Received: 19 September 2022 | Revised: 8 March 2023 | Accepted: 9 March 2023

DOI: 10.1002/agr.21807

RESEARCH ARTICLE

Agribusiness An International Journal WILEY

Pandemic pricing: Evidence from German grocery e-commerce

Svetlana Fedoseeva[1] | Ellen Van Droogenbroeck[2]

[1]Institute for Food and Resource Economics, University of Bonn, Bonn, Germany

[2]Department of Applied Economics, Vrije Universiteit Brussel (Free University of Brussels), Brussels, Belgium

Correspondence
Svetlana Fedoseeva, Institute for Food and Resource Economics, University of Bonn, Nussallee 21, 53115 Bonn, Germany.
Email: svetlana.fedoseeva@ilr.uni-bonn.de

Funding information
Deutsche Forschungsgemeinschaft

Abstract

The sudden demand spike for online grocery purchases during the Covid-19 pandemic and supply bottlenecks caused by disrupted global value chains put immense pressure on prices. We analyze the prices of the largest German online grocers to test how these challenges affected prices during the first wave of the pandemic. Using a large dataset of online price quotes, we shed light on the magnitude of price changes across retailer types, product categories, and stages of the pandemic. We show that online prices went up as the intensity of Covid-19 containment measures increased. The magnitude of price increases was heterogeneous across retailers and product categories: pure online retailers showed a lower price response compared to hybrid stores, while the prices of essential food items such as baby foods and pantry products increased more than those of other product categories or beverages. [EconLit Citations: E31, Q31].

KEYWORDS
Covid-19, e-commerce, food prices, Germany, retailing

Abbreviations: BACON, blocked adaptive computationally efficient outlier nominators algorithm; EU, European Union; RQ, research question; US, United States.

1 | INTRODUCTION

The Covid-19 pandemic has caused enormous disruptions to society, leading to significant changes in areas such as teleworking (Hosoda, 2021; Ton et al., 2022), education (García-Morales et al., 2021; Zhao & Watterston, 2021), digital payment (Santosa et al., 2021; Van Droogenbroeck & Van Hove, 2022), and food retailing (Jensen et al., 2021; Tyrväinen & Karjaluoto, 2022). Although buying groceries online was already on the rise over the last decade (FMI, 2018), Covid-19 has accelerated this trend as online grocers worldwide have experienced a surge in sales during the pandemic. For the United States, the Adobe Digital Economy Index report reveals that monthly online grocery spending more than doubled, from $3.1 billion prepandemic to $6.7 billion in 2022. Since the outburst of the pandemic in March 2020 and February 2022, US consumers spent $1.7 trillion on e-groceries, which is $609 billion more than in 2018 and 2019 combined (Verdon, 2022). Across Europe, the online grocery channel grew by about 55% on average in 2020, compared with an average growth rate of 10% in 2019 (Herbert et al., 2021). This unprecedented growth is observed worldwide, and 7.2% of groceries are now bought online, up from 6.3% in 2020 and 4.8% in 2019 (Van Rompaey, 2022).

Food is the category that has seen the biggest shift in shopping habits and consumer behavior has led to an unprecedented surge in demand during the pandemic. Several studies have reported significant changes in food practices, including the reduction of food waste and changes in eating routines (Rodgers et al., 2021; Roe et al., 2021). Some studies have found an increased emphasis on health concerns when making food choices and a shift toward healthier diets (Ben Hassen et al., 2021; Rodgers et al., 2021), while others have found evidence of unhealthy food consumption (Poelman et al., 2021). In addition, lockdown measures and the associated closure of restaurants, hotels, and canteens, have led to a decrease in expenditures on food away from home and an increase in food purchases for home consumption (Ellison et al., 2021; Filimonau et al., 2022).

Although stores for essential goods, including supermarkets, remained open and there was no real risk of major supply shortages, consumers worldwide started to exhibit panic buying behavior and stocked up on as much food as they could (Alaimo et al., 2020; Baarsma & Groenewegen, 2021; Chenarides et al., 2021). To avoid public places and reduce personal physical interactions, consumers switched to online channels for purchasing their groceries in many countries (Alaimo et al., 2020; Chenarides et al., 2021; Conway et al., 2020; Ellison et al., 2021; Jensen et al., 2021; Li et al., 2020). Customers who already purchased groceries online before the pandemic reported increased usage of the channel, while others started using e-grocery services for the first time (Conway et al., 2020; Günday et al., 2020; Jensen et al., 2021). In a recent study in Sweden, Fuentes et al. (2022) conducted ethnographic interviews with both groups and concluded that during the pandemic, online grocery changed from a convenient mode of grocery shopping to a necessary coping technique used by consumers.

Several authors suggest that e-grocery shopping will not return to prepandemic levels (Conway et al., 2020; Dwivedi et al., 2020; Gomes & Lopes, 2022; Günday et al., 2020). According to Jensen et al. (2021), 58% of respondents planned to continue shopping for groceries online regardless of pandemic conditions in the United States. A more recent report by McKinsey & Company and EuroCommerce (2022) expects the European e-grocery market to continue growing in the midterm and to take up over 20% of the market by 2030, depending on the country and scenario.

The sudden increase in demand for online grocery purchases has led to overbooked delivery slots, halted membership applications, and short-run stockouts (Hobbs, 2020; Singh et al., 2021). These challenges, combined with disrupted global value chains and supply bottlenecks, have put pressure on prices, leading to food inflation worldwide. Despite this, research on the behavior of food retailers and their use of price as a rationing mechanism during the pandemic is limited.

Existing research on price dynamics during the Covid-19 pandemic focuses on specific product categories (Agyei et al., 2021; Hirvonen et al., 2021; Ruan et al., 2021) or relies on existing databases such as the monthly producer prices index of food (Hamulczuk & Skrzypczyk, 2021), the World Food Programme (Dietrich et al., 2022), or consumer prices indexes (Akter, 2020; Bai et al., 2022). Most studies that use market data obtained by web scraping techniques focus on a single retailer. For example, Jaworski (2021) collected daily price information about individual food and nonalcoholic beverage products for one of Poland's major supermarket chains. Based on these data, the authors were able to provide reliable estimates of monthly and annual food inflation about 30 days before the final official indexes were published. Hillen (2021), in a study for the United States, examined how the globally active online grocer Amazon Fresh reacted to the extraordinary surge in demand. Based on a dataset of daily price quotes for the customer location in Los Angeles, they conclude that the overall price level at Amazon Fresh did not increase during the pandemic, but even slightly decreased for several product groups. However, during the lockdown phase, prices for certain highly demanded product groups increased and fewer prices were communicated as promotional prices. When data is collected from multiple food retailers, existing studies either do not focus particularly on grocery prices (Peña & Prades, 2021) or only cover family-owned retail shops (Goeb et al., 2022).

