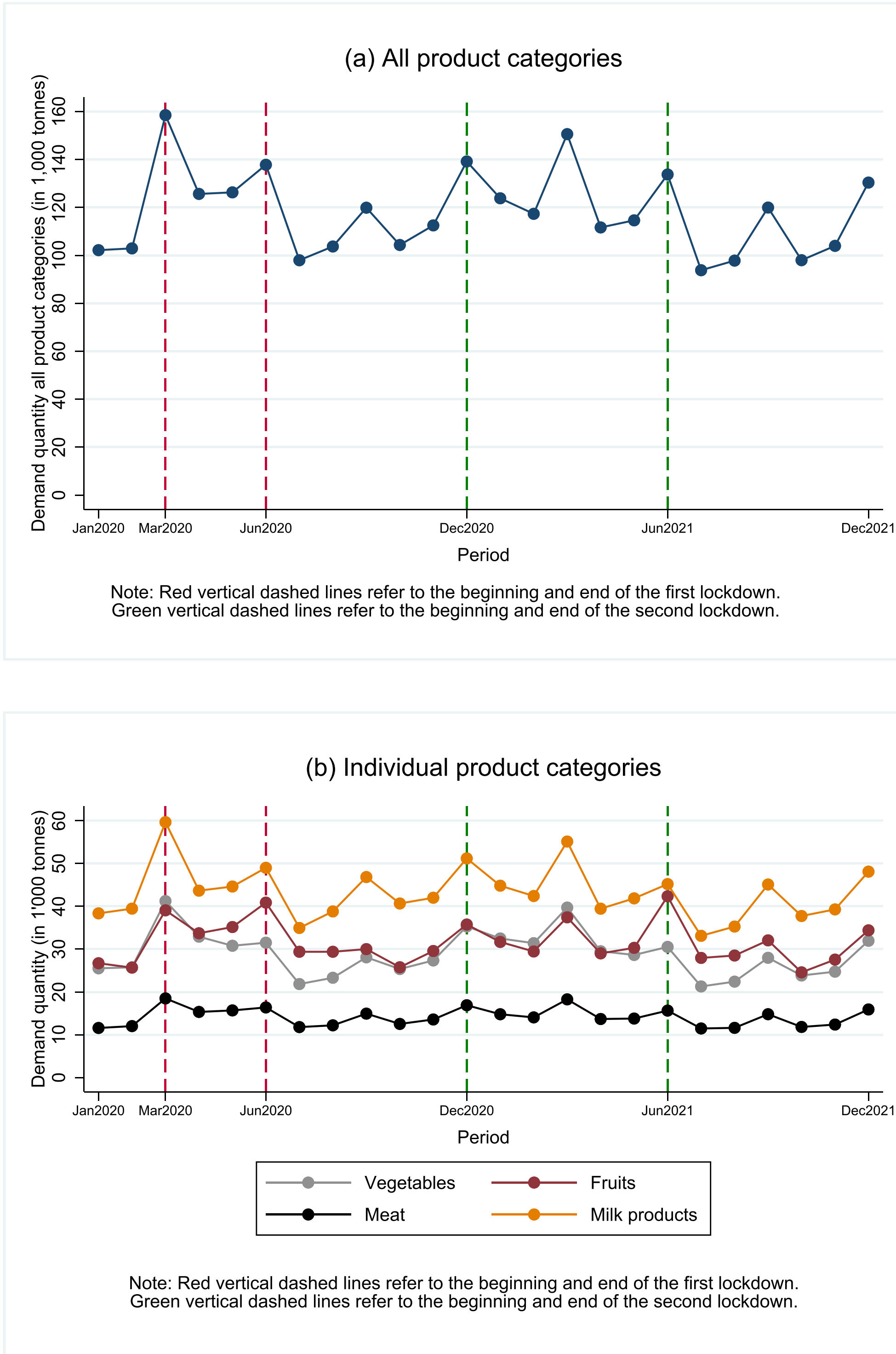

Fig. 2. Development of consumer food demand quantities (in tonnes) for (a) all product categories as an aggregate and (b) individual product categories for the years 2020 and 2021.

stringency. Therefore, our setting allowed us to identify the effects of different levels of policy stringency on consumer food demand. In other words, we compared food demand in periods with strict COVID-19 policies to food demand in periods with less strict COVID-19 policies.

