Price Setting Before and During the Pandemic: Evidence from Swiss Consumer Prices

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Abstract

We provide new evidence on price rigidity at the product level based on microdata underlying the Swiss consumer price index from 2008 to 2020. We find that the frequency of price changes has increased over the last decade, in particular among products where collection switched to online prices, reflecting the rise of e-commerce. Furthermore, price changes tend to be synchronized within rather than across stores. Time variations in inflation can be attributed mainly to variations in the frequency of both price increases and price decreases. In the first year of the pandemic, the frequency of price adjustments changed little on average, while temporary sales responded countercyclically to the respective demand conditions across sectors.

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Non-technical summary

Prices do not respond immediately to changes in supply and demand. This characteristic plays an important role in many macroeconomic models. It leads monetary stimulus to affect real economic activity and to slowly transmit into inflation. The importance of sluggish price adjustment for the monetary transmission mechanism is widely accepted. Nevertheless, understanding the extent of price rigidity and the factors influencing price adjustments is crucial for macroeconomic modeling and policymakers committed to price stability.

This paper provides new evidence on price rigidity in Switzerland based on the analysis of price quotes underlying the Swiss consumer price index. The focus is on levels and trends in price-setting characteristics between 2008 and 2020. Special attention is paid to the impact of the COVID-19 pandemic in 2020. The pandemic and ensuing lockdown provide an interesting perspective on the response of price-setting behavior to a large-scale disruption of the economy.

The main results of the study can be summarized as follows. First, the average monthly share of price changes has increased steadily between 2008 and 2019, the last year before the pandemic. While about one in four prices was adjusted each month in 2008, this ratio rose to about one in three prices in 2019. A substantial share of price changes is due to temporary sales. However, the upward trend in price adjustment frequency is also clearly visible when temporary sales are excluded from the sample. Consumer electronics feature among the goods with the largest increase in the frequency of price adjustment. This reflects the rise of e-commerce and the fact that consumer electronics prices in Switzerland have exclusively been collected via the internet since 2016. Online prices tend to be changed more frequently than prices in brick-and-mortar stores, possibly reflecting intense competition, high price transparency, and other factors. Results from a panel regression are consistent with the view that intense competition by reducing profit margins contributes to making prices more flexible.

Second, we find that variations in the frequency of price changes and variations in the size of price changes contribute to varying degrees to variations in inflation. In particular, our findings suggest that the size of price changes contributes more than the frequency of price changes to variations in inflation. However, because the frequency of price increases and the frequency of price decreases tend to move in opposite directions after a shock, variations in the frequency of price increases and variations in the frequency of price decreases taken separately contribute substantially to variations in inflation.

Third, we find that price changes are synchronized within rather than across stores. As firms adjust their prices, they tend to change them for multiple products simultaneously. There is little synchronization of price changes of a given good across stores. However, the synchronization of price changes within a store across goods is substantial. This result is consistent with the view that price adjustments are costly and therefore tend to be synchronized within stores.

Fourth, the response of the frequency of price changes to the COVID-19 pandemic was small overall. The high degree of uncertainty might have contributed to this result. However, the response varied widely depending on the market conditions in the various sectors. While the frequency of price changes increased in some sectors, it declined in others. We also note that temporary sales responded countercyclically to the respective market conditions. Temporary sales were conducted more often in sectors with weak demand and less often in sectors with strong demand. Although results from a specific event should not be generalized, the pattern in the data lends support to the view that temporary sales respond to macroeconomic shocks.

To conclude, we note that the empirical findings presented in this paper highlight recent changes in the way prices are set. In particular, they point out an upward trend in the frequency of price changes, and they emphasize the effect of the rise of e-commerce and the importance of sectoral heterogeneity in analyzing price-setting behavior.

1 Introduction

Price rigidity is a cornerstone of many macroeconomic models. The assumption that prices do not respond immediately to changes in supply and demand gives rise to monetary non-neutrality. Monetary stimulus affects real activity and transmits slowly into inflation. Therefore, understanding the extent of price rigidity and the factors influencing price adjustments is vital for policymakers committed to price stability.

This paper provides new evidence on the level of and changes in price rigidity in Switzerland since 2008. We document various characteristics of price-setting behavior based on microdata underlying the Swiss consumer price index (CPI). The characteristics considered include the frequency and size of price changes, the contributions of the frequency and size of price changes to inflation dynamics, the distribution of price changes, and the synchronization of price changes across outlets and goods. In addition, because our sample includes data for 2020, we examine how the COVID-19 pandemic affected price-setting behavior at the outbreak and throughout the first year of the pandemic.

The data are monthly price quotes collected by the Swiss Federal Statistical Office (FSO) to construct the Swiss CPI. Our sample covers the period January 2008 to December 2020. We identify 160,000 individual products at the outlet level for 1,300 different goods and services, collected in more than 3,000 stores across Switzerland. After excluding administered prices, prices based on unit value indices, and some others, the sample consists of 7.4 million price quotes and covers up to 60 percent of CPI expenditures.

There is a vast empirical literature on price-setting behavior, some of which is based on CPI microdata.[1] Bils and Klenow (2004), Klenow and Kryvtsov (2008), and Nakamura and Steinsson (2008) use CPI micro prices to characterize price rigidity in the United States. Similarly, Dhyne et al. (2006) summarize price adjustment features of 50 narrowly defined products for ten euro area countries from 1996 to 2001. Gautier et al. (2021) expand and update that study as part of the Price-Setting Microdata Analysis Network (PRISMA) established by the European System of Central Banks (ESCB). For Switzerland, Kaufmann (2009) examines price rigidity in Swiss consumer prices using quarterly data from 1993 to 2005. On a smaller scale, Föllmi et al. (2016) analyze price setting in a range of non-tradable services (hairdressers, cinemas, food & drinks in restaurants), representing 4 percent of the Swiss CPI.

Our contribution to this literature is twofold. First, we update and extend earlier results

[1] Klenow and Malin (2010) and Nakamura and Steinsson (2013) provide comprehensive reviews of micro price studies and summarize the available microeconomic evidence on price-setting behavior.

on price rigidity and price-setting behavior. Our data allow exploring new aspects of price rigidity, including the effect of the rise of e-commerce. The share of price quotes collected online (consumer electronics, clothing, footwear, and furnishing items) increased sharply in recent years to about 20 percent in 2020. Several recent studies have focused on the effect of the rise of e-commerce on price setting in specialized data sets. Using web-scraped prices from multi-channel retailers in the US, Cavallo (2018a) documents that online competition has increased the frequency of price changes from 2008 to 2017. Gorodnichenko and Talavera (2017) and Gorodnichenko et al. (2018b) show that prices in online marketplaces are more flexible than the micro prices collected in-store. By uncovering similar trends in the Swiss CPI microdata, we document the role of online retailing as a source of greater price flexibility in data underlying a national CPI.

Second, we analyze the effect of the COVID-19 pandemic on price setting at the CPI micro level. The pandemic and the measures to contain it greatly restricted business operations and consumer expenditures. Lacking real-time access to CPI micro prices, early studies resorted to other data sources to study firms' price-setting behavior in response to the COVID-19 shock. Balleer et al. (2020) use firm-level data from a monthly business tendency survey conducted in Germany. They document a dominant role of demand shortages in the short run, leading to a substantial rise in the probability of decreasing prices. Alvarez and Lein (2020) focus on online price data collected from Swiss online stores. They find that price adjustments were more frequent for food and non-alcoholic beverage items and less frequent for recreation and culture items during the lockdown in April 2020.

Our analysis of CPI micro prices covers a wide range of issues. In line with earlier studies, we find evidence of considerable price rigidity. The frequency of price changes is 26.9 percent, meaning that more than one in four prices change every month. Price increases (13.6 percent) and price decreases (13.4 percent) are equally frequent. Temporary sales and product substitutions are common in Swiss consumer prices and account for about two percentage points each of the frequency of price changes. Cross-sectoral heterogeneity is another prominent feature of price adjustment frequencies. Prices of energy and unprocessed food change most frequently while prices of services are adjusted relatively infrequently. Overall, consumer prices in Switzerland are more flexible than the euro area average (Gautier et al., 2021) but about as flexible as in the United States (Nakamura and Steinsson, 2008) if we disregard price changes related to temporary sales in the comparison with the United States.

We observe that price rigidity has weakened over time. The frequency of price changes increased steadily from 23.2 percent in 2008 to 31.4 percent in 2019. This development is not the result of a broad-based tendency toward more frequent price adjustments but rather reflects a significant increase in the frequency of price changes in a subset of the CPI. We show that products for which the FSO has moved to collect prices online are among the items with the largest increase in the price adjustment frequency. The greater price transparency and competition in online markets may explain why firms change prices more often. Estimating a fixed-effects model shows that average profit margins have a negative effect on the frequency of price changes. This supports the view that the rise of e-commerce has increased the frequency of price changes by increasing competition and reducing profits.

Turning to the size of price adjustments, we find that the average absolute size of price changes is 11.1 percent, and price decreases (11.6 percent) are slightly larger than price increases (10.5 percent). While excluding temporary sales leads to smaller absolute price changes (8.2 percent), excluding product substitutions barely affects the result (10.8 percent). At the sectoral level, price changes are particularly large for semi-durable goods (21.5 percent) and smallest for energy products (2.7 percent). In contrast to the frequency, the size of price changes moved relatively little over time: It was 11.9 percent in 2008 and 10.6 percent in 2019.

In assessing the contributions of the frequency and absolute size of price changes to variations in inflation, we find that variations in the size provide a larger contribution than variations in the frequency of price changes. However, the weak contribution of variations in the frequency of price changes largely reflects offsetting movements in the frequency of price increases and the frequency of price decreases. Considered separately, variations in the frequency of price increases and decreases contribute significantly to variations in inflation.