The goal of this paper is to investigate retail price changes across store types, product categories, and different stages of the Covid-19 pandemic. We use a unique dataset of roughly 99 million price observations for the full grocery assortments of the largest German online retailers to examine how prices were affected by the challenges of the pandemic, in particular, by the stringency of Covid-19 containment measures. With a compound annual growth rate of 23.2%, the German e-grocery market is predicted to experience the highest relative growth among European countries, rising from $1.3 billion in 2018 to a value of $3.8 billion in 2023 (Statista, 2021).

The high frequency of data collection and the coverage of retailers and products in our sample make it one of the most detailed analyses of Covid-19 containment policy effects on the grocery retailing prices at a country level available to date. The scope of our data enables us to contribute to the existing knowledge of pandemic pricing in the grocery sector in several ways. First, by using daily price quotes for the entire grocery assortments of the largest German online retailers, we assess whether and how food prices have been affected during the first wave of the Covid-19 pandemic and explicitly account for the stringency of Covid containment policy. Furthermore, we show that this effect remains when we control for price increases in costs of production and imports. We also test the heterogeneity of the Covid-19 effect on prices depending on different intrinsic (product category-specific, e.g., perishable vs. storable items) and extrinsic (retailer-specific) characteristics of the products.

The remainder of the paper is organized as follows. Section 2 presents the data and methodology. Section 3 reports the main results and summarizes the outcomes of robustness checks. Section 4 discusses our findings and concludes.

2 | DATA AND METHODOLOGY

Our data consists of price quotes collected from the six largest online full-assortment grocery retailers in Germany. Two retailers (Amazon.de and Amazon Fresh) operate online only. Bringmeister, MyTime, Real, and Rewe are hybrid (multichannel) retailers that sell their products both offline and online. Bringmeister was the delivery service of Edeka at the time of data collection. MyTime belongs to the Bünting group. Rewe and Real operate under the same name across their distribution channels. The data covers the period from September 1, 2019, to June 30, 2020, for the geographical location of Berlin (Germany). The data collection took place daily at the same time using a web scraping script. For each product, we observe the product name and description, product category, unique identification number, and price, which are all freely available online and accessible without login. On a few occasions when we could not access prices for some retailers, the data were imputed using the values from the previous day (less than 1.8% of data were imputed). We have not, however, imputed any missing values of prices for products that were out of stock. Prices were collected for the entire food and beverage assortment. When we eliminate the duplicates and items with prices below 0.05 euro per unit, the resulting sample consists of over 99 million observations and includes price quotes for roughly 800,000 products (see Appendix A for a summary).

In the empirical part of our analysis, we trace the prices in online grocery retailing in Germany during the first wave of the Covid-19 pandemic. Using daily price quotes for the entire grocery assortments of the leading supermarkets and online retailers in Germany, we assess whether and how food prices have been affected by the pandemic, distinguishing between retailer types and product categories, and the stringency of Covid-19 containment policy in the country.

To characterize the state of Covid-19 spread in the world and Germany, we first divide our sample into six episodes based on the timeline of Covid-related events (The Associated Press, 2021). The *pre-Covid* stage began in September 2019 and lasted through the end of November. The *international uncertainty* stage was mostly associated with the Covid-19 spread in China. It began on December 1, when the first symptomatic case was registered in the country, and continued until January 26, 2020. On January 27, the first case was registered in Germany, and the country entered the stage of increased *domestic uncertainty*, which continued until March 3. During this period, the assessment of local authorities gradually shifted from the risk of the virus spreading in Germany being low to the possibility of Covid-19 turning into a global pandemic and spreading in Germany as well. The next stage, *spread*, started on March 4, when the first mass event, the Leipzig Book Fair, was canceled. On March 9, the first two Covid-19 deaths were reported in Germany, and by March 10, all German regions had reported Covid-19 cases. On March 13, German states mandated school closures. A few days later, Germany closed its borders to its neighboring countries. On March 22, the nationwide lockdown was agreed upon, and the next stage, *lockdown*, began. In mid-April, the German chancellor announced that "fragile intermediate success" had been achieved in the fight against the pandemic and after May 4, restrictions were gradually relaxed and cases began to decline until the end of our sample period on June 30. This last stage in our data is *opening*. In the following, we refer to the first wave of Covid-19 and those six episodes when we discuss the Covid-19 timeline.[1]

Appendix B plots the mean and median sample price throughout the timeline of the first wave of Covid-19 in Germany. Both the mean and the median price comparison (results of the mean equality test and Wilcoxon rank-sum test are available on request) indicate significant differences across the timeline stages when compared to the pre-Covid period and between consecutive episodes. Prices, particularly the mean sample price, clearly increased around the spread stage. It is important to keep in mind, however, that changes in price aggregates over time might reflect, besides the changes in prices themselves, shifts in product composition offered by retailers, that is, changes in product assortment. The increase in the mean sample price observed in Appendix B does not necessarily tell us much about specific price changes (e.g., the price of product A increased over time) and could instead indicate shifts in offered assortments (i.e., more expensive products being offered instead of cheaper alternatives).

In the empirical part of our study, we focus on price changes at the product level (i.e., within product-retailer price changes). Our first research question (RQ1) is whether price increases can be observed across various stages of the Covid-19 timeline "within" individual product prices sold by retailers in the sample:

$$(\ln)Price_{ijkt} = \alpha + \boldsymbol{\beta' Timeline_t} + \psi_{ik} + u_{ijkt}. \qquad (1)$$

The products observed in the study are not consistently matched across retailers, and each product offered by a retailer is treated as an individual item. The use of product-retailer-specific fixed effects is appropriate in this case due to the discrepancies in prices for identical products across German grocery retailers (Fedoseeva et al., 2017). In Equation (1), the subscripts i, j, k, and t represent a product, product category, retailer, and period, respectively. We control for time-invariant heterogeneity of prices between products and retailers by the full set of fixed effects, ψ_{ik}.

[1]While some studies use a three-period distinction—preparation, lockdown, postlockdown—to measure the price developments in the US market, in the descriptive part we adopt a more disaggregated timeline to account for changes in prices that took place already in, for example, the anticipation of faster pandemic spread and related social distancing measures. Furthermore, in the later stage of our analysis, we depart from the timeline definition and use the stringency index to evaluate the relationship between the intensity of Covid-19 containment measures and prices.

The vector $\boldsymbol{\beta}$ represents the coefficients associated with the Covid-19 timeline. The coefficients obtained from the equation estimated in levels can be interpreted as a change in price that occurred as we moved along the Covid-19 timeline from the pre-Covid period (the reference period) to a later stage of the pandemic. Coefficients from a semi-logarithmic specification can be converted into a percentage change in price due to shift along the timeline using the semi-logarithmic transformation formula $(e^{\beta} - 1) \times 100$.

Our constructed timeline closely follows the development of the stringency index (dotted line in Appendix B), which is a measure of the strictness of a government's response to the Covid-19 pandemic (Hale et al., 2021). The stringency index is based on a combination of factors, such as school and workplace closures or travel restrictions, and it shows the extent to which social and economic activity has been restricted to contain the pandemic. It is highly correlated with key indicators of Covid-19 intensity, including new (0.67) and total infections (0.86), or intensive care unit admissions (0.81).