As individuals were affected by COVID-19 policy stringency, agri-food supply chains were disrupted, causing global agri-food trade to decrease by 5–10% in 2020 [27,28]. With regard to potential confounding factors, one could argue that disrupted food supply chains could have negatively affected the food supply and therefore food availability. Even though supermarket shelves for non-perishable goods such as toilet paper, pasta and flour were temporarily empty during the first lockdown, the Swiss food supply was resilient toward the shock. Consequently, the Swiss food supply was at no time in danger [29]. Against this background, one could argue that lockdowns which were earlier imposed in neighboring countries, could cause anticipation effects in domestic food demand. As we use monthly and not daily or weekly data on consumer food demand quantities, we are confident that potential anticipation effects vanish. In Switzerland, changes in consumer prices for food and non-alcoholic beverages potentially affecting food demand were not substantially during 2020 and 2021. Compared to the previous month, changes in Swiss consumer prices ranged between -1% and +1% [30]. Beside consumer prices, consumer food demand quantities might be additionally influenced by certain product characteristics, such as organically produced or fair-foods. We can capture such product characteristics by including product fixed effects in the econometric model or by including a dummy variable indicating organic and conventional products. Moreover, unemployment and loss of income could have an impact on food demand. According to figures of the (Swiss) State Secretariat for Economic Affairs [31], the unemployment rate during the pandemic reached its peak with 3.2% in June 2020. Afterwards, the unemployment rate constantly decreased reaching the lowest level during the pandemic with 2.5% in December 2021. However, an unemployment rate of 3.2% can still be considered as full employment, and except for 2018 and 2019, the unemployment rates from 2010 to 2017 were on average on similar levels as in June 2020. The monetary compensation for people who temporarily lost their jobs owing to the pandemic was increased and twice extended to ensure economic security [32]. Therefore, job and income loss shouldn't have an impact on food demand.

2.2.2. Estimating the effect of COVID-19 policy stringency on consumer food demand

2.2.2.1. Baseline estimation: Dummy variable fixed effects regression. To estimate the effect of Swiss COVID-19 policy stringency on consumer demand quantities, we first applied a dummy variable fixed effects regression model [33], which takes the following functional form:

$$Y_{pmt} = \beta_0 + \beta_1 Stringency\ Index_{mt} + \theta_p + \lambda_t + \varepsilon_{pmt} \tag{2}$$

where Y_{pmt} represents the dependent variable consumer demand quantity (in tonnes) of food product p at month m and year t. β_0 depicts the intercept, and β_1 is the average treatment effect (ATE) of the continuous treatment variable represented by the Stringency Index at month m and year t. Additionally, we included product fixed effects θ_p to account for unobserved time invariant product characteristics (e.g., food standards and labels such as the fair-trade standard) and year fixed effects λ_t to control for unobserved time-related factors influencing demand quantity of the considered food products. Therefore, β_1 captures changes in food demand for the same product over time caused by variations in COVID-19 policy stringency. ε_{pmt} denotes the error term for unobserved characteristics of food product p at month m and year t. Owing to exogeneity of COVID-19 policies, we assumed that β_1 and ε_{pmt} are not correlated, enabling us to estimate the unbiased effect. Equation (1) was estimated by means of ordinary least squares (OLS) regression with robust standard errors for all product categories, meat, milk products, vegetables, and fruits.

As a sensitivity analysis, we estimated the following equation:

$$Y_{pmt} = \beta_0 + \beta_1 Stringency\ Index_{mt} + \beta_2 Organic_p + \gamma_g + \lambda_t + \varepsilon_{pmt} \tag{3}$$

where $Organic_p$ represents a binary variable indicating whether a food product p was organic (value = 1) or conventional (value = 0). While all other variables are defined as in Equation (2), in Equation (3), we replaced product fixed effects θ_p with product group fixed effects γ_g because the organic dummy would be collinear with the product fixed effects. Results based on Equation (3) can found in Table A2 in the Appendix.

2.2.2.2. Dose–response function. To identify the link between COVID-19 policy stringency and consumer food demand quantity, we estimated a dose–response function with continuous treatment for the years 2020 and 2021. In our case, the Stringency Index (i.e., the continuous treatment ranging from 0 to 100) represented the dose, and the outcome (i.e., consumer food demand quantity) was the response. A dose–response function can be applied in various settings where a policy intervention affects an outcome. For instance, Sitko et al. [34] analyzed the relationship between food aid and the adoption of climate-adaptive agricultural practices in the context of smallholder households in Ethiopia and Malawi. Mack et al. [35] provided evidence on the effects of EU Rural Development funds for micro-enterprises and tourism activities on the number of newly established enterprises in the treated rural communities of Romania.

As previously stated in Subsection 2.2.1, we assumed exogeneity of the treatment and unconfoundedness. Therefore, we applied a dose–response function with continuous treatment under unconfoundedness according to Cerulli [9]. The regression equation of response Y can be written as follows:

$$Y_{pmt} = \mu + w_{pmt} \times ATE + x_{pmt}\delta_0 + w_{pmt} \times \left(x_{pmt} - \overline{x}\right)\delta_1 + w_{pmt} \times \{h(s_{mt}) - \overline{h}\} \tag{4}$$

where Y_{pmt} represents the dependent variable consumer demand quantity (in tonnes) of food product p at month m and year t. μ depicts a scalar. The binary treatment variable w_{pmt} indicates whether a food product p at month m and year t is affected by COVID-19 policies (value = 1) or not (value = 0). Additionally, δ_0 denotes the coefficient for a vector of M product- and/or time-related control variables x_{pmt}, whereby $x_{pmt} = (x_{1pmt}, x_{2pmt}, \ldots x_{Mpmt})$. In our specification of the dose–response function, we included product and year fixed effects as control variables (see Subsection 2.2.2.1). As a sensitivity analysis, we included the organic dummy and replaced product fixed effects with product group fixed effects (results can be found in Figure A1 in the Appendix). $\overline{x}$ depicts the average value of a control variable x_{pmt}. Accordingly, δ_1 represents the coefficient capturing the within effect $(x_{pmt} - \overline{x})$ times the binary treatment variable w_{pt}. Finally, $h(s_{mt})$ denotes a general derivable function of the continuous treatment variable s_{mt} (i.e., the Stringency Index), and $\overline{h}$ is the average value of this function.