The synchronization of price changes also can have important macroeconomic consequences. Whether all firms change their prices simultaneously (synchronization) or only a fraction of firms adjust prices in every period (staggering) affects the propagation of nominal shocks. Staggering tends to amplify real effects. We find little synchronization of price changes of a given good across outlets. By contrast, the synchronization rate across goods (within a given outlet) is sizable. As firms adjust their prices, they tend to change them for multiple products simultaneously. This effect is weaker for smaller outlets than for larger ones.

Finally, the analysis of price-setting behavior after the outbreak of the COVID-19 pandemic shows that the overall response in price setting was modest, which is surprising in light of the unprecedented size of the shock. There are two reasons for the weak response of the aggregate frequency of price changes. First, responses varied widely across sectors, keeping the aggregate response muted. Second, the high uncertainty associated with the pandemic may have impeded price adjustments. At the aggregate level, prices were adjusted less frequently in spring 2020 compared to the preceding years. The frequency of price decreases, in particular, dropped with the onset of the crisis in spring 2020, driven by less frequent price decreases in the food sector. Regarding temporary sales, we find that the pandemic increased the frequency of sales in the non-energy industrial goods (NEIG) sector and decreased the frequency of sales in the food sector. Hence, temporary sales responded countercyclically to the respective demand conditions. This is consistent with the view that firms use their sales policy to adjust to aggregate shocks (e.g., Klenow and Willis, 2007; Kryvtsov and Vincent, 2021).

The remainder of this paper is organized as follows. Section 2 describes the microdata underlying the Swiss CPI. Section 3 presents our empirical evidence on price rigidity in Switzerland, focusing on the frequency and size of price changes. Section 4 analyzes how these two dimensions of price setting contribute to variations in inflation. Section 5 studies the synchronization of price changes. Section 6 examines the effect of the COVID-19 pandemic on price-setting characteristics. Section 7 concludes.

2 Data

The data consist of monthly price quotes collected by the FSO from January 2008 to December 2020 to construct the CPI for Switzerland.[2]

2.1 Price quotes

A price quote $P_{p,s,t}$ is the price of an individual product p sold in a particular store s in a given month t. Price quotes are transaction prices, i.e., the prices paid by consumers for a specific good or service, including indirect taxes, customs duties, environmental taxes, and subsidies. For each price quote, the FSO records the product category, the store, the year and month of price collection, the packaging size, and other attributes

[2]The data has been provided to the Swiss National Bank and the KOF Swiss Economic Institute at ETH Zurich by the Swiss Federal Statistical Office based on a confidentiality agreement and cannot be shared.

to be discussed below. This information allows us to track individual prices over time. We call the sequence of price quotes $(P_{p,s,t}, P_{p,s,t+1}, \ldots, P_{p,s,t+t_i})$ corresponding to one individual product collected in one specific outlet a "price spell."

The individual price quotes in a price spell can refer to different package sizes, i.e., the package size for a particular product can change over time. We use the information on the packaging unit to calculate the unit price of items to recover a consistent price per unit. This ensures that price changes due solely to changes in the package size are not counted as price changes.

While the FSO tracks the prices of products at the barcode level, the true identity of the products remains masked by narrowly defined product categories (e.g., seasoned rice specialties). These categories come from the basket of goods and services, which contains all products representing household consumption expenditure in Switzerland. The basket has followed the classification of individual consumption by purpose (COICOP) since May 2000.[3] It is divided into six hierarchical levels, which build on each other sequentially. At the top, it consists of twelve "main groups" (which correspond to the two-digit COICOP level), such as "Food and non-alcoholic beverages," "Clothing," or "Recreation and culture." Main groups are further divided into product groups, expenditure items, intermediate aggregates, and varieties. "Expenditure items" (five-digit COICOP level) correspond to the basket level for which the FSO publishes price indices and expenditure weights. "Varieties" (ten-digit COICOP level) correspond to the lowest level of the survey scheme and determine the categories for which the FSO collects prices of goods and services. The FSO defines varieties at the national level to account for the specifics of Swiss consumer behavior. In 2020, the basket consisted of 268 expenditure items and 1,188 varieties.

CPI weights account for the relative importance of the components of the basket of goods and services. The main source for weighting the basket components is the Household Budget Survey (HBS), conducted every year among private households with permanent residence in Switzerland. The FSO reweights the basket each year using the survey results from the previous two years.[4] CPI weights are available at the expenditure-

[3] The basket of goods and services is usually updated every five years, most recently in December 2020.

[4] Determining the CPI weights based on household survey results from the previous two years is almost always appropriate because consumption patterns do not change rapidly over time. However, the COVID-19 pandemic and the lockdown measures in 2020 abruptly changed consumption patterns for some time. Seiler (2020) uses debit card transactions data to recalculate CPI weights and construct an alternative "COVID inflation." He finds that during the lockdown in April 2020, COVID inflation was 0.6 percentage points higher than the CPI inflation rate suggested.

item level. We set the weight of an individual price quote equal to the weight of its expenditure item, divided by the number of quotes collected for that item. With this method, all products that belong to the same item will have equal importance in the aggregation. We use these weights to compute aggregate statistics.[5] The statistics at the expenditure-item level are unweighted averages.

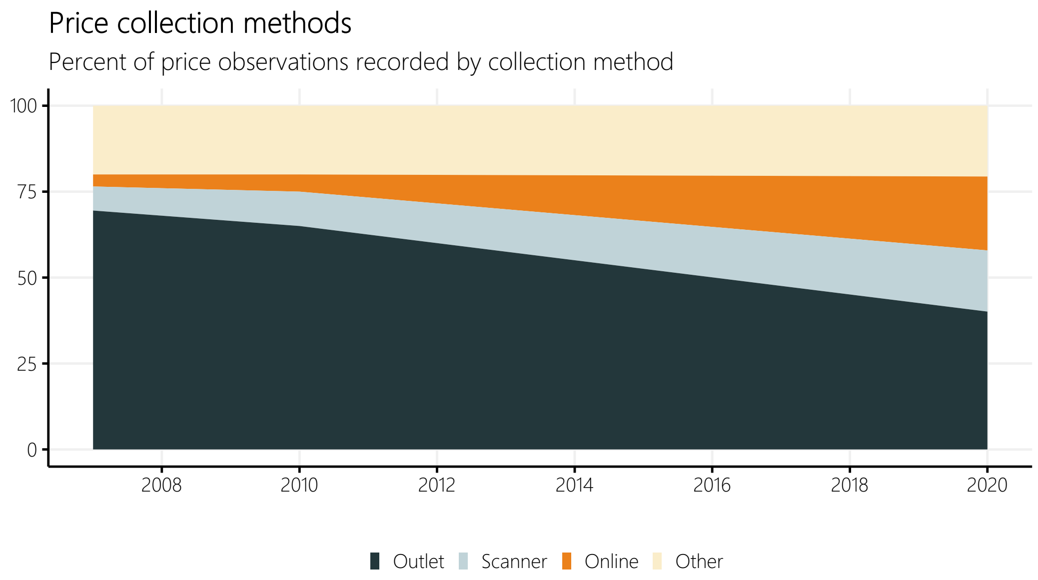

Figure 1: Development of price collection methods from 2008 to 2020. The figure shows the percentage of prices collected by each collection method. "Outlet" refers to the share of price quotes collected in stores. "Scanner" refers to prices collected as part of scanner data. "Online" refers to prices collected on the internet. "Other" includes prices collected by other means, such as paper forms, e-mail, telephone, online surveys, or secondary data sources. Sources: FSO (2021); Herren (2022).

Traditionally, the FSO has collected most prices directly in the outlets. This practice involves price collectors visiting the stores, finding the products to be collected, and recording their prices. Figure 1 shows the approximate shares of different price collection methods in the total of all price observations. The share of price observations recorded directly in stores has declined substantially over time. Fewer than half of all prices were still recorded directly in the stores in 2020.

In 2008, the FSO started collecting prices from major retailers through scanner data. Scanner data is generated in stores when the barcode printed on the products is scanned at the cash registers. Using scanner data in price collection reduces administrative efforts

[5] In this study, we use time-varying CPI weights like Klenow and Kryvtsov (2008). An alternative approach consists in using time-invariant CPI weights, like, for example, Nakamura and Steinsson (2008).

and increases the quality of the data. At the same time, it allows selecting the most representative products since it also includes sales information. The retailers collect their data continuously during the first 14 days of the month and transmit it to the FSO, which then calculates prices per item as an average of all transaction prices paid by consumers, including promotions. The FSO introduced scanner data in July 2008 and broadened the range of product categories for which prices are collected as scanner data in April 2010, April 2012, and December 2016. By 2020, it collected about 20 percent of all price quotes as scanner data. As shown in Figure A.1 in the appendix, most of these prices are prices for food and near-food products (including personal care, washing and cleaning products, and animal food).

More recently, the FSO started to collect prices on the internet to adapt the price survey to changes in consumer behavior. For selected local stores or chains that used to be surveyed in the field, the survey method was changed to an online collection if they have a reliable website. In addition, the FSO also takes into account outlets that only emerged with the rise of e-commerce. Some items have already been surveyed partly via the internet for quite some time. From January 2016 onwards, the FSO collected prices of consumer electronics, package holidays, and air transport. In 2020, about 20 percent of all collected prices came from the internet.

Today, the FSO collects most prices every month. The frequency of price collection changed significantly in January 2008, when the FSO started collecting most quarterly collected prices every month, as shown in Figure 2. Since then, it has collected only prices of a relatively small number of products at a lower than monthly frequency. These are products whose prices are known to change infrequently (e.g., rents), seasonal products for which the collection months are determined by availability (e.g., winter jackets), and products for which price changes are known in advance and widely communicated (e.g., postal services or public transportation).

In the empirical analysis, we characterize price-setting behavior through the properties of price changes (e.g., the frequency and size of price changes). We pay attention to the sensitivity of our results to price changes related to temporary sales and product substitutions. The following subsections explain how we identify temporary sales and product substitutions in the data and treat these phenomena in the analysis.