In the second part of the analysis, we investigate the impact of containment measures on prices. While some studies have found that food prices remained stable following the outbreak of the pandemic on international markets (Barrett, 2020; Béné, 2020; Devereux et al., 2020), the effects of Covid-19 and related containment measures on food prices are nonuniform (Dietrich et al., 2022). Factors such as increased home cooking, panic buying, and stockpiling have put pressure on prices from the demand side, while supply bottlenecks caused by the pandemic have contributed to supply-side pressure (Engemann & Jafari, 2022). Our second research question (RQ2) is whether pandemic-containment measures have contributed to price increases in German online retailing. We regress prices on the stringency index to assess the magnitude of price differences due to Covid-induced policy responses. As in Equation (1), we include the full set of product-retailer fixed effects, ψ_{ik}, to estimate the within-product price effect of the pandemic, and retailer-specific weekday effects, μ_{kt}, to account for potential temporal weekly patterns in price adjustments or promotions:

$$\ln Price_{ijkt} = \alpha + \gamma Stringency_t + \mu_{kt} + \psi_{ik} + u_{ijkt}. \tag{2}$$

Dietrich et al. (2022) argue that price increases are driven by commodities that are not produced locally and need to be imported. Containment measures may also affect overall inflation (Jiang et al., 2022), and unless we explicitly control for inflationary pressure on the supply side of the food and beverage sector, we may systematically overestimate the direct effect of Covid-related restrictions on prices. Hence, our third research question (RQ3) is whether the effect of Covid-induced policy measures on prices persists when we control for inflation:

$$\ln Price_{ijkt} = \alpha + \gamma Stringency_t + \mu_{kt} + \psi_{ik} + \omega_{jt} + u_{ijkt}. \tag{3}$$

In Equation (3), we include month-product category fixed effects, ω_{jt}, to capture the product-category-specific price development over time. In the base specification, we distinguish between alcoholic beverages versus food and nonalcoholic beverages. Using more disaggregated product categories (as in Appendix A) does not affect the results. In the robustness section, we alternatively use the German producer price index or import price indices for EU and non-EU imports of food and beverages interchangeably to account for increases in costs.

Our final research questions address heterogeneity in the effects of Covid-containment policies on prices across retailer (RQ4) and product types (RQ5). Pure online retailers have different assortments, face different costs, and sometimes serve different consumer groups than more traditional multichannel supermarkets (Aurier & Mejía, 2020; Brynjolfsson et al., 2003). Evidence from the US suggests that pure online retailers may have deliberately avoided price increases in an attempt to capture larger market shares (Hillen, 2021). The pandemic also disproportionately affected certain product categories. Akter (2020) shows that meat, seafood, and vegetables were most affected, while Kassas and Nayga (2021) and Hillen (2021) argue that storable and easy-to-cook products that were in high demand and often out of stock saw the largest price increases. To test for heterogeneity in the effects of Covid-related restrictions on prices, we interact the *Stringency* variable with the dummies for retailer (Equation 4) and product types (Equation 5) and the vector of individual product category variables (Equation 5.1):

$$\ln Price_{ijkt} = \alpha + \gamma Stringency_t + \zeta Stringency_t \times Hybrid_k + \mu_{kt} + \psi_{ik} + \omega_{jt} + u_{ijkt}. \tag{4}$$

$$\ln Price_{ijkt} = \alpha + \gamma Stringency_t + \eta Stringency_t \times Storable_j + \theta Stringency_t \times Perishable_j + \mu_{kt} + \psi_{ik} + \omega_{jt} + u_{ijkt}. \tag{5}$$

$$\ln Price_{ijkt} = \alpha + \boldsymbol{\beta'Product_j} \times Stringency_t + \mu_{kt} + \psi_{ik} + \omega_{jt} + u_{ijkt}. \tag{5.1}$$

Hybrid is a dummy variable that takes the value of 1 for multichannel retailers (Bringmeister, MyTime, Real, and Rewe) and 0 for pure online retailers. *Storable* is the dummy variable that takes the value of 1 for baby foods, cooking ingredients, instant meals, jams and spreads, muesli and cereals, oils and vinegar, pantry products, snacks and sweets, and frozen products, and is 0 for all other products. *Perishable* is the dummy variable that takes the value of 1 for dairy products, fruits and vegetables, fresh and chilled products, and is 0 otherwise. The reference group in Equation (5) is *Beverages*. The vector ***Product*** in Equation (5.1) represents all individual product categories dummy variables in the sample, and we "decompose" the overall effect of Covid-19 containment measures on prices into category-specific effects.

All equations are estimated with Stata 15 using the *reghdfe* estimator (Correia, 2017) to handle a large number of observations and fixed effects. To evaluate the robustness of our results, we assess the sensitivity of the estimates by using alternative measures of inflation in Equation (3), exclusion of individual product categories, or extending the analysis with direct measures of pandemic intensity. Finally, we repeat the price analysis only for products that were continuously available through the sample period and apply the blocked adaptive computationally efficient outlier nominators (BACON) algorithm (Billor et al., 2000) to deal with potential outliers.

3 | RESULTS

Table 1 reports the results from Equation (1). We observe price increases along the Covid-19 timeline (RQ1): The highest absolute increases in prices in the whole sample are related to the stages of lockdown and opening (about 0.28 euros). In relative terms that implies a roughly 1% (1.5%) price increase during the uncertainty and spread (lockdown and opening) stages respectively, compared to the pre-pandemic level.

While Table 1 compares price levels at the product level across the Covid-19 timeline, Table 2 reports the magnitude of price effects due to pandemic-induced restrictions (column 1, RQ2) once we control for inflationary pressure (column 2, RQ3).

Both Covid-induced restrictions and higher prices of food and beverage production and imports affect retailing prices. Once we control for factors that affect all products within broadly defined product categories over time (our proxy for inflation) with fixed effects, the magnitude of the stringency coefficient goes down somewhat, although its sign and statistical significance remain unaffected. The highest value of the stringency index in the sample period was 76.85 (see Appendix C), which implies a price increase of 0.5% (0.006×76.85) compared to the pre-pandemic period during the periods of the most stringent containment measures.

The estimated Covid-containment effects, however, are not uniform across store formats and product types (columns 3-4, RQs 4-5). The prices of multichannel retailers increased more than the prices of pure online grocers. During the peak of the lockdown, the pandemic-related measures led to price increases of 1.5% ($[0.003 + 0.017] \times 76.85$) for multichannel retailers, yet barely changed for pure online players, by 0.2%, compared to the prepandemic stage. The prices of food items are affected more by the pandemic and containment measures than those of beverages. While the prices of beverages did not change, the prices of storable (perishable) products

TABLE 1 Changes in product prices along the Covid-19 timeline.