The basic coefficients μ, ATE, δ_0, and δ_1 (whereby $\delta = (\delta_1 - \delta_0)$) were estimated by means of an OLS regression using a second-degree polynomial function. The ATE can be directly estimated from this regression, whereas the average treatment effect on treated ($ATET$) and the average treatment effect on untreated ($ATENT$) units can be estimated by plugging basic coefficients into the following equations:

$$ATET = \mu + \overline{x}_{s>0}\delta + \overline{h}_{s>0} \tag{5}$$

$$ATENT = \mu + \overline{x}_{s=0}\delta \tag{6}$$

The dose–response is then given by averaging $ATE(x, s)$ over x so that the dose–response function is a function of treatment intensity s:

$$ATE(s) = \begin{cases} ATET + \{h(s) - \overline{h}_{s>0}\} & if \quad s > 0 \\ ATENT \quad if \quad s = 0 \end{cases} \tag{7}$$

The dose–response function was separately estimated for all product categories, meat, milk products, vegetables, and fruits.

2.2.3. Identifying the heterogeneous effects of the two COVID-19 lockdowns

To disentangle the effects of the two COVID-19 lockdowns on consumer food demand quantities, we estimated:

$$Y_{pmt} = \beta_0 + \beta_1 First\ lockdown_{mt} + \beta_2 Second\ lockdown_{mt} + \theta_p + \lambda_t + \varepsilon_{pmt} \tag{8}$$

where the dependent variable, the product and time fixed effects, and the error term are as previously defined. Additionally, we included two dummy variables to estimate the effect of the two lockdowns. Accordingly, β_1 represents the coefficient for the dummy variable *First lockdown*, which takes the value of 1 for the period of the first lockdown (i.e., March to June 2020) and 0 otherwise. Likewise, β_2 depicts the coefficient for the dummy variable *Second lockdown*, which takes the value of 1 for the period of the second lockdown (i.e., December 2020 to May 2021) and 0 otherwise. We did not include the Stringency Index as a control variable in Equation (8) because COVID-19 policy stringency was the highest during the two lockdowns. Therefore, policy stringency was captured by the two lockdown dummy variables. Equation (8) was estimated using OLS regression with robust standard errors. To examine whether the coefficients β_1 and β_2 were equal, we performed the Wald test. The null hypothesis of the Wald test is that the difference between the two coefficients is equal to zero.

3. Results

3.1. The effect of COVID-19 policy stringency on consumer food demand quantities

The results of the dummy variable fixed effects OLS regression based on Equation (2) are presented in Table 2. Additional model fit statistics can be found in Table A3 in the Appendix. Results are provided for all product categories, meat, milk products, vegetables, and fruits.

For all product categories and individual product categories, we identified the expected positive sign of our variable of interest. For instance, a unit increase in COVID-19 policy stringency caused the demand for each product to increase by an average of 3.0 tonnes. This implies that the more stringent Swiss COVID-19 policies were, the higher the consumer food demand was. The strongest effect of policy stringency on consumer demand was observed for the milk products category, where a one-unit increase in the Stringency Index led to an average 4.7-tonne increase in the demand for each milk product. In contrast, the smallest effect was observed for the meat product group, where a one-unit increase in the Stringency Index caused the demand for each meat product to increase by an average of 1.2 tonnes. For all and individual product categories, including the organic dummy in the regression equation and replacing product fixed effects with product group fixed effects did not substantially change coefficient magnitudes or statistical significance levels (Table A2 in the Appendix).

In contrast to the dummy variable fixed effects OLS estimates, the application of the dose–response function provided a more nuanced evaluation of the effect of COVID-19 policy stringency on consumer food demand quantities. The results of the dose–response function for all product categories, meat, milk products, vegetables, and fruits are presented in Fig. 3. Statistically significant dose–response relationships and their 10% significance levels are marked by a box with dotted lines. For simplification, we present the results for the dose–response function by comparing consumer food demand during periods without lockdown when COVID-19 policies were in force (average Stringency Index value = 38.0) with consumer food demand during periods of lockdown (average Stringency Index value = 56.0). Values on the y-axis refer to the difference in consumer food demand between the periods with the treatment (i.e., Stringency Index value > 0) and without the treatment (i.e., Stringency Index value = 0). Thus, positive values on the y-axis represent an increase and negative values a decrease in consumer food demand compared to periods without the treatment. Accordingly, the period in absence if COVID-19 policies (i.e., January 2020) is the reference point for consumer food demand. The application of the dose-response covers the years 2020 and 2021.