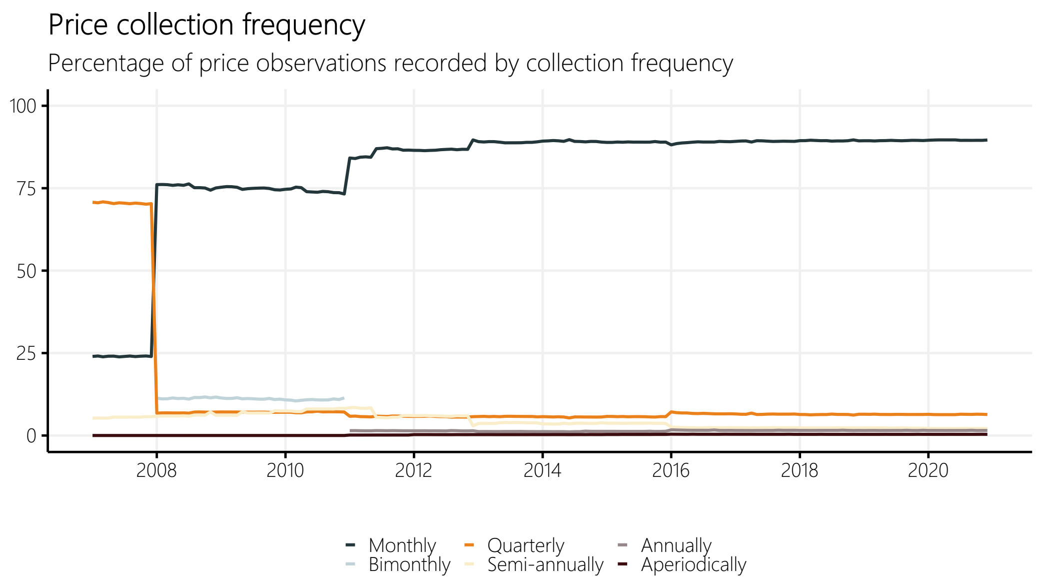

Figure 2: Development of price collection frequency from 2008 to 2020. The figure shows the percentage of prices collected at each frequency.

2.2 Temporary sales

A salient feature of price spells is their high-frequency variation due to temporary sales. Temporary sales involve price discounts for selected products over a limited period. Sales often reflect seasonal patterns rather than macroeconomic conditions. Therefore, it is instructive to distinguish between "posted prices" (prices including temporary sales) and "regular prices" (prices excluding temporary sales) and to analyze price changes in posted and regular prices separately. In the latter case, we exclude sale prices by replacing every sale price with the last observed non-sale price. The data allow us to identify sale prices because the FSO price collectors flag a price observation as a sale price if the discount is temporary and granted to all consumers without restriction.

A concern with the FSO flag for identifying sale prices is that it might be subject to measurement error. For example, a sale price might have been recorded as a regular price because the lower price was not indicated as a special offer on the product. To address this issue, we apply two different sale-filtering techniques as a robustness check in our empirical analysis: the symmetric V-shaped filter proposed by Nakamura and Steinsson (2008) and the running mode filter proposed by Kehoe and Midrigan (2015). The V-shaped filter deems a price change as temporary if the price returns to its original level within a certain window. If it fails to do so, the price is considered a regular price. The running mode filter removes temporary price increases and decreases by creating "regular" prices based on the modal price in a running window.

2.3 Product substitutions and price imputations

An important principle of price collection is to collect prices of the same items over time to capture the evolution of prices only. However, consumer markets evolve rapidly, and no single product will likely be observed over several years. It is common for items to change, for new items to enter the market while others disappear and need to be replaced, or for items to become temporarily or permanently unavailable. For these cases, the FSO has established rules for substituting products and accounting for quality adjustments (see FSO, 2016).

The most common types of product substitution include direct substitutions which apply to products that share the same features or are very similar (e.g., wines with different vintages), the chain method which applies to products that may have changed but whose primary function is the same (e.g., the mozzarella of another brand sells better than the one for which prices were collected so far), and non-replacement which applies if no other substitution technique can be used. Figure 3 shows the percentage of substituted products in the monthly collected prices of our sample. On average, direct substitution accounts for 1.8 percent of all price observations per month, non-replacement for 1.5 percent, and the chain method for only 0.3 percent. We also observe that substitutions of all types have become more frequent over time.

It is often instructive to analyze prices including and excluding price changes related to product substitution separately. In the first case, we assume that a price spell continues despite product substitution, taking potential quality adjustment into account. This procedure follows Klenow and Kryvtsov (2008) and is our baseline treatment. In the second case, we start a new price spell with every product substitution. Under this assumption, we exclude all price changes associated with product replacement.

A related concern are price imputations, meaning that a price is assigned to an item for which the price is missing in a given period. We attempt to exclude price imputations from our sample so they do not affect, for example, the share of price adjustments in a given month.

Some imputed prices cannot be identified and excluded from our sample. A case in point

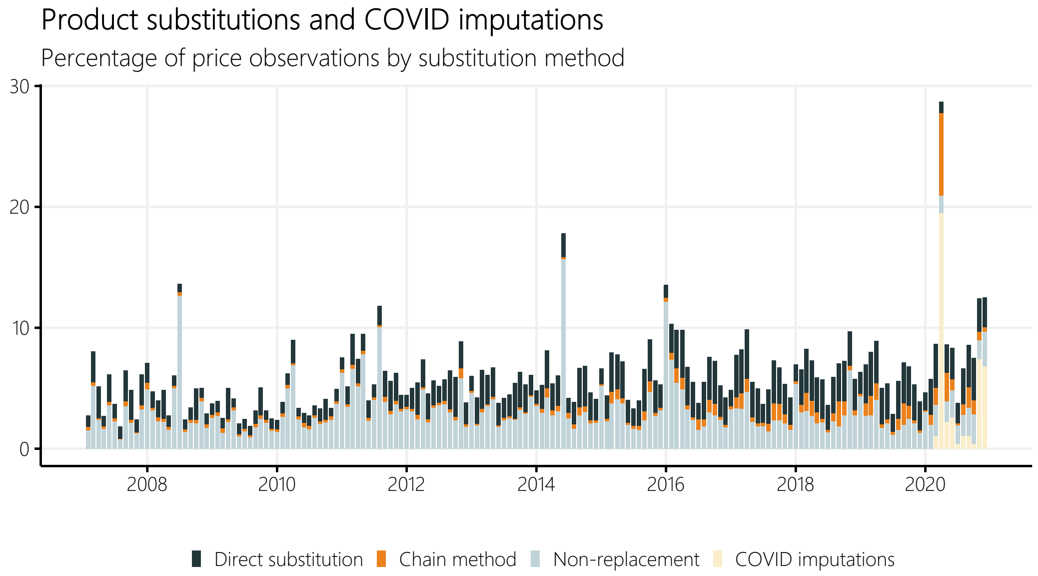

Figure 3: Development of product substitutions from 2008 to 2020. The figure shows the percentage of the most common types of product substitution in our sample. "Direct substitution" is used when the old and new products share the same features or are very similar. The new product replaces the previous one, and any price difference is considered fully. The "chain method" applies to products that may have changed but whose primary function is the same. Any price difference between the old and new product is split into a difference in quality and price, but only the price difference is included in calculating the CPI. "Non-replacement" occurs if no other substitution method is applicable. The price spell of the old product is discontinued, and a new price spell is started. No price comparison is made. "COVID imputations" are price imputations during the COVID-19 pandemic.

are the imputed prices of temporarily unavailable products. In these cases, the price of an item is updated by carrying forward the price of the previous period. Generally, prices may be updated this way not more than twice before the item needs to be replaced in the third month. Because the FSO does not flag price imputations at the level of individual price quotes, these kinds of imputed prices cannot be identified in our data set.

However, our data allow us to identify and exclude two other cases of imputed prices. The first are the imputed prices of seasonal products. Prices of seasonal products are collected only during their season. In the other months of the year, the last observed price is carried forward until the seasonal product is again scheduled for price survey.[6] On average, 15.4 percent of all price observations (representing 14.8 percent of total CPI expenditures) are carried forward in this way each month. We can identify these price

[6] If seasonal products are missing within their season or if the product in the following season is not identical to the product of the previous season (e.g., there is a new version of the winter jacket), the regular rules for product replacement apply.

imputations because every item in our data set comes with a flag indicating the months it is scheduled for price collection.

The second are price imputations during the COVID-19 pandemic. During that period, the FSO could only field a partial price collection in many areas. This is because many outlets and service providers were temporarily closed or unavailable (e.g., hairdressers or restaurants) and because there were acute stock availability issues due to unusually high demand or low supply (e.g., toilet paper). The FSO took various measures to maintain a local price survey wherever possible. For example, the field survey was replaced by an online survey for closed stores if stores had an online store. In these cases, the FSO replaced the products using the "chain method" and flagged the replacements as product substitutions in our data set. Where this was not possible, the FSO employed two imputation techniques depending on the number of missing prices. When the number of missing prices was high or the price changes within the same product category were large and relatively homogeneous, the imputed prices were set to reflect the movement in the observed prices of products belonging to the same product category. When the number of missing prices was low or the price changes within the same category were small, the last recorded price was carried forward, implying no price adjustment.

The FSO listed the expenditure items whose prices were partially or fully imputed during the COVID-19 pandemic in the monthly press releases on the Swiss CPI.[7] To capture all eventual imputations, we assume that all price observations of the affected items in any month were imputed. These observations are labeled "COVID imputations" in Figure 3. The figure indicates the important role of price substitutions and imputations during the COVID-19 pandemic in 2020.

2.4 Data treatment and sampling decisions

Our sample covers the period from January 2008 to December 2020, spanning 156 months. The beginning of this period is determined by the significant change in the price collection frequency, as illustrated in Figure 2 above. Prices of most goods and services were collected quarterly until December 2007 and monthly from January 2008 onwards. This allows us to consistently analyze monthly price changes over the period under consideration.