	Price (1)	lnPrice (2)
International uncertainty	0.109***	0.005***
	(0.006)	(0.000)
Domestic uncertainty	0.199***	0.011***
	(0.010)	(0.000)
Spread	0.231***	0.013***
	(0.013)	(0.000)
Lockdown	0.275***	0.015***
	(0.013)	(0.000)
Opening	0.286***	0.016***
	(0.016)	(0.000)
Constant	22.406***	2.358***
	(0.006)	(0.000)
Product × Retailer FE	Yes	Yes
Adjusted R^2	0.99	0.99
Observations	99,198,397	99,198,397

Note: ***, **, * refer to statistical significance at 99%, 95%, and 90% levels. Robust standard errors clustered at the level of individual products (755,649 clusters) are reported in parentheses. Pre-Covid is the reference period. 78,492 singleton observations were dropped from the estimation.

increased by 0.009% (0.020%) per each unit increase in the value of the Stringency index. Appendix D summarizes the stringency effects for individual product categories. Across product groups, the highest pandemic-related effect is observed for baby foods, instant meals, and pantry products, which were the subject of stockpiling and panic buying. The average price increases following a one-unit rise in stringency index value in those groups are 0.042%, 0.033%, and 0.025%, respectively, resulting in a price increase in the range of 1.92%–3.23% compared to the prepandemic period. Prices of fruits and vegetables and fresh and chilled products, including meat and fish, increased more than the sample average, corroborating the findings of earlier studies.

Our main conclusions regarding the positive impact of the Covid-19 containment policies on prices and its statistical significance remain robust to using alternative measures of inflation (Appendix E), exclusion of individual product categories from the sample (results available on request), extending the empirical specification with direct measures of pandemic intensity (Appendix F), or restricting the analysis to continuously available items only (Appendix G). Finally, the BACON procedure did not reveal any outliers up to the 50th percentile, rendering correction for outliers unnecessary.

4 | DISCUSSION AND CONCLUSION

While the changes in the demand side of the food retail market induced by Covid-19 have been extensively studied, less is known about the seller side. There is little research on the actual behavior of food retailers and their potential use of price as a rationing mechanism during the pandemic. Most existing studies either focus on specific product

TABLE 2 The impact of Covid-induced restrictions on prices.

	lnPrice (1)	lnPrice (2)	lnPrice (3)	lnPrice (4)
Stringency (×100)	0.018***	0.006***	0.003***	−0.001
	(0.000)	(0.000)	(0.000)	(0.001)
Stringency × Hybrid			0.017***	
			(0.000)	
Stringency × Storable				0.009***
				(0.001)
Stringency × Perishable				0.020***
				(0.002)
Constant	2.361***	2.364***	2.364***	2.364***
	(0.000)	(0.000)	(0.000)	(0.000)
Product × Retailer FE	Yes	Yes	Yes	Yes
Retailer × Weekday FE	Yes	Yes	Yes	Yes
Product category × Month FE	No	Yes	Yes	Yes
Adj. R^2	0.99	0.99	0.99	0.99
Observations	99,198,397	99,198,397	99,198,397	99,198,397

Note: ***, **, * refer to statistical significance at 99%, 95%, and 90% levels. Robust standard errors clustered at the level of individual products (755,649 clusters) are reported in parentheses. 78,492 singleton observations were dropped from the estimation. For the Stringency index variable and its interactions, we report coefficients multiplied by 100, the resulting values are percent price effects due to an increase in the stringency index by one unit. Beverages (Online only retailers) are the reference categories.

categories or rely on existing databases to show how prices changed during Covid-19. The few studies that collect market data focus on one retailer or, if they do collect data for multiple food retailers, do not cover a wide range of the grocery market. Our study fills this gap in the literature by using a unique dataset of roughly 99 million price observations collected from the largest German e-grocers to examine how prices were affected by the challenges of the first wave of Covid-19, in particular by the stringency of the Covid-19 containment policies.

We show that during the first wave of Covid-19, retailers adjusted their prices to overcome supply bottlenecks and a surge in online demand. The average assortment price became more expensive along the Covid-19 timeline compared to the pre-pandemic level, and prices at the individual product level were adjusted upwards (RQ1). Prices were the highest during the lockdown and opening, although they started increasing already at the uncertainty stages.

The Covid-19 containment policy responses have led to an increase in prices (RQ2). Our results show that on average, prices increased by 0.017% with each one-unit increase in the stringency index, which measures the strictness of pandemic-related containment policies. During the lockdown, the value of the stringency index reached 76.85, resulting in a 1.3% increase in prices. This result is largely in line with findings from more aggregated price data for the European markets (Akter, 2020). When we account for the higher production and import costs, which also contributed to a price increase, the impact of the stringency measures reduces to 0.5% but remains statistically significant (RQ3).

Across retailers, the Covid-19 effect on prices is uneven (RQ4), with price increases being considerably higher for multichannel retailers that operate both online and offline compared to pure online sellers (0.017% vs. 0.003%, respectively, per each one-unit increase in the value of the stringency index). These discrepancies could be due to Amazon's expansion strategy, as the company has been investing in its market share and loyal consumers and avoided large price increases at the beginning of the pandemic (Hillen, 2021). Among different product categories (RQ5), necessity products, storable convenience foods (such as baby food, instant meals, and pantry items), and fresh produce (including fruits and vegetables, and fresh and chilled products) saw the highest price increases.

The sharp increase in the average assortment price (Appendix B) in our sample appears to be driven by the changes in inventory, such as stock-outs of cheaper items, or assortments changes, such as increasing the share of more expensive products in the offered assortment or replacing cheaper items by more expensive alternatives in individual product groups. The differences between unit values and prices highlight the risks of using simple mean or median price comparisons in datasets of retailers whose assortments are changing constantly, and they call for further research on the relationship between prices and assortments.

A few words of caution are due here. Although our dataset includes hybrid retailers, which allows us to compare Covid-related price adjustments online and offline, we do not aim at explaining the entire brick-and-mortar grocery sector pricing. In addition to supermarkets, which often operate as multichannel retailers, discounters also play an important role in offline grocery retailing in Germany, but they do not participate in full-assortment grocery e-commerce, so they are not included in our analysis. Furthermore, our data is geographically limited to a single country, and our findings are not easily generalizable to other locations. However, Amazon, the largest German grocery e-retailer, is internationally relevant (it is the second largest food retailer in the United States and Europe) and is currently expanding its grocery services worldwide. Cavallo (2018) suggests that within-Amazon pricing discrepancies across locations are rather small. This conclusion seems to hold when we compare our findings for Amazon Fresh in Germany with those of Hillen (2021) for the US market. Unless this is a coincidence, our results can be used as a benchmark for other markets with a strong Amazon presence.

Finally, our analysis and data are limited to the first wave of Covid-19. Extending the price time series to study dynamic price adjustments during a global economic shock that has been extended repeatedly or using granular data to forecast inflation in real time would be a logical extension of our analysis, and we call for ongoing efforts to create and maintain a dataset that would enable this kind of research.

ACKNOWLEDGMENTS

This work was supported by the German Research Foundation (research grant FE 1830/1-1) received by Svetlana Fedoseeva. DFG had no involvement in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. All opinions expressed in the manuscript are authors' own. Open access funding enabled and organized by Projekt DEAL.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Not applicable.