For all product categories, starting from a Stringency Index value of 30, we observed a constantly increasing statistically significant positive relationship between policy stringency and food demand quantity. The maximum consumer food demand was reached at a Stringency Index value of 72.5, corresponding to April 2020, when the first lockdown was in force. The demand for each product within all product categories was on average 62 tonnes higher during periods of lockdown (average Stringency Index value = 56.0) compared to periods without lockdown (average Stringency Index value = 38.0). In other words, the demand for all food products increased on average by a factor of 2.5 due to the imposition of the lockdowns. The meat product category exhibited a statistically significant increase in consumer demand for a Stringency Index value range between 29 and 72.5. The dose–response function for milk products showed a similar shape as the one for meat. While meat product demand was on average 1.7 times higher during the two lockdown periods, the demand for milk products was on average 1.6 times higher. The consumer demand for vegetables sharply increased with Stringency Index values greater than 40. Of the four product categories, the demand for vegetables exhibited the largest increase. During the two lockdowns, the demand for vegetables was on average 5.0 times higher compared to periods without lockdown. For the product category fruits, we observed statistically non-significant estimates of the dose–response function until a Stringency Index value of 40. Nevertheless, the difference in fruit demand between a Stringency Index value of 40 and 56 was on average 49 tonnes for each fruit product.

The dose–response function specification with the organic dummy and product group fixed effects showed similar patterns. However, the estimates from the sensitivity analysis were slightly more imprecise than the estimates of our main specification. In particular, except for fruits, the confidence intervals of the estimates from the sensitivity analysis were broader than those for our main specification. Nevertheless, consumer food demand increased with more stringent policies. Consequently, the results of the dummy variable fixed effects OLS regression and the dose–response function clearly indicate that H1 cannot be rejected.

3.2. The heterogeneous effects of the two COVID-19 lockdowns on consumer food demand quantities

Results from the dose–response function revealed that the consumer food demand increased with more stringent COVID-19 policies over the years 2020 and 2021 (Fig. 3). Especially during the two Swiss lockdowns, COVID-19 policies were very stringent (Fig. 1). Therefore, we aimed to disentangle the effects of the two lockdowns on consumer food demand quantities.

Table 3 shows the results of the dummy variable fixed effects OLS regression based on Equation (8) for all product categories, meat, milk products, vegetables, and fruits. Additional model fit statistics can be found in Table A4 in the Appendix. The last row of Table 3 indicates whether the null hypothesis (H_0) of the Wald test of equality of the two lockdown effects can be rejected or not.

During the first lockdown, the consumer food demand for all product categories was on average 158 tonnes per food product higher, whereas during the second lockdown, the demand for all products was on average 95 tonnes per food product higher. The Wald test indicated that the difference between the two coefficients was statistically significantly different from zero ($p = 0.022$). This implies that the first lockdown caused a stronger increase in consumer food demand quantities for all

Table 2
Results of the dummy variable fixed effects OLS regression based on Equation (1).

Independent variable	Consumer Food Demand Quantity (Tonnes)				
	All Product Categories	Meat	Milk Products	Vegetables	Fruits
Stringency Index	2.958*** (0.318)	1.234*** (0.195)	4.685*** (0.763)	3.492*** (0.376)	3.434*** (1.166)
Product fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
N	4389	1439	816	1152	982
R^2	0.923	0.895	0.973	0.928	0.691