We exclude three types of observations a priori. First, we exclude imputed prices from

[7] Table A.1 in the appendix lists these items for each month of 2020. Table A.2 quantifies the extent of product substitutions and COVID imputations over the same period.

our sample. As shown in Section 2.3, although we cannot identify all imputed prices, we can identify the imputed prices of seasonal products in the off-season and the price imputations during the COVID-19 pandemic (March 2020 to December 2020). Second, we exclude items for which the FSO constructs auxiliary indices to track price movements rather than actual price quotes. Examples include rental prices or books. In total, there are 11 index-based items, which account for 27.8 percent of the CPI in 2020.[8] Third, we exclude items of administered and semi-administered prices, for they are set by government authorities and centrally collected.[9] Examples are electricity, public transport services, or medicines. In total, there are 18 items of administered and semi-administered prices, which account for 23.1 percent of the CPI in 2020.[10]

By excluding price observations reflecting indices and administered or semi-administered prices, we exclude items for which measurement errors are frequent. However, measurement errors raise concerns beyond these two restrictions.[11] Therefore, we further treat our data as follows. First, we correct quantities for measurement errors when quantity changes are greater than a factor of 10 (or smaller than a factor of 1/10) and apply a carry-forward procedure to replace errors in quantities. We do this because changes in the measurement unit affect the unit price of items. This procedure corrects as few as 204 observations in the data set. Second, we remove price changes greater than the 99th percentile of absolute log price changes and smaller than the 1st percentile for every variety.[12] As a result, we drop fewer than 2 percent of all price changes.

Table 1 summarizes the effects of our sampling decisions on our data sample. The baseline data sample contains 7.4 million price quotes from over 163,000 price spells. They spread over 241 expenditure items and nearly 1,300 varieties. The sample covers 56.3 percent of the CPI basket in 2020. The largest expenditure items excluded are

[8]Items of index-based price observations are: Housing rentals; Rental of garages, parking spaces; Medicines; Medical services at local surgery; In-patient hospital services; Public transport: direct service; Public transport: combined services; Postal services; Personal computers; Books and brochures; Private health insurance.

[9]"Administered prices" cover the prices of goods and services which are fully set or mainly influenced by the government. "Semi-administered prices" cover the prices of goods and services on which the government, including any national regulator, has a significant influence.

[10]Items of administered and semi-administered prices are: Taxes for provision of the apartment; Gas; Electricity; Remote heating; Other services in respect of personal transport equipment; Public transport services by rail and road; Postal services; Entries in sports facilities; Fees for radio and TV reception; Social protection services; Medicines; Medical services; Other medical services; Hospital services; Taxi; Basic academic and vocational education; Higher vocational education and universities; Insurance.

[11]See Eichenbaum et al. (2014) and Appendix B.2 for a discussion of measurement errors in small price changes.

[12]In Table B.8 in the appendix, we discuss the sensitivity of our price-setting moments to alternative thresholds for trimming price changes in our data sample.

Table 1: Summary statistics of the data sample covering the period from January 2008 to December 2020 after applying our sampling decisions.

	Jan 2008 – Dec 2020	CPI weight 2020 (%)
Price quotes		
Total	7,405,138	56.3
Average per month	47,469	
Price spells	163,320	
Temporary sales	364,758	
Substitutions	255,745	
Outlets	3,213	
Expenditure items	241	
Varieties	1,268	
Sample composition (%)		
Food	32.9	12.8
NEIG	46	18.7
Energy	2.2	3.8
Services	18.9	21.0

rents and homeowners' imputed rents, health services, and transportation services, whose average weights in the CPI are 23 percent, 14 percent, and 3 percent. The broad coverage of our data set allows us to calculate indicators of price rigidity that are representative of consumer goods and services.

3 Evidence on the frequency and size of price changes

This section presents our results on the frequency and size of price changes in Switzerland from January 2008 to December 2020. We examine these characteristics of price-setting behavior from both a cross-sectional and time-series perspective.

3.1 The frequency of price changes

The frequency of price changes for variety i in month t is defined as

$$f_{i,t} = \frac{\sum_{p,s} \omega_{p,s,t} I_{p,s,t}}{\sum_{p,s} \omega_{p,s,t}}, \tag{1}$$

where $I_{p,s,t}$ is an indicator that takes the value 1 if the price of product p of variety i in outlet s has changed from the previous month $t-1$, and 0 otherwise. The weight $\omega_{p,s,t}$ is calculated as the CPI share of variety i divided by the number of prices collected for that variety in month t. The frequency of price changes thus captures the share of prices that change in a given month. By analogy, we calculate the frequency of price increases, $f^+_{i,t}$, by considering only price increases in the price change indicator, $I^+_{p,s,t}$, and the frequency of price decreases, $f^-_{i,t}$, by considering only price decreases in the price change indicator, $I^-_{p,s,t}$. The aggregate frequency of price changes, f_t, is the weighted average frequency across varieties using CPI expenditure weights.

Table 2 provides average statistics on the frequency of price changes from January 2008 to December 2020. To assess the sensitivity of our results to the treatment of temporary sales and product substitutions, the table also presents results for the average frequency of price changes when we exclude these types of price changes from the data.

Table 2: Frequency of price adjustments

	Frequency of price adjustments			
	Changes f	Increases f^+	Decreases f^-	Share of Increases
Including sales, including substitutions				
Mean	26.9	13.6	13.4	54.7
Median	15.2	5.9	5.0	
Std. dev.	30.6	20.1	21.3	
Excluding sales, including substitutions				
Mean	25.1	12.7	12.4	55.5
Median	11.1	4.5	3.5	
Std. dev.	30.9	20.1	21.3	
Including sales, excluding substitutions				
Mean	24.9	12.4	12.5	54.6
Median	12.8	4.7	4.1	
Std. dev.	30.1	19.6	21.1	
Excluding sales, excluding substitutions				
Mean	23.1	11.7	11.4	56.0
Median	8.8	3.5	2.4	
Std. dev.	30.5	19.7	21.1	

Notes: The sample ranges from January 2008 to December 2020. The frequency of price "changes," "increases," and "decreases" refer to the weighted averages of the share of price changes, increases, and decreases, respectively. The mean frequency of price changes is calculated by first computing the frequency of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Median statistics and statistics of standard deviations are calculated analogously. "Share of increases" refers to the share of price increases in all price changes. Frequencies of price adjustments are reported in percent per month.

We first focus on our baseline sample, which includes temporary sales and product substitutions. The mean frequency of price changes is 26.9 percent from January 2008 to December 2020. Hence, more than one in four prices changes every month. This result suggests that price rigidity is a pervasive feature of consumer prices in Switzerland: Prices are sticky and do not change continuously. Price increases (13.6 percent) are about as frequent as price decreases (13.4 percent). More than half of all price changes are price increases (54.7 percent). The median frequency of price changes (15.2 percent) is significantly lower than the mean, implying that the distribution of the frequency of price changes is right-skewed.[13] The standard deviation of variety-level adjustment frequencies is large (30.6 percent), which indicates considerable heterogeneity in the frequency of price changes.

Temporary price reductions due to sales contribute significantly to the frequency of price changes.[14] Price changes due to temporary sales are very frequent: 9.2 percent of all price changes are temporary sales.

We can calculate the frequency of price changes without sale prices by replacing any price identified as a sale price with the last non-sale price. As a result, the mean frequency of price changes drops by 2 percentage points from 26.9 percent to 25.1 percent, while the median frequency is reduced by 4 percentage points from 15.2 percent to 11.1 percent. Thus, price changes related to sales are an important aspect of price setting. As shown in Appendix B.1, these results are not very sensitive to the method used to identify and filter temporary sales.[15]

Product substitutions are another factor affecting the frequency of price changes. Disregarding price adjustments associated with product substitutions decreases the mean frequency of price changes by 2 percentage points, from 26.9 percent to 24.9 percent. Studies on US data find similar results: Excluding product substitutions reduces the mean frequency of price changes from 27.7 percent to 26.5 percent (Nakamura and Steinsson, 2008) and from 26.1 percent to 23.6 percent (Bils and Klenow, 2004). Nakamura and Steinsson (2012) point out that firms may wait for product replacements to

[13] Kaufmann (2009) reports a median frequency of price changes of 15.4 percent in Swiss CPI microdata from 2000 to 2005. However, comparing this finding with our result does not carry much practical significance because the former is based on quarterly data and therefore assumes that prices change at most once per quarter.

[14] About 4.3 percent of all price quotes are flagged by the FSO as sales (see Table 1). Temporary sales are less frequent in Switzerland than in the US. Klenow and Kryvtsov (2008) find that about 11 percent of price records are sales, and Nakamura and Steinsson (2008) find a share of 7.4 percent. However, temporary sales are more frequent in Switzerland than in some euro area countries. For example, 2.5 percent of the observations are related to temporary sales in France (Berardi et al., 2015). That being said, results may be influenced by the fact that national statistical offices apply different rules for classifying a price as a sale price.

[15] We assess the robustness of our results to alternative sale filters by applying the symmetric V-shaped filter proposed by Nakamura and Steinsson (2008) and the running mode filter proposed by Kehoe and Midrigan (2015). Table B.1 in the appendix shows that the mean frequency of price changes is 25.1 percent and 20.1 percent if the price data are filtered by the V-shaped sale filter with a 1-month and 3-month window, and 24.1 percent if the data are filtered by the running mode filter with a 3-month window. Except for the case of the V-shaped filter with a 3-month window, these results are close to those reported in Table 2 (25.1 percent) where temporary sales are identified by the FSO sale flags.

change their prices because the cost of price adjustment is low at this moment.[16]

Eichenbaum et al. (2014) emphasize the role of measurement problems that lead to spurious small price changes in CPI microdata. They identify 27 items as problematic in the US CPI. We are able to match 20 of these 27 items with their counterparts in the Swiss data. Table B.3 in the appendix reports results on the frequency of price adjustment excluding these 20 items. The mean frequency of price adjustment is 27.7 percent, compared to 26.9 percent using our baseline sample (Table 2). The difference is small, consistent with the view that most prices identified as problematic by Eichenbaum et al. (2014) have been removed by our sampling decisions for our baseline sample (see Section 2.4).