ORCID

Svetlana Fedoseeva http://orcid.org/0000-0001-7345-3009
Ellen Van Droogenbroeck https://orcid.org/0000-0001-7043-2376

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1002/agr.21807.

REFERENCES

Agyei, S. K., Isshaq, Z., Frimpong, S., Adam, A. M., Bossman, A., & Asiamah, O. (2021). COVID-19 and food prices in sub-Saharan Africa. *African Development Review*, *33*, S102–S113. https://doi.org/10.1111/1467-8268.12525

Akter, S. (2020). The impact of COVID-19 related 'stay-at-home' restrictions on food prices in Europe: Findings from a preliminary analysis. *Food Security*, *12*(4), 719–725. https://doi.org/10.1007/s12571-020-01082-3

Alaimo, L. S., Fiore, M., & Galati, A. (2020). How the COVID-19 pandemic is changing online food shopping human behaviour in Italy. *Sustainability*, *12*(22), 9594. https://doi.org/10.3390/su12229594

The Associated Press. (2021). Germany's COVID timeline: From first case to 100,000 dead. *The Associated Press*, November 25, 2021. https://abcnews.go.com/Health/wireStory/germanys-covid-timeline-case-100000-dead-81389672

Aurier, P., & Mejía, V. D. (2020). The interplay of brand-line assortment size and alignability in the sales of brand-lines and line-extensions of frequently purchased products. *Journal of Business Research*, *117*, 163–175. https://doi.org/10.1016/j.jbusres.2020.05.024

Baarsma, B., & Groenewegen, J. (2021). COVID-19 and the demand for online grocery shopping: Empirical evidence from the Netherlands. *De Economist*, *169*(4), 407–421. https://doi.org/10.1007/s10645-021-09389-y

Bai, Y., Costlow, L., Ebel, A., Laves, S., Ueda, Y., Volin, N., Zamek, M., & Masters, W. A. (2022). Retail prices of nutritious food rose more in countries with higher COVID-19 case counts. *Nature Food*, *3*(5), 325–330. https://doi.org/10.1038/s43016-022-00502-1

Barrett, C. B. (2020). Actions now can curb food systems fallout from COVID-19. *Nature Food*, *1*(1), 319–320.

Béné, C. (2020). Resilience of local food systems and links to food security—A review of some important concepts in the context of COVID-19 and other shocks. *Food Security*, *12*, 805–822.

Billor, N., Hadi, A. S., & Velleman, P. F. (2000). BACON: Blocked adaptive computationally efficient outlier nominators. *Computational Statistics & Data Analysis*, *34*(3), 279–298.

Brynjolfsson, E., Hu, Y., & Smith, M. D. (2003). Consumer surplus in the digital economy: Estimating the value of increased product variety at online booksellers. *Management Science*, *49*(11), 1580–1596. https://www.jstor.org/stable/4134002

Cavallo, A. (2018). *More Amazon effects: Online competition and pricing behaviors. National Bureau of Economic Research* (NBER working paper No. w25138). https://www.nber.org/papers/w25138

Chenarides, L., Grebitus, C., Lusk, J. L., & Printezis, I. (2021). Food consumption behavior during the COVID-19 pandemic. *Agribusiness*, *37*(1), 44–81. https://doi.org/10.1002/agr.21679

Conway, M. W., Salon, D., da Silva, D. C., & Mirtich, L. (2020). How will the COVID-19 pandemic affect the future of urban life? Early evidence from highly-educated respondents in the United States. *Urban Science*, *4*(4), 50. https://doi.org/10.3390/urbansci4040050

Correia, S. (2017). reghdfe: Stata module for linear and instrumental-variable/GMM regression absorbing multiple levels of fixed effects. Statistical Software Components S457874, Boston College Department of Economics. https://ideas.repec.org/c/boc/bocode/s457874.html

Devereux, S., Béné, C., & Hoddinott, J. (2020). Conceptualising COVID-19's impacts on household food security. *Food Security*, *12*(4), 769–772.

Dietrich, S., Giuffrida, V., Martorano, B., & Schmerzeck, G. (2022). COVID-19 policy responses, mobility, and food prices. *American Journal of Agricultural Economics*, *104*(2), 569–588. https://doi.org/10.1111/ajae.12278

Van Droogenbroeck, E., & Van Hove, L. (2022). COVID-19 and point-of-sale payments in Belgium: How the older generation also learned to love contactless. *Journal of Payments Strategy & Systems*, *16*(1), 17–27.

Dwivedi, Y. K., Hughes, D. L., Coombs, C., Constantiou, I., Duan, Y., Edwards, J. S., Gupta, B., Lal, B., Misra, S., Prashant, P., Raman, R., Rana, N. P., Sharma, S. K., & Upadhyay, N. (2020). Impact of COVID-19 pandemic on information management research and practice: Transforming education, work and life. *International Journal of Information Management*, *55*, 102211. https://doi.org/10.1016/j.ijinfomgt.2020.102211

Ellison, B., McFadden, B., Rickard, B. J., & Wilson, N. L. W. (2021). Examining food purchase behavior and food values during the COVID-19 pandemic. *Applied Economic Perspectives and Policy*, *43*(1), 58–72. https://doi.org/10.1002/aepp.13118

Engemann, H., & Jafari, Y. (2022). COVID-19 and changes in global agri-food trade. *Q Open*, *2*, qoac013. https://doi.org/10.1093/qopen/qoac013

Fedoseeva, S., Herrmann, R., & Nickolaus, K. (2017). Was the economics of information approach wrong all the way? Evidence from German grocery r(e)tailing. *Journal of Business Research*, *80*, 63–72. https://doi.org/10.1016/j.jbusres.2017.07.006

Filimonau, V., Vi, L. H., Beer, S., & Ermolaev, V. A. (2022). The COVID-19 pandemic and food consumption at home and away: An exploratory study of English households. *Socio-Economic Planning Sciences*, *82*, 101125. https://doi.org/10.1016/j.seps.2021.101125

FMI. (2018). FMI and Nielsen report: 70% of consumers will be grocery shopping online by 2024. Retrieved March 1, 2023, from https://www.fmi.org/newsroom/latest-news/view/2018/01/29/fmi-and-nielsen-report-70-of-consumers-will-be-grocery-shopping-online-by-2024

Fuentes, C., Samsioe, E., & Östrup Backe, J. (2022). Online food shopping reinvented: Developing digitally enabled coping strategies in times of crisis. *The International Review of Retail, Distribution and Consumer Research*, *32*(2), 130–150. https://doi.org/10.1080/09593969.2022.2047758

García-Morales, V. J., Garrido-Moreno, A., & Martín-Rojas, R. (2021). The transformation of higher education after the COVID disruption: Emerging challenges in an online learning scenario. *Frontiers in Psychology*, *12*, 616059. https://doi.org/10.3389/fpsyg.2021.616059

Goeb, J., Maredia, M., Win, K. Z., Masias, I., Lambrecht, I., Boughton, D., & Minten, B. (2022). Urban food prices under lockdown: Evidence from Myanmar's traditional food retail sector during COVID-19. *Applied Economics*, *54*, 5412–5441. https://doi.org/10.1080/00036846.2022.2044999