***, ** and * denote significance at 1%, 5% and 10% respectively. Robust standard errors in parentheses.

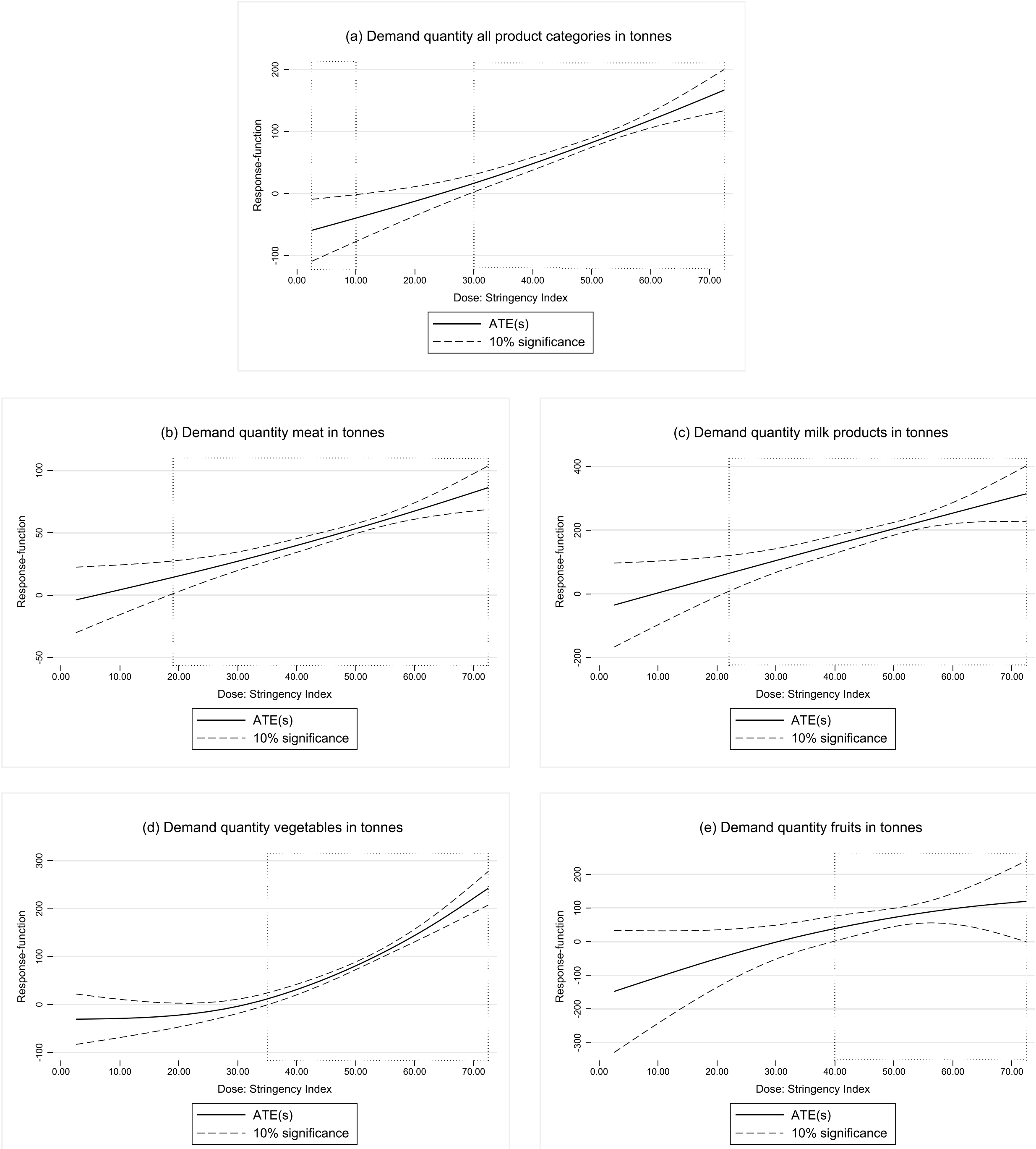

Fig. 3. Results of the dose–response function for (a) all product categories, (b) meat, (c) milk products, (d) vegetables, and (e) fruits.

Table 3
Results of the dummy variable fixed effects OLS regression based on Equation (7) for all product categories, meat, milk products, vegetables, and fruits.

	Consumer Food Demand Quantity (Tonnes)				
Independent variable	All Product Categories	Meat	Milk Products	Vegetables	Fruits
First lockdown	158.113*** (21.099)	59.312*** (10.981)	247.898*** (64.376)	175.695*** (24.702)	208.730*** (70.716)
Second lockdown	94.504*** (17.606)	36.068*** (9.000)	169.787*** (42.911)	148.193*** (17.443)	54.317 (65.961)
Product fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
N	4,389	816	1,439	1,152	982
R^2	0.924	0.896	0.973	0.932	0.694
Wald test H_0 rejected	Yes	Yes	No	No	No

***, ** and * denote significance at 1%, 5% and 10% respectively. Robust standard errors in parentheses.

products than the second lockdown. For the milk products ($p = 0.310$), fruits ($p = 0.120$), and vegetables ($p = 0.348$) categories, we observed no statistically significant differences in the increase in demand quantities between the first and second lockdowns. During the first lockdown, the demand for meat was on average 59 tonnes higher per product, whereas during the second lockdown, the demand was on average 36 tonnes higher per product. The Wald test indicated that the difference between the two coefficients was statistically significantly different from zero ($p = 0.097$).

While we found no statistically significant differences in consumer demand for milk products, fruits, or vegetables, the consumer demand was statistically significantly higher for all product categories and meat during the first lockdown. Except for fruits, we observed a peak in demand in March 2020 when the first lockdown began (Fig. 2). For three out of five models, we found no statistically significant differences in consumer food demand between the two lockdowns. Consequently, we reject H2.

4. Discussion

4.1. Methodological approach

The COVID-19 pandemic was considered a natural experiment. In this context, a variety of studies considered the COVID-19 pandemic as an exogenous shock affecting societies in multiple ways. Gelo and Dikgang [25] estimated the causal effect of exogenous job loss caused by a national lockdown on food insecurity outcomes (i.e., child hunger and loss of money to buy food). Gao et al. [24] likewise consider the COVID-19 pandemic as an exogenous public health shock, to estimate the learning effects of intensive health information campaigns on nutrient intake during the pandemic. In the same vein as previous studies, Posel et al. [23] claim that the COVID-19 pandemic offers a unique natural experiment. The authors argue that the source of unemployment is very likely to be exogenous to individuals, allowing for identifying a causal link between job loss and mental health issues.