Heterogeneity in the frequency of price changes across sectors

There is substantial cross-sectional heterogeneity in the frequency of price changes. Figure 4 shows the distribution of the frequency of price changes across varieties. Most product categories have adjustment frequencies of up to 25 percent per month. However, the distribution has a long right tail, showing a non-negligible share of products with significantly higher frequencies of price changes.

Table 3 shows the average frequency of price changes for various sectors. These sectors are food, non-energy industrial goods (NEIG), energy, and services, together with subcategories. The sectors and subcategories correspond to the COICOP-HICP special aggregates defined by Eurostat. Prices in the energy sector are adjusted most frequently (mean frequency of 86.6 percent), while the frequency of price changes is lowest for services (17.1 percent). The large difference is likely due to differences in the volatility of input prices. Prices of energy goods like fuel or heating oil depend not only on the world market price of crude oil but also on the exchange rate, which fluctuate daily and often widely. For services, by contrast, the largest input factor is labor, whose price tends to be fixed in long-term contracts and does not vary much in the short run.

Among food products, the mean frequency of price changes is more than twice as large for unprocessed foods (46.4 percent) as for processed foods (21.4 percent). Again, the high frequency of price changes for unprocessed food is likely due to the strong dependence of these prices on world market prices and exchange rates. Similarly, the frequency of price

[16] In Switzerland, about 3.4 percent of all price quotes are accompanied by a product substitution (see Table 1). Klenow and Kryvtsov (2008) and Bils and Klenow (2004) report similar shares of 3.0 percent and 3.4 percent for the US.

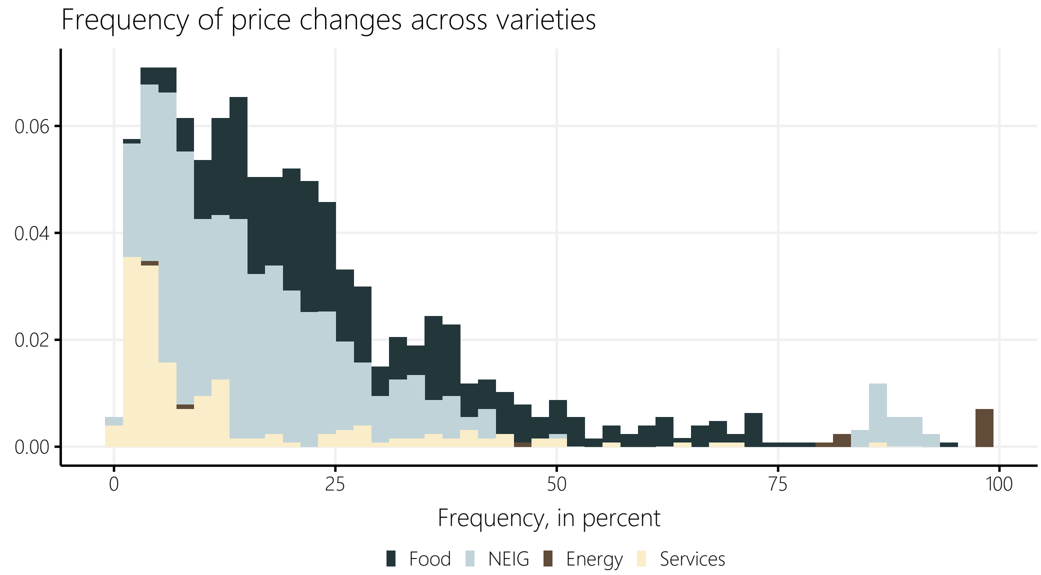

Figure 4: Distribution of the frequency of price changes across varieties in the Swiss CPI from January 2008 to December 2020. The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions.

changes for durable goods (27.4 percent) is more than twice as large as for non-durable goods (12.4 percent). The high frequency of price changes for durable goods might be due to the fact that they are often sold in highly competitive retail markets with low profit margins.

Temporary sales and product substitutions contribute to varying degrees to the frequency of price changes in different sectors. As shown in Table 3, temporary sales account for 5.4 percent and product substitutions for 4.1 percent of all price observations in the goods sector. By contrast, the share of sales is comparatively low in the food sector and close to zero in the services and energy sectors.

Frequency of price changes over time

We now turn to the time-series evidence on the frequency of price changes and examine how firms have changed their prices over time. Figure 5 illustrates the cross-sectional distributions of the frequency of price changes from January 2008 to December 2020. For each month, the figure shows the mean, the median, the interquartile range (dark-shaded area), and the 15th–85th percentile range (light-shaded area) of the frequency of

Table 3: Frequency of price adjustments by sector

	Coverage	Mean frequency of price adjustments			Median frequency of price adjustments			Sales	Substitution
		Changes f	Increases f^+	Decreases f^-	Changes f	Increases f^+	Decreases f^-		
Food	12.8	27.7	14.6	13.2	24.0	11.4	9.8	1.4	1.2
Unprocessed food	3.3	46.4	23.3	23.1	43.6	20.5	20.0	1.7	2.4
Processed food	9.5	21.4	11.6	9.8	18.8	9.1	7.7	1.3	0.8
NEIG	18.6	21.6	9.4	12.2	13.3	4.9	5.3	5.9	4.1
Durable goods	8.6	27.4	10.9	16.6	16.4	5.2	6.1	5.4	4.0
Semi-durable goods	7.6	16.8	8.2	8.6	12.2	4.6	5.4	7.9	5.5
Non-durable goods	2.4	12.4	7.0	5.4	10.2	5.1	3.8	2.0	0.8
Energy	3.8	86.6	44.3	42.3	97.3	46.7	45.5	0.2	0.1
Services	21.0	17.1	9.5	7.6	3.4	2.0	0.0	0.2	3.9
Housing	1.6	24.3	16.3	8.0	22.6	14.1	5.9	0.0	1.0
Transport	1.8	58.9	32.3	26.6	72.1	36.9	30.4	0.0	4.5
Communication	2.7	7.7	4.6	3.1	0.0	0.0	0.0	0.0	2.7
Recreation	14.0	15.2	8.3	6.9	3.6	2.5	0.0	0.2	4.3

Notes: The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions. “Coverage” indicates the average CPI expenditure weight of the sector over the sample period. The frequency of price “changes,” “increases,” and “decreases” refer to the weighted averages (medians) of the share of price changes, increases, and decreases, respectively. The frequency of price changes is calculated by first computing the frequency of price changes for each variety and then taking a weighted mean (median) across all varieties by sector using CPI expenditure weights. “Sales” denotes the share of sale price observations in all price quotes. “Substitution” denotes the share of product substitutions in all price quotes. Frequencies of price adjustments are reported in percent per month. Sectors correspond to the COICOP-HICP special aggregates by Eurostat. Food includes alcohol and tobacco. Services correspond to the overall index excluding goods (i.e., food, non-energy industrial goods, and energy). Services related to recreation also include repairs and personal care.

price changes calculated across varieties.

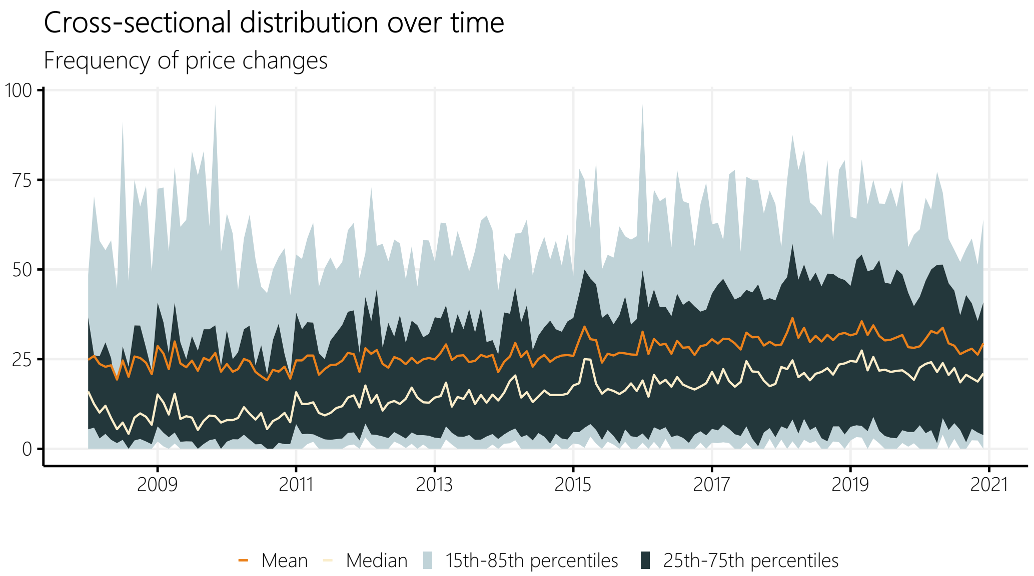

Figure 5: Distribution of the frequency of price changes across varieties in Swiss CPI microdata. The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions. The figure depicts the mean, the median, the interquartile range (dark-shaded areas), and the 15th-85th percentile range (light-shaded areas). The frequency of price changes is reported in percent per month.

Three observations stand out. First, the frequency of price changes varies considerably over time and shows some distinct peaks and troughs. Some of these periods have straightforward explanations. For example, the substantial increase in the frequency of price changes in early 2015 most likely reflects the effect of the marked Swiss franc appreciation following the decision of the Swiss National Bank (SNB) to discontinue the minimum exchange rate for the Swiss franc against the euro.[17]

Second, the average frequency of price changes increases slightly but steadily from 23.2 percent in 2008 to 31.4 percent in 2019, implying that price changes have become more flexible on average. This finding is robust to alternative data treatments (e.g., the exclusion of temporary sales or product substitutions), methodological changes in price collection (i.e., changes in the basket composition, changes in the price collection frequency, or the introduction of scanner data), and the use of constant rather than time-varying basket weights when aggregating item-level frequencies of price changes (Figure B.1 in

[17] The SNB enforced a minimum exchange rate of 1.20 CHF per EUR from 6 September 2011 to 15 January 2015. After the discontinuation of the minimum exchange rate floor, the Swiss franc appreciated sharply before stabilizing at around 1.10 CHF per EUR in 2015 and 2016.

the appendix). Furthermore, we find that the increase in the frequency of price changes is not the result of an increase in the number of goods sold per outlet (Figure B.2 in the appendix).