Gomes, S., & Lopes, J. M. (2022). Evolution of the online grocery shopping experience during the COVID-19 pandemic: Empiric study from Portugal. *Journal of Theoretical and Applied Electronic Commerce Research*, *17*(3), 909–923. https://doi.org/10.3390/jtaer17030047

Günday, G., Karabon, M., Kooij, S., Moulton, J., & Omeñaca, J. (2020). How European shoppers will buy groceries in the next normal. Retrieved March 1, 2023, from https://www.mckinsey.com/industries/retail/our-insights/how-european-shoppers-will-buy-groceries-in-the-next-normal

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Webster, S., Cameron-Blake, E., Hallas, L., Majumdar, S., & Tatlow, H. (2021). A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). *Nature Human Behaviour*, *5*, 529–538. https://doi.org/10.1038/s41562-021-01079-8

Hamulczuk, M., & Skrzypczyk, M. (2021). COVID-19, spatial market integration and producer prices: A case study of EU agri-food markets. *Studies in Agricultural Economics*, *123*(2), 53–61. https://doi.org/10.7896/j.2137

Ben Hassen, T., El Bilali, H., Allahyari, M. S., Berjan, S., & Fotina, O. (2021). Food purchase and eating behavior during the COVID-19 pandemic: A cross-sectional survey of Russian adults. *Appetite*, *165*, 105309. https://doi.org/10.1016/j.appet.2021.105309

Herbert, R., Nyssens, J.-A., Vallöf, R., & Wachinger, T. (2021). A year like no other for European grocery retailers: The state of the industry post, 2020. Retrieved March 1, 2023, from https://www.mckinsey.com/industries/retail/our-insights/a-year-like-no-other-for-european-grocery-retailers-the-state-of-the-industry-post-2020

Hillen, J. (2021). Online food prices during the COVID-19 pandemic. *Agribusiness*, *37*(1), 91–107. https://doi.org/10.1002/agr.21673

Hirvonen, K., Minten, B., Mohammed, B., & Tamru, S. (2021). Food prices and marketing margins during the COVID-19 pandemic: Evidence from vegetable value chains in Ethiopia. *Agricultural Economics*, *52*(3), 407–421. https://doi.org/10.1111/agec.12626

Hobbs, J. E. (2020). Food supply chains during the COVID-19 pandemic. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, *68*(2), 171–176. https://doi.org/10.1111/cjag.12237

Hosoda, M. (2021). Telework amidst the COVID-19 pandemic: Effects on work style reform in Japan. *Corporate Governance: The International Journal of Business in Society*, *21*(6), 1059–1071. https://doi.org/10.1108/CG-09-2020-0390

Jaworski, K. (2021). Measuring food inflation during the COVID-19 pandemic in real time using online data: A case study of Poland. *British Food Journal*, *123*(13), 260–280. https://doi.org/10.1108/BFJ-06-2020-0532

Jensen, K. L., Yenerall, J., Chen, X., & Yu, T. E. (2021). US consumers' online shopping behaviors and intentions during and after the COVID-19 pandemic. *Journal of Agricultural and Applied Economics*, *53*(3), 416–434. https://doi.org/10.1017/aae.2021.15

Jiang, T., Liu, T., Tang, K., & Zeng, J. (2022). Online prices and inflation during the nationwide COVID-19 quarantine period: Evidence from 107 Chinese websites. *Finance Research Letters*, *49*, 103166. https://doi.org/10.1016/j.frl.2022.103166.

Kassas, B., & Nayga, R. M. (2021). Understanding the importance and timing of panic buying among U.S. Households during the COVID-19 pandemic. *Food Quality and Preference*, *93*, 104240. https://doi.org/10.1016/j.foodqual.2021.10424

Li, J., Hallsworth, A. G., & Coca-Stefaniak, J. A. (2020). Changing grocery shopping behaviours among Chinese consumers at the outset of the COVID-19 outbreak. *Tijdschrift Voor Economische en Sociale Geografie*, *111*(3), 574–583. https://doi.org/10.1111/tesg.12420

Mathieu, E., Ritchie, H., Rodés-Guirao, L., Appel, C., Giattino, C., Hasell, J., Macdonald, B., Dattani, S., Beltekian, D., Ortiz-Ospina, E., & Roser, M. (2020). Coronavirus Pandemic (COVID-19). Retrieved March 1, 2023, from https://ourworldindata.org/coronavirus

McKinsey & Company, EuroCommerce. (2022). State of Grocery Europe 2022. Retrieved March 1, 2023, from https://www.mckinsey.com/industries/retail/our-insights/state-of-grocery-europe

Peña, J., & Prades, E. (2021). *Price setting in Chile: Micro evidence from consumer on-line prices during the social outbreak and Covid-19*. *Banco de Espana* (Working Paper No. 2112). https://doi.org/10.2139/ssrn.3806309

Poelman, M. P., Gillebaart, M., Schlinkert, C., Dijkstra, S. C., Derksen, E., Mensink, F., Hermans, R. C. J., Aardening, P., de Ridder, D., & de Vet, E. (2021). Eating behavior and food purchases during the COVID-19 lockdown: A cross-sectional study among adults in the Netherlands. *Appetite*, *157*, 105002. https://doi.org/10.1016/j.appet.2020.105002

Rodgers, R. F., Lombardo, C., Cerolini, S., Franko, D. L., Omori, M., Linardon, J., Guillaume, S., Fischer, L., & Tyszkiewicz, M. F. (2021). "Waste not and stay at home" evidence of decreased food waste during the COVID-19 pandemic from the US and Italy. *Appetite*, *160*, 105110. https://doi.org/10.1016/j.appet.2021.105110

Roe, B. E., Bender, K., & Qi, D. (2021). The impact of COVID-19 on consumer food waste. *Applied Economic Perspectives and Policy*, *43*(1), 401–411. https://doi.org/10.1002/aepp.13079

Van Rompaey, S. (2022). Online now accounts for 7.2% of grocery market share. Retrieved March 1, 2023, from https://www.retaildetail.eu/news/food/online-groceries-now-account-for-7-2-market-share/

Ruan, J., Cai, Q., & Jin, S. (2021). Impact of COVID-19 and nationwide lockdowns on vegetable prices: Evidence from wholesale markets in China. *American Journal of Agricultural Economics*, *103*(5), 1574–1594. https://doi.org/10.1111/ajae.12211

Santosa, A. D., Taufik, N., Prabowo, F. H. E., & Rahmawati, M. (2021). Continuance intention of baby boomer and X generation as new users of digital payment during COVID-19 pandemic using UTAUT2. *Journal of Financial Services Marketing*, *26*(4), 259–273. https://doi.org/10.1057/s41264-021-00104-1

Singh, S., Kumar, R., Panchal, R., & Tiwari, M. K. (2021). Impact of COVID-19 on logistics systems and disruptions in food supply chain. *International Journal of Production Research*, *59*(7), 1993–2008. https://doi.org/10.1080/00207543.2020.1792000