Consequently, we argue that owing to exogeneity of COVID-19 policies, we are able to estimate the unbiased effect of COVID-19 policy stringency on consumer food demand [26]. In this context, Zang and Li [36] use the same research design, by estimating the causal effect of exogenously given mobility intervention policies on park visits during COVID-19 in a quasi-experimental setting. Schnake-Mahl et al. [37] likewise consider COVID-19 policies as given exogenously to individuals. In their quasi-experimental research design, the authors estimate the causal impact of policies keeping indoor dining closed on COVID-19 rates among large US cities.

We compared food demand in periods with strict COVID-19 policies to food demand in periods with less strict COVID-19 policies. Plenty of research has already demonstrated that routines were radically disrupted, with society facing tremendous changes in a very short period of time [38]. In addition to changing food consumption patterns, very strict policies such as a complete lockdown of the economy caused substantial changes in individuals' work situations [39,40], mobility and travel behaviors [41,42], physical activity [43,44], and mental health [45,46]. While some of these changes were temporary, others might have long-lasting effects on private life and the working world.

However, our study has its limitations. First, our empirical analyses cover unprocessed or less-processed food products. The food demand for processed food products such as pizza, burgers or ice cream might have differently reacted to changes in policy stringency. Second, food demand quantities were not available on individual or household level. Therefore, we were not able to control for changes in income or changes in food preferences.

4.2. Empirical findings

Our results confirm that both Swiss lockdowns likely caused people to spend more time on cooking and baking at home instead of eating out [47–49]. Findings from Denmark revealed that people with stronger negative emotional reactions to the first lockdown were more likely to increase cooking activities [50]. In general, food choice and eating behavior influence emotions and vice versa [51,52]. In this context, plenty of studies revealed that stringent COVID-19 policies led to an increase in depression, anxiety, and stress among children, adolescents, and adults [53–55]. Accordingly, eating behavior changed as a reaction to stringent COVID-19 policies such as lockdowns. However, the reported changes in eating behavior were heterogeneous. While some studies reported favorable changes in eating behavior with an increase in fresh produce and reductions in comfort food and alcohol consumption, other studies found a reduction in fresh produce and increases in comfort foods, including sweets, fried foods, snack foods, and processed foods [56]. With a few exceptions, our analyses are based on unprocessed or less-processed food products, which represent the basis for home cooking activities. This might be the reason why we observed an increase in demand for all individual product categories with more stringent policies. However, a more disaggregated evaluation at the product level might have revealed contrasting results. For instance, it could be possible that for some products such as red meat, demand decreased, while for chicken meat, demand increased.

During the first lockdown in 2020, the borders were closed, preventing Swiss consumers from purchase food in neighboring countries (i.e., Germany, France, Italy, and Austria), which led to higher food purchases in Switzerland. As an additional driver of increased food demand, the phenomenon of food panic buying, hoarding, and excessive stockpiling was observed during the first lockdown [16,57,58]. Accordingly, Swiss food retailers reported record sales for 2020 [59].

Consequently, the interaction of various factors as reactions to or causes of stringent COVID-19 policies influenced the food demand of Swiss inhabitants in 2020 and 2021. In particular, emotional eating to elevate mood in exceptional situations increased home cooking activities owing to the closures of restaurants and borders. Additionally, food panic buying might be considered an important influencing factor of increased consumer food demand in Switzerland.

5. Conclusions

We estimated the unbiased effect of COVID-19 policy stringency on consumer food demand quantities for the basic food categories of meat, milk products, vegetables, and fruits. For this purpose, we separately used dummy variable fixed effects OLS regressions and dose–response functions. In contrast to the bulk of scientific studies focusing on the impact of the pandemic on consumer behavior, our empirical analyses were based on longitudinal consumer data at the product level for the years 2020 and 2021. The longitudinal dimension of our analyses allowed us to additionally identify the heterogeneous effects of the two COVID-19 lockdowns.

Our baseline OLS estimates revealed that policy stringency increased the total consumer demand (i.e., all food categories considered as an aggregate) and the demand for individual product categories (i.e., meat, milk products, vegetables, and fruits). For instance, a one-unit increase in the Stringency Index led to an average 3.0-tonne increase per product in total consumer food demand.

The application of the dose–response function provided more nuanced findings than baseline OLS estimates. Consumer demand constantly increased whenever the stringency level was 30 or higher. In particular, results of the dose–response function indicated that total consumer demand increased on average 2.5 times per product due the imposition of the two lockdowns. While the lowest increase in consumer demand was observed for meat (average demand increase of 1.6 times), the highest increase in consumer demand was observed for vegetables (average demand increase of 5.0 times).