Third, the interquartile range of price adjustment frequencies widens over time. In particular, the 75th percentile increases more than the 25th percentile. This suggests that the increase in the average frequency is not the result of a broad-based tendency towards more frequent price changes but a marked increase in price adjustment frequencies in a subset of the CPI.

To illustrate which components of the CPI are responsible for this increase in the overall frequency of price adjustment, Figure 6 shows the distribution of item-level frequencies for four sectors (food, NEIG, services, and energy) over the periods 2008 to 2010 and 2017 to 2019.[18]

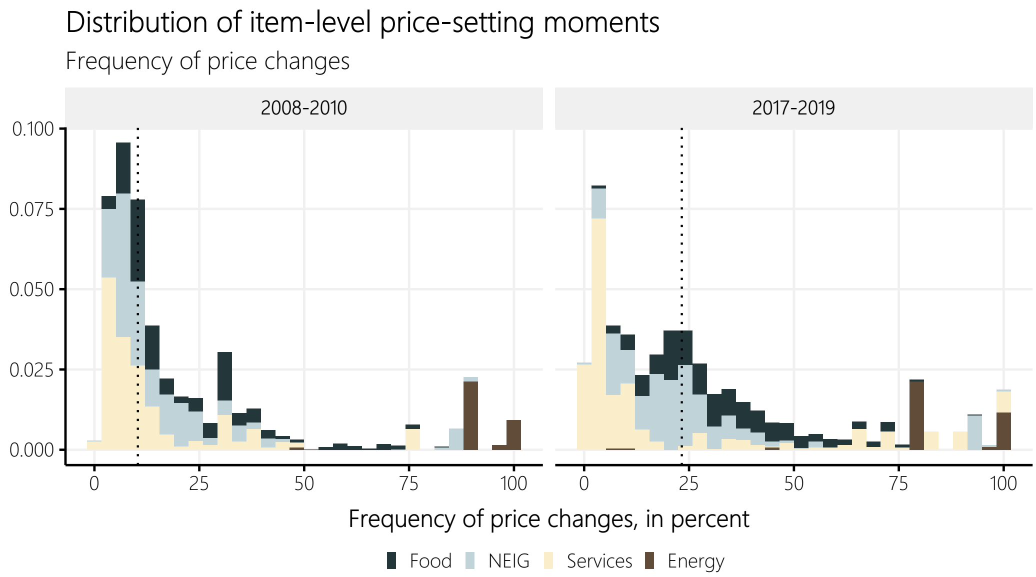

Figure 6: Distribution of the frequency of price changes across expenditure items from January 2008 to December 2010 (left panel) and from January 2017 to December 2019 (right panel). The samples include price changes due to temporary sales and product substitutions. Contributions of sectors (food, goods, services, and energy) are weighted by constant CPI expenditure weights across periods. The vertical dotted lines show the median frequency of price changes.

The comparison of the sectoral distributions shows that the frequency of price changes increased most visibly in the food and NEIG sectors. On average, it increased from

[18]We omit 2020 to exclude the effect of the COVID-19 pandemic on the result.

Table 4: Frequency of price adjustments by sector: 2008–2010 and 2017–2019

	N	Frequency of price adjustments			CPI weight
		Changes	Increases	Decreases	
2008–2010					
Food	66	20.3	10.9	9.4	12.9
NEIG	79	16.6	7.2	9.4	20.4
Services	35	12.8	8.1	4.7	20.6
Energy	4	92.6	48.6	44.0	4.5
2017–2019					
Food	79	32.6	17.2	15.4	13.5
NEIG	95	26.2	12.8	13.4	17.5
Services	45	23.4	12.3	11.1	21.2
Energy	5	83.2	46.7	36.5	3.3

Notes: The samples range from January 2008 to December 2010 and from January 2017 to December 2019 and include price changes due to temporary sales and product substitutions. "N" denotes the number of expenditure items. The frequency of price "changes," "increases," and "decreases" refer to the weighted averages of the share of price changes, increases, and decreases, respectively. The frequency of price changes is calculated by first computing the frequency of price changes for each variety and then taking a weighted mean across all varieties by sector using CPI expenditure weights. Frequencies are reported in percent per month.

20.3 percent to 32.6 percent for food items and from 16.6 percent to 26.2 percent for NEIG (see Table 4). This increase is substantial, as both sectors account for more than half of our sample by expenditure weight. For services, we note a marked increase at both tails of the distribution. Nevertheless, the average frequency of price changes for services increased substantially from 12.8 percent in the period 2008 to 2010 to 23.4 percent in the period 2017 to 2019. At the same time, the average frequency of price changes declined for energy goods (from 92.6 percent to 83.2 percent).

Among the products with the largest increase in price adjustment frequencies are those for which e-commerce has become a major retail channel over the last decade. In Switzerland, sales in online and mail-order business more than doubled from CHF 5.1 billion in 2010 to CHF 10.3 billion in 2019, while retail sales in brick-and-mortar stores declined from CHF 91.1 billion to CHF 81.3 billion over the same period.[19] The online share varies considerably across product groups. By far the largest share is accounted for by consumer electronics. In 2010, around 15 percent of all consumer electronics items were sold over the internet. In 2019, the share amounted to 36 percent.

The FSO accounts for these changes in consumer behavior and shopping habits of Swiss households by collecting an increasing share of prices online. Since January 2016, the

[19] The data are assembled as part of the overall market survey for online retail in Switzerland by HANDELSVERBAND.swiss together with GfK and in cooperation with Swiss Post (HANDELSVERBAND.swiss, 2022).

prices of consumer electronics have been collected exclusively via the internet.[20] Figure 7 illustrates the effect of the methodological change in the collection of consumer electronics prices on their frequency of price changes. Since prices are collected exclusively online, the frequency of price changes has more than doubled. This discontinuity indicates that price-setting behavior differs greatly depending on the sales channel (online versus stationary retail). A similar picture emerges for international package holidays and air transport, the only other items for which the FSO switched to collecting prices exclusively online. For these items, the frequency of price changes increased by a factor of 4.1 and 1.3, respectively, in early 2016.

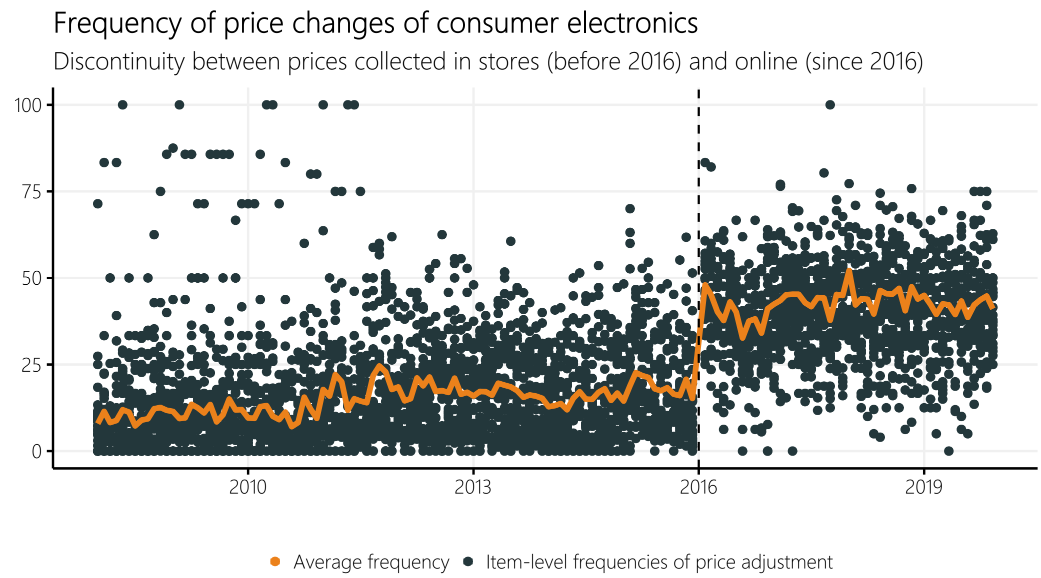

Figure 7: Item-level frequencies of price adjustments of consumer electronics items. The sample ranges from January 2008 to December 2019 and includes price changes due to temporary sales and product substitutions. The prices of consumer electronics items have been collected exclusively via the internet as of January 2016 (and previously in regular outlets and only partially online).

The rising share of online prices in CPI microdata is not the only channel through which online prices affect the average frequency of price changes. Another channel goes through the effect of the rise of e-commerce on the price-setting behavior of stationary retailers. Because stationary retailers and online platforms compete with each other, the

[20]Consumer electronics includes the following items: telecommunication equipment; television sets; audiovisual appliances; photographic, cinematographic equipment and optical instruments; IT peripheral devices and accessories; computer software; storage devices and contents; games, toys and hobbies; game consoles and electronic games.

higher frequency of changes in online prices is likely to affect the price-setting behavior of stationary retailers as well. For many NEIG expenditure items, the FSO collects prices both in-store and online.[21] However, our data do not allow us to quantify the relative importance of the two channels. The reason is that we do not know whether a price observation has been collected from a stationary retailer or an online platform, except for prices for consumer electronics, air transport, and package holidays since January 2016 (FSO, 2016).