Statista. (2021). Forecasted online grocery market size in selected European nations from 2018 to 2023. Retrieved March 1, 2023, from https://www.statista.com/statistics/960484/online-grocery-market-sizes-europe/

Statistisches Bundesamt. (2022). Price indices for agriculture and forestry. Retrieved March 1, 2023, from https://www.destatis.de/EN/Themes/Economy/Prices/Price-Indices-In-Agriculture-And-Forestry/Tables/Producer-prices-agriculture.html#241846

Ton, D., Arendsen, K., De Bruyn, M., Severens, V., Van Hagen, M., Van Oort, N., & Duives, D. (2022). Teleworking during COVID-19 in the Netherlands: Understanding behaviour, attitudes, and future intentions of train travellers. *Transportation Research Part A, Policy and Practice*, *159*, 55–73. https://doi.org/10.1016/j.tra.2022.03.019

Tyrväinen, O., & Karjaluoto, H. (2022). Online grocery shopping before and during the COVID-19 pandemic: A meta-analytical review. *Telematics and Informatics*, *71*, 101839. https://doi.org/10.1016/j.tele.2022.101839

Verdon, J. (2022). The pandemic changed how we shop for groceries, Adobe Report Shows. Retrieved March 1, 2023, from https://www.forbes.com/sites/joanverdon/2022/03/15/the-pandemic-changed-how-we-shop-for-groceries-adobe-report-shows/?sh=1eda03c24bb1

Zhao, Y., & Watterston, J. (2021). The changes we need: Education post-COVID-19. *Journal of Educational Change*, *22*(1), 3–12. https://doi.org/10.1007/s10833-021-09417-3

How to cite this article: Fedoseeva, S., Van Droogenbroeck, E. (2023). Pandemic pricing: Evidence from German grocery e-commerce. *Agribusiness*, 1–18. https://doi.org/10.1002/agr.21807

APPENDIX A

(Table A1).

TABLE A1 Summary statistics for prices in the sample.

	Products		Observations		Prices	
	Number	Share	Number	Share	Mean	Median
Total	834,141	100	99,276,889	100	22.54	10.69
By store type:						
Multichannel	75,953	9.11	13,452,776	13.55	4.96	2.40
Online-only	758,188	90.89	85,824,113	86.45	25.29	12.90
By product category:						
Alcoholic beverages	187,046	22.42	16,749,507	16.87	49.74	28.64
Baby foods	12,265	1.47	1,657,573	1.67	13.48	7.13
Cooking ingredients	152,171	18.24	18,706,645	18.84	13.42	7.9
Dairy products	14,957	1.79	2,566,402	2.59	13.09	2.19
Fresh and chilled items	16,339	1.96	2,471,484	2.49	23.7	6.77
Frozen products	10,838	1.30	1,747,918	1.76	5.96	3.29
Fruits and vegetables	17,669	2.12	1,743,680	1.76	43.68	27.3
Instant meals	36,728	4.40	5,492,566	5.53	12.16	5.49
Jams and spreads	22,006	2.64	3,264,472	3.29	18	9.99
Müsli and cereals	10,143	1.22	1,400,733	1.41	12.85	7.38
Nonalcoholic beverages	130,748	15.67	13,713,782	13.81	21.54	12.99
Oil and vinegar	49,992	5.99	7,458,235	7.51	18.18	10.31
Pantry products	22,897	2.74	3,329,481	3.35	15.25	8.98
Snacks and sweets	150,342	18.02	18,974,411	19.11	17.24	9.49

APPENDIX B

(Figure B1).

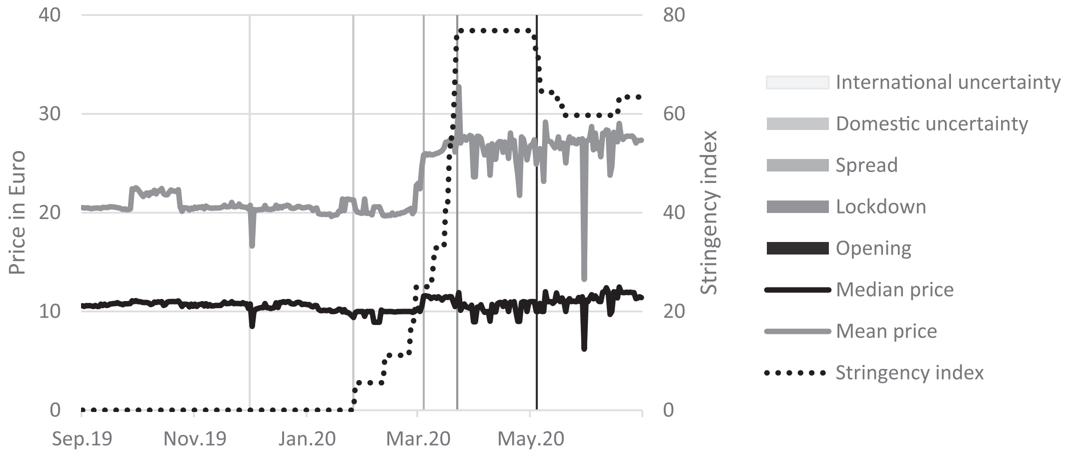

FIGURE B1 Evolution of the mean (median) sample prices and the stringency index during the first wave of Covid-19 in Germany. Please refer to the text for the definition of the timeline stages and additional information on events from the first Covid-19 wave in Germany.

APPENDIX C

(Table C1).

TABLE C1 Descriptive statistics of explanatory variables.

	Mean	STD	Min	Max
Inflation (Statistisches Bundesamt, 2022)				
Producer price index (food), September 2019 = 100	101.86	1.69	99.28	104.09
Import price index (EU), September 2019 = 100	102.58	1.76	100	104.98
Import price index (non-EU), September 2019 = 100	101.90	1.23	100	103.67
Covid-19 (Mathieu et al., 2020)				
Stringency index	26.18	31.49	0	76.85
New infections, thousands	0.64	1.38	0	6.93
Total infections, thousands	51.42	76.71	0	195.42

APPENDIX D

(Figure D1).