To disentangle the effects of the two lockdowns on consumer food demand, we additionally applied a regression analysis capturing the periods of the two lockdowns using two dummy variables. The increase in total food and meat demand during the first lockdown was significantly higher than the increase in total food demand during the second lockdown. For the milk products, vegetables, and fruits categories, we identified no differences in consumer demand between the first and second lockdowns.

The sudden spread of COVID-19 at the beginning of 2020 prompted policymakers to impose the first lockdown with the aim of protecting the population. This unusual situation caused people to panic buy, hoard, and excessively stockpile food, resulting in partially empty supermarket shelves. In Switzerland, the peak in food demand was reached in March 2020, the first month of the first lockdown. The dynamics of panic buying ended rather abruptly, and consumer food demand for Swiss groceries dropped substantially with the reopening of restaurants and borders to neighboring countries.

6. Policy implications and future directions

Policymakers need to be aware that drastic measures such as a lockdown highly likely lead to substantial changes in food demand and eating habits. In our case, we were able to show that stringent COVID-19 policies specifically, a lockdown entailing the closing of restaurants inevitably led to the phenomenon that eating out was replaced by cooking at home, explaining the increase in demand of unprocessed or less-processed food products. An intensification of cooking and baking at home can be considered a positive reaction [60,61]. By contrast, an intensification of snacking on, for example, cookies, chips and chocolate, when it was recommended to work from home, has to be considered as a negative side effect of stringent policies [62]. Accordingly, information campaigns in normal times highlighting the positive effects of home cooking and baking as well as highlighting the positive impacts of healthy foods for mind and body should be intensified during extraordinary times such as a lockdown.

Advances in the availability of long-term consumer data should be exploited to enhance our understanding of consumer response to unforeseen national or global shocks. Therefore, future research could ex-post investigate the link between COVID-19 policy stringency and consumer food demand for several countries (e.g., other countries from the European continent). Given that country-specific policy responses to the pandemic, including the timing and duration of lockdowns, were different, it would be interesting to see, whether similar patterns can be observed as for the case study of Switzerland. While data on COVID-19 policy stringency from the OxCGRT are freely available, consumer data are usually owned by private agencies, such as the market research company Nielsen, and have to be purchased. Accordingly, cross-country research would require collaboration with research institutions from foreign countries and the acquisition of additional project funding.

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CRediT authorship contribution statement

Christian Ritzel: Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Gabriele Mack:** Writing – original draft, Validation, Supervision, Methodology, Funding acquisition, Conceptualization. **Dela-Dem Doe Fiankor:** Writing – original draft, Validation, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Data availability

Data will be made available on request.

Appendix

Table A1
Database of consumer food demand quantities: product category, product group, and number of organic and conventional food products in 2020 and 2021.

Product Category	Product Group	Number of Organic Food Products in 2020	Number of Conventional Food Products in 2020	Number of Organic Food Products in 2021	Number of Conventional Food Products in 2021
Meat	Veal	3	3	3	3
	Lamb	1	1	1	1
	Beef	8	8	8	8
	Pork	5	5	5	5
	Chicken	4	4	4	4
	Charcuterie	9	9	9	9
Milk products	Butter	2	2	2	2
	Cheese	6	6	6	6
	Yogurt	4	4	4	4
Vegetables	Fruit vegetables	5	5	5	5
	Lettuces	4	4	4	4
	Cabbage vegetables	4	4	4	4
	Root and tuber vegetables	6	6	6	6
	Onion and leek vegetables	4	4	4	4
	Mushrooms	1	1	1	1
Fruits	Apples	1	1	1	1
	Pears	1	1	1	1
	Berries	3	3	3	3
	Stone fruits	5	5	5	5
	Grapes	1	1	1	1
	Citrus fruits	4	4	4	4
	Exotic fruits	6	6	6	6

Table A2
Sensitivity analysis: Results of the dummy variable fixed effects OLS regression based on Equation (2).

	Consumer Food Demand Quantity (Tonnes)				
Independent variable	All Product Categories	Meat	Milk Products	Vegetables	Fruits
Stringency Index	2.959*** (0.854)	1.233*** (0.444)	4.685 (3.974)	3.492*** (1.217)	3.482* (1.993)
Organic	-923.783*** (32.494)	-433.053*** (15.238)	-1772.580*** (136.943)	-816.742*** (40.824)	-1060.226*** (66.313)
Product group fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
N	4389	1439	816	1152	982
R^2	0.496	0.457	0.545	0.350	0.343
F value (*p*-value)	90 (0.000)	122 (0.000)	47 (0.000)	145 (0.000)	45 (0.000)
Root-mean-square error	1078	289	1956	693	1048
Akaike information criterion	73,795	20,402	14,692	18,348	16,455
Bayesian information criterion	73,968	20,450	14,730	18,394	16,504

***, ** and * denote significance at 1%, 5% and 10% respectively. Robust standard errors in parentheses.

Table A3
Additional model fit statistics for the dummy variable fixed effects OLS regression based on Equation (2).