The evaluation of the frequency of price adjustments over time suggests that the increased consideration of prices from online markets, where price adjustment frequencies are higher, has contributed to the observed increase in the overall frequency of price changes. Earlier studies found related results in other data sets. Using web-scraped prices from multi-channel retailers in the US, Cavallo (2018a) documents that the aggregate frequency of price changes has been increasing between 2008 and 2017. Gorodnichenko and Talavera (2017) and Gorodnichenko et al. (2018b) show that prices in online marketplaces are far more flexible than the micro prices collected in stores. Cavallo (2018a) investigates how online competition affects price-setting behavior and provides evidence that prices of goods that can easily be found on Amazon tend to be adjusted more frequently. He states that these results are consistent with intense online competition characterized by low margins, dynamic pricing technologies and price transparency on the internet. By uncovering similar trends in our data, we document the role of online retailing as a source of greater price flexibility in micro price data underlying a national CPI.

Determinants of the frequency of price changes

This section examines the effect of profits, inflation, and other variables on the frequency of price changes. We have seen above that the price adjustment frequency appears to be higher for online prices than for prices collected in-store. As pointed out by Cavallo (2018a), this difference may reflect the comparatively high degree of competition in e-commerce. Standard economic theory suggests that intense market competition results in smaller profits. Therefore, we approximate the degree of competition by profit margins.

[21] An example are consumer electronics before 2016. Other examples are clothing, footwear, or home furnishing items (FSO, 2016).

We estimate a fixed-effects model of the form

$$f_{j,t} = \alpha + X_{j,t}\beta + \mu_j + \nu_{j,t}, \tag{2}$$

where $f_{j,t}$ denotes the monthly frequency of price changes for expenditure item j, the matrix $X_{j,t}$ summarizes the explanatory variables, μ_j captures unobservable time-invariant, individual-specific effects, and $\nu_{j,t}$ are independent and identically distributed disturbances with mean zero and variance σ_ν^2.

The explanatory variables include an estimate of the average profit margin per expenditure item ($\text{Profit}_{j,t}$), core inflation (Core_t), year-on-year changes in world commodity prices (P_t^*), the absolute size of the output gap ($|Y_t|$), and a measure of fluctuations in the EURCHF exchange rate ($|\Delta\text{EURCHF}_t|$). In addition, a set of dummy variables controls for monthly seasonality, the introduction of scanner data, and changes in the value-added tax (VAT) rate.[22]

The profit margins are defined as net profits in percent of revenue. They are approximated based on annual data at the NACE Rev. 2 division level from the production and value-added statistics published by the FSO.[23] These profits include not just profits at the retail level but also the profits further upstream. Therefore, the profit margins used in the estimation of Equation (2) are not more than approximations of the true profit margins of retailers.

We estimate Equation (2) in monthly data from January 2008 to December 2020, excluding temporary sales, product substitutions, and energy items. Table 5 shows the estimation results for the full sample (Column 2) and separately for the sectors food, NEIG, and services (Columns 3 to 5).

[22] In January 2011, the VAT rate was temporarily increased from 7.6 percent (3.6 percent for basic human needs services) to 8.0 percent (3.8 percent) to contribute to the financing of Switzerland's Disability Insurance. In January 2018, this additional financing expired, and the VAT rate was set to 7.7 percent (3.7 percent).

[23] The data on net profits and revenues are annual observations from 2008 to 2018. For the last two years, 2019 and 2020, we extrapolate the 2018 data at a constant rate. We bridge these data from the General Classification of Economic Activities (NACE) over the European Classification of Products by Activity (CPA) into the Classification of Individual Consumption by Purpose (COICOP) within the international, integrated system of statistical classifications using an unweighted correspondence table (from CPA Ver. 2 to COICOP 1999) provided by Eurostat. For example, the expenditure item "Butter" (1285) belongs to the COICOP category "Oils and fats" (01.1.5), which maps into 16 distinct CPA subcategories, such as "Fats of bovine animals, sheep, goats or pigs" (10.11.50), "Olive oil, crude" (10.41.23) or "Margarine and similar edible fats" (10.42.10) – all of which in turn are part of NACE division "Manufacture of food products" (10). Thus, profit margins associated with "Butter" are determined by the average profit margins of NACE division "Manufacture of food products."

Table 5: Factors affecting the frequency of price changes

	Dependent variable:			
	Frequency of price changes			
	All sectors	Food	NEIG	Services
$\text{Profit}_{j,t}$	-0.037^{***}	-0.042^{***}	-0.082^{***}	-0.038^{**}
	(0.011)	(0.011)	(0.027)	(0.015)
Core_t	1.193^{***}	1.032	0.859^{***}	2.145^{**}
	(0.444)	(0.689)	(0.245)	(0.919)
P_t^*	-0.038^{**}	-0.046^{*}	-0.013	-0.027
	(0.016)	(0.025)	(0.008)	(0.028)
$\lvert Y_t \rvert$	0.027	0.006	0.099^{***}	-0.015
	(0.020)	(0.027)	(0.015)	(0.058)
$\lvert\Delta\text{EURCHF}_t\rvert$	0.041	0.036	0.097^{**}	-0.045
	(0.091)	(0.134)	(0.047)	(0.150)
Month	Yes	Yes	Yes	Yes
VAT	Yes	Yes	Yes	Yes
Scanner	Yes	Yes	Yes	No
Observations	22,414	9,706	10,152	2,556
R^2	0.119	0.289	0.027	0.026
Adjusted R^2	0.110	0.282	0.017	0.011
F Statistic	157.718^{***}	205.524^{***}	15.511^{***}	4.008^{***}

Notes: Fixed-effects estimation in monthly data from January 2008 to December 2020, excluding energy items and price changes due to temporary sales and product substitutions. Frequencies of price changes at the expenditure item level ($f_{j,t}$) are calculated based on CPI prices for food, NEIG, and services. Profit margins ($\text{Profit}_{j,t}$) are annual profit margins approximated from the NACE division level. Core inflation (Core_t) is the year-on-year inflation rate of the CPI excluding fresh and seasonal products, energy, and fuel. Growth in commodity prices (P_t^*) is year-on-year percentage change in the Thomson Reuters Core Commodity CRB Index. Output gap ($\lvert Y_t \rvert$) is the percentage deviation of real GDP from HP-filtered real GDP. Exchange rate fluctuations ($\lvert\Delta\text{EURCHF}_t\rvert$) are the cumulative absolute percentage changes in EURCHF exchange rate over the last three months. SCC-adjusted standard errors reported in parentheses: *p<0.1; **p<0.05; ***p<0.01

We find that profit margins ($\text{Profit}_{j,t}$) have a statistically significant negative effect on the frequency of price changes.[24] This result holds for the total and the three individual sectors. Figure 8 plots the cumulative change in the frequency of price changes for each expenditure item from 2008 to 2020 against the corresponding change in the profit margin. The negative relationship is apparent, in particular for NEIG expenditure items. This result is consistent with the view that the rise of e-commerce, by increasing competition and reducing profit rates, positively affected the frequency of price adjustments.

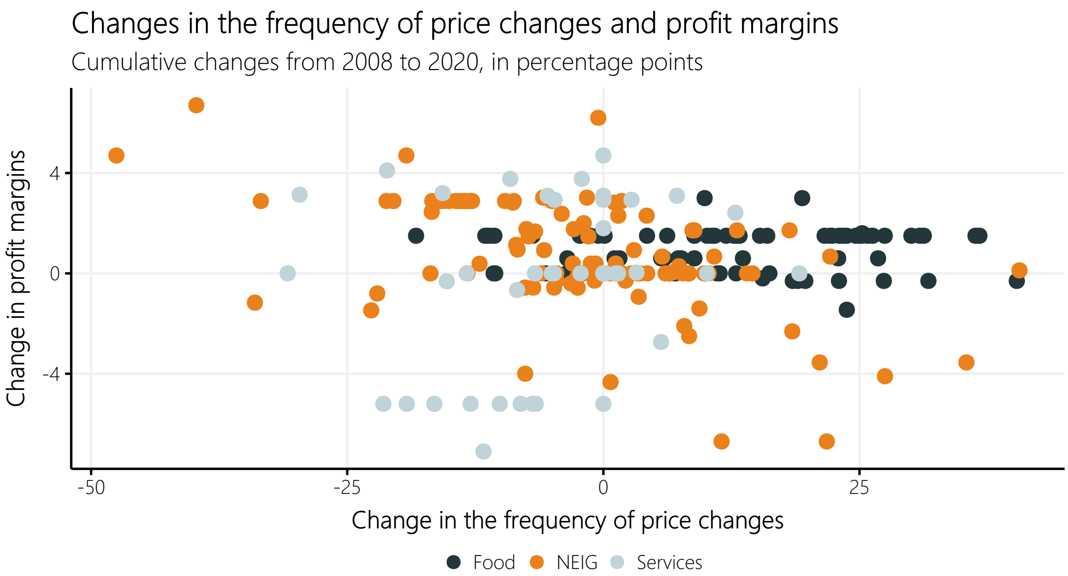

Figure 8: Cumulative changes in the profit margins and the frequency of price changes from January 2008 to December 2020 (in percentage points). The sample excludes energy items and price changes due to temporary sales and product substitutions. Each point refers to one expenditure item.

With respect to the coefficients on the other explanatory variables, we find that the frequency of price change increases with the core inflation rate. Menu cost models imply that higher inflation induces firms to adjust their prices more frequently. During the period under review, core inflation was low and stable, averaging around 0.5 percent. Therefore, it cannot explain the observed upward trend in the average frequency of price

[24] In Table B.6 in the appendix, we report results on the influence of the same set of variables on the size of price changes.

adjustments.[25] The parameter measuring the effect of the absolute value of the output gap and the absolute changes in the EURCHF exchange rate are all positive, consistent with standard menu cost models. However, they are only significant for the NEIG sector.

3.2 The size of price changes

Turning to the size of price changes, we define the average size of price changes for variety i, $\Delta p_{i,t}$, as the mean of all non-zero log price changes in month t. Absolute values of log price changes are used for the average absolute size of price changes, $|\Delta p_{i,t}|$. Similar to the analysis of the frequency of price changes, we also consider the size of price increases, Δp_t^+, and the size of price decreases, Δp_t^-. The aggregate size of price changes in month t, Δp_t, is the weighted average size across varieties using CPI expenditure weights.