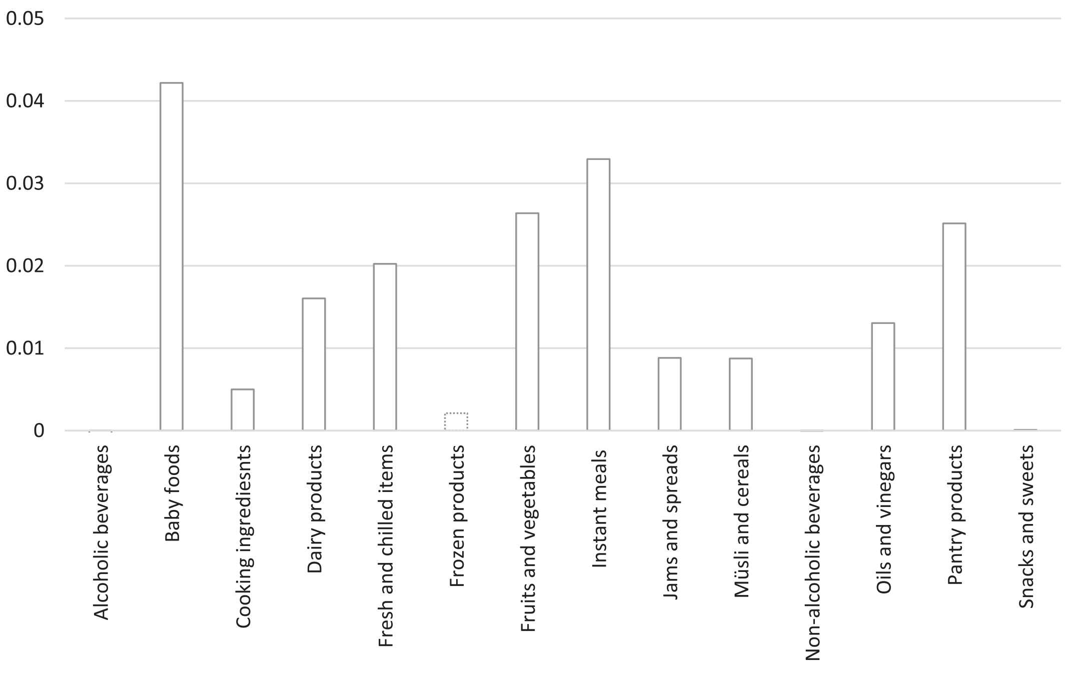

FIGURE D1 Product-category-specific Covid-19 containment effects. The bars represent the category-specific *Stringency* effects (in %) estimated with Equation (5.1). Empirical specification includes a full set of product × retailer, day-of-the-week × retailer, and month × product-type fixed effects. Standard errors are clustered at the product-retailer level (755,651 clusters). The adjusted R^2 is 0.99. All coefficients apart from those related to categories frozen products, snacks and sweets, and beverages are statistically significant ($p < 0.10$).

APPENDIX E

(Table E1).

TABLE E1 The impact of Covid-induced restrictions: Alternative inflation measures.

	lnPrice (1)	lnPrice (2)	lnPrice (3)
Stringency (×100)[a]	0.019***	0.016***	0.016***
	(0.000)	(0.000)	(0.000)
Producer price index food (×100)	0.105***		
	(0.000)		
Import price index (EU) (×100)		0.139***	
		(0.000)	
Import price index (non-EU) (×100)			0.175***
			(0.000)
Constant	2.254***	2.219***	2.184***
	(0.005)	(0.005)	(0.007)
Product × Retailer FE	Yes	Yes	Yes
Retailer × Weekday FE	Yes	Yes	Yes
Adj. R^2	0.99	0.99	0.99
Observations	99,198,397	99,198,397	99,198,397

Note: ***, **, * refer to statistical significance at 99%, 95%, and 90% levels. Robust standard errors clustered at the level of individual products (755,649 clusters) are reported in parentheses. 78,492 singleton observations were dropped from the estimation. [a]For the Stringency and Inflation variables we report coefficients multiplied by 100, the resulting values are percent effects due to an increase in the stringency index or the respective price index by one unit.

APPENDIX F

(Table F1).

TABLE F1 The impact of Covid-induced restrictions: Equations (3–5) with Covid-19 controls.

	lnPrice (1)	lnPrice (2)	lnPrice (3)	lnPrice (4)	lnPrice (5)
Stringency (×100)[a]	0.004***	0.008***	0.006***	0.003***	−0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Stringency × *Hybrid* (×100)				0.017***	
				(0.001)	
Stringency × *Storable* (×100)					0.009***
					(0.001)
Stringency × *Perishable* (×100)					0.020***
					(0.002)
Covid-19 new cases (×100)	0.022***		0.016***	0.015***	0.016***
	(0.000)		(0.003)	(0.004)	(0.004)
Covid-19 total cases (×100)		−0.002***	−0.001***	−0.001***	−0.001***
		(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.364***	2.364***	2.364***	2.364***	2.364***
	(0.00)	(0.000)	(0.000)	(0.000)	(0.000)
Product × Retailer FE	Yes	Yes	Yes	Yes	Yes
Retailer × Weekday FE	Yes	Yes	Yes	Yes	Yes
Product category × Month FE	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.99	0.99	0.99	0.99	0.99
Observations	99,198,397	99,198,397	99,198,397	99,198,397	99,198,397

Note: ***, **, * refer to statistical significance at 99%, 95%, and 90% levels. Robust standard errors clustered at the level of individual products (755,649 clusters) are reported in parentheses. 78,492 singleton observations were dropped from the estimation. [a]For the Stringency index variable and its interactions and for Covid-19 variables we report coefficients multiplied by 100, the resulting values are percent effects due to an increase in the stringency index by one unit or in the Covid-19 indicator by 1000 cases.

APPENDIX G

(Table G1).

TABLE G1 The impact of Covid-induced restrictions: Continuously available items only.

	lnPrice (1)	lnPrice (2)	lnPrice (3)	lnPrice (4)
Stringency (×100)[a]	0.020***	0.011***	0.000	0.007***
	(0.001)	(0.001)	(0.000)	(0.002)
Stringency × *Hybrid* (×100)			0.028***	
			(0.000)	
Stringency × *Storable* (×100)				0.003
				(0.002)
Stringency × *Perishable* (×100)				0.020***
				(0.003)
Constant	1.899***	1.901***	1.901***	1.901***
	(0.000)	(0.000)	(0.000)	(0.000)
Product × Retailer FE	Yes	Yes	Yes	Yes
Retailer × Weekday FE	Yes	Yes	Yes	Yes
Product category × Month FE	No	Yes	Yes	Yes
Adj. R^2	0.99	0.99	0.99	0.99
Observations	15,933,415	15,933,415	15,933,415	15,933,415

Note: ***, **, * refer to statistical significance at 99%, 95%, and 90% levels. Robust standard errors clustered at the level of individual products (55,160 clusters) are reported in parentheses. [a]For the Stringency index variable and its interactions, we report coefficients multiplied by 100, the resulting values are percent price effects due to an increase in the stringency index by one unit. Beverages (Online-only retailers) are the reference categories. Only products that were available >275 days of the sample are included in the analysis.

AUTHOR BIOGRAPHIES

Svetlana Fedoseeva is a researcher at the Institute of Food and Resource Economics, University of Bonn, Germany. Svetlana holds a doctorate in Agricultural Economics (2016) and a master's degree in Economics from the University of Giessen, Germany. Her research interests are in international trade and e-commerce.

Ellen Van Droogenbroeck (Doctor in Applied Economics: Commercial Engineer, Vrije Universiteit Brussel, 2018) is an Assistant Professor at the Department of Applied Economics (APEC) of the Faculty of Economic and Social Sciences & Solvay Business School at the Vrije Universiteit Brussel (Free University of Brussels). Her current research interests include online grocery shopping, e-commerce, payment instruments, and retail.