Model fit statistics	All Product Categories	Meat	Milk Products	Vegetables	Fruits
F value (*p*-value)	231 (0.000)	209 (0.000)	368 (0.000)	168 (0.000)	129 (0.000)
Root-mean-square error	429	130	489	235	731
Akaike information criterion	65,847	18,142	12,457	15,900	15,781
Bayesian information criterion	67,028	18,463	12,627	16,153	15,996

Table A4
Additional model fit statistics for the dummy variable fixed effects OLS regression based on Equation (7).

Model fit statistics	All Product Categories	Meat	Milk Products	Vegetables	Fruits
F value (*p*-value)	236 (0.000)	211 (0.000)	357 (0.000)	170 (0.000)	132 (0.000)
Root-mean-square error	427	129	485	229	730
Akaike information criterion	65,812	18,131	12,443	15,835	15,780
Bayesian information criterion	67,000	18,458	12,617	16,092	16,000

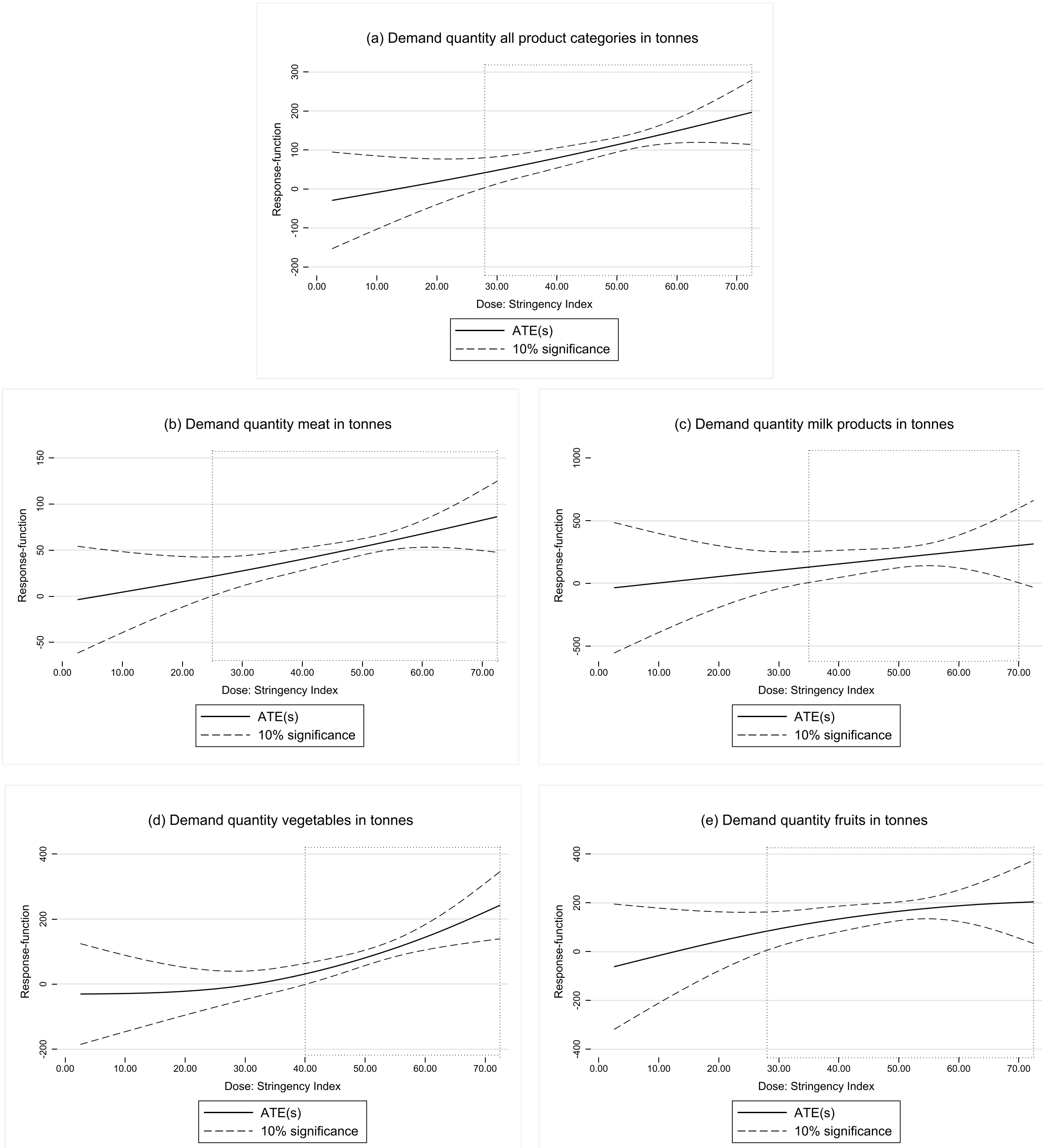

Fig. A1. Sensitivity analysis: Results of the dose–response function for the different model variants for (a) all product categories, (b) meat, (c) milk products, (d) vegetables, and (e) fruits.

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