Table 6 provides average statistics on the size of price changes from January 2008 to December 2020. The table presents results for the average size of price changes using the samples with and without temporary sales and product substitutions.

We first focus on our baseline sample, which includes temporary sales and product substitutions. The average size of absolute price changes is 11.1 percent from 2008 to 2020, with price increases averaging 10.5 percent and price decreases averaging 11.6 percent. The median size of absolute price changes is much smaller at 7.8 percent (with price increases averaging 7.0 percent and price decreases averaging 8.2 percent).[26]

Excluding sale prices reduces the average absolute size of price changes substantially by about 3 percentage points (Table 6).[27] The standard deviation also turns out to be smaller, suggesting that sale-related price changes are larger than regular price changes. When we exclude substitution-related price changes, the average absolute size of price changes is marginally smaller than in the baseline sample. Average price increases are half a percentage point smaller (9.9 percent versus 10.5 percent). In contrast, average price decreases are almost the same as in the baseline data set (11.3 percent versus 11.6

[25]Studies focusing on periods with high and volatile inflation often identify rising (falling) trend inflation rates as the main factor behind trend increases (decreases) in price adjustment frequencies. For example, Nakamura et al. (2018) show for the US that when CPI inflation rose above 10 percent during the Great Inflation of the 1970s and early 1980s, the frequency of price changes increased persistently (while the absolute size of price changes did not change significantly).

[26]Kaufmann (2009) reports a median absolute size of price changes of 13.6 percent in quarterly Swiss CPI microdata from 2000 to 2005. The difference to our result is likely due to the increase in the frequency of price changes, reflecting to some extent the shift from quarterly to monthly data and the decline in the level of inflation.

[27]However, the effect of the exclusion of temporary sales on the absolute size of price changes depends on the filtering technique applied to identify and exclude temporary sales (see Table B.2 in the appendix).

Table 6: Size of price adjustments

	Size of price adjustments			
	Average Changes Δp	Absolute Changes $\lvert\Delta p\rvert$	Increases Δp^+	Decreases Δp^-
Including sales, including substitutions				
Mean	0.1	11.1	10.5	-11.6
Median	0.5	7.8	7.0	-8.2
Std. dev.	11.7	10.8	11.0	11.6
Excluding sales, including substitutions				
Mean	0.4	8.2	7.9	-8.7
Median	0.5	6.3	5.7	-6.4
Std. dev.	8.0	7.4	7.6	8.6
Including sales, excluding substitutions				
Mean	-0.2	10.8	9.9	-11.3
Median	0.4	7.2	6.4	-7.6
Std. dev.	12.1	11.1	10.8	11.8
Excluding sales, excluding substitutions				
Mean	0.4	7.4	7.0	-7.8
Median	0.5	5.5	5.0	-5.5
Std. dev.	7.4	6.8	6.9	7.8

Notes: The sample ranges from January 2008 to December 2020. The size of "average" price changes, "absolute" price changes, price "increases," and "decreases" refer to the weighted averages of the average size of price changes, the absolute size of price changes, size of price increases and size of price decreases, respectively. The mean size of average price changes is calculated by first computing the average size of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Median statistics and statistics of standard deviations are calculated analogously. Price changes are reported in percent per month.

percent). This asymmetry is consistent with the view that firms use product replacements as an opportunity to raise prices.

Distribution of the size of price changes

The distribution of all non-zero price changes pooled over the period from January 2008 through December 2020 is displayed in Figure 9. The histogram shows the distribution of price changes including temporary sales, while the red line shows the distribution when price changes dues to temporary sales are excluded from the sample.[28] Table 7 complements Figure 9 by providing summary statistics.

The distribution of non-zero price changes shows that the proportion of small price changes is large. The mass of the distribution is centered around zero. 10 percent of all price changes are smaller than 1 percent, and 25 percent are smaller than 2 percent. 86

[28] Both distributions are weighted using CPI weights and cut off extreme price changes larger than 50 percent.

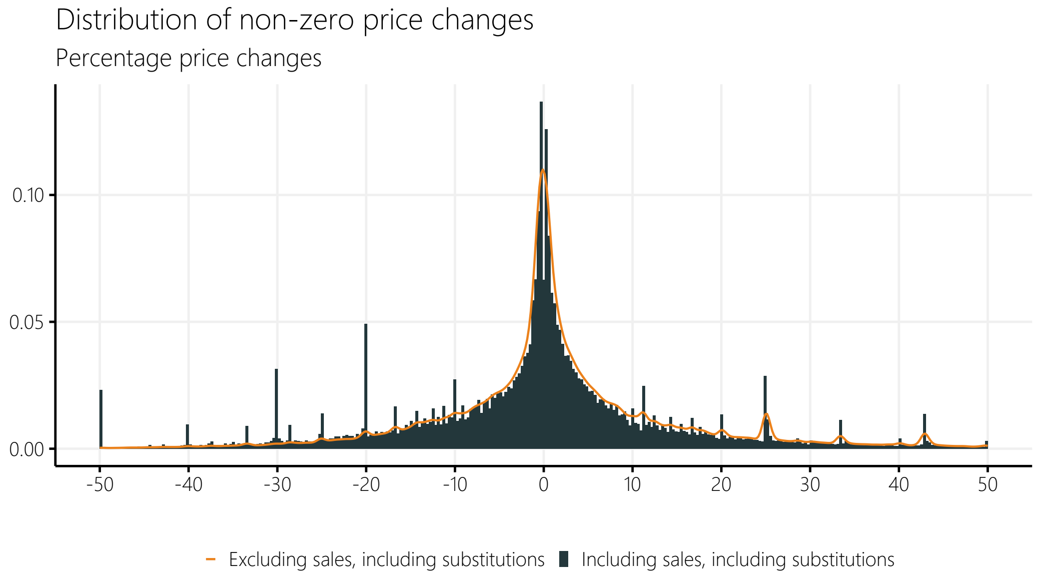

Figure 9: Distribution of non-zero price changes in the Swiss CPI from January 2008 to December 2020. The histogram (in blue) shows the distribution of price changes including temporary sales. The red line shows the distribution of price changes excluding temporary sales. Price changes are calculated as percentage changes. The figure shows price changes between −50 percent and 50 percent. The distribution uses about 1.4 million data points and is weighted using CPI weights.

percent of the price changes, and 73 percent of standardized price changes fall within one standard deviation of the mean. This is a high value compared to the normal distribution, which only has around 68 percent in the same interval. We also find that large price changes are not rare. The distribution of price changes has fat tails: the 75th percentile is equal to 13 percent, while the 90th percentile is equal to 30 percent. The large proportion of very small price changes is reflected in a kurtosis above 3 (standard normal distribution). The kurtosis of the standardized price changes is 4.8 (Table 7), and 5.2 if temporary sales are excluded (see Table B.7 in the appendix). Evidence from studies of CPI data for other countries gives similar results. The kurtosis is estimated at 4.9 (Vavra, 2014) and 5.1 (Nakamura and Steinsson, 2008) for the US, 8.0 for France (Alvarez et al., 2016), and 4.0 for Hungary (Karadi and Reiff, 2019).

Another characteristic of the distribution of price changes are the notable peaks at attractive sizes of price changes like −20 percent, −30 percent, −40 percent, and −50 percent or +25 percent and +33 percent (Figure 9). These peaks are primarily related to temporary sales and disappear to a large extent in the distribution of non-sale price changes.

Table 7: Distribution of the size of price adjustments

	Size of price adjustments				
	Changes Δp	Abs. changes $\|\Delta p\|$	Increases Δp^+	Decreases Δp^-	Stand. changes z
Mean	0.0	11.0	10.6	-11.4	0.7
10th percentile	-17.7	0.6	0.6	-36.9	0.1
25th percentile	-4.5	1.7	2.5	-22.3	0.2
50th percentile	0.3	4.7	8.1	-9.5	0.5
75th percentile	4.7	13.4	20.8	-2.4	0.9
90th percentile	16.7	29.8	37.6	-0.5	1.5
Standard deviation	21.2	16.7	17.0	16.4	0.6
Skewness	0.2				-0.0
Kurtosis	8.9				4.8

Notes: The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions. The size of average price "changes," "absolute" price changes, price "increases," "decreases," and "standardized" price changes refer to the weighted averages of the average size of price changes, the absolute size of price changes, size of price increases, size of price decreases, and size of standardized price changes, respectively. The mean size of average price changes is calculated by first computing the average size of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Statistics of other moments are calculated analogously. Price changes are reported in percent per month.

Heterogeneity in the size of price changes across sectors

Results on the size of price changes for various sectors are summarized in Table 8. We find substantial heterogeneity across sectors. Absolute price changes are largest for NEIG (mean: 15.8 percent) and smallest in the energy sector (2.7 percent). The average absolute size of price changes for food and services is 8.9 percent and 12.6 percent, respectively. In all sectors, price decreases are slightly larger than price increases. Median results show the same patterns.

Size of price changes over time

We conclude this section by presenting time-series evidence on the absolute size of price changes. Figure 10 illustrates the cross-sectional distribution from January 2008 to December 2020. For each month, it shows the mean, the median, the interquartile range (dark-shaded area), and the 15th–85th percentile range (light-shaded area) of the absolute size of price changes, $|\Delta p_{i,t}|$.

In contrast to the results for the adjustment frequency, we observe no trend in the absolute size of price changes. It was 11.9 percent in 2008 and 10.6 percent in 2019. Still, the absolute size of price changes varies over time. Some fluctuations in the mean and the median may be attributable to seasonal variations. Other movements are likely

Table 8: Size of price adjustments by sector

		Mean size of price adjustments				Median size of price adjustments			
	Coverage	Average Changes Δp	Absolute Changes $\lvert\Delta p\rvert$	Increases Δp^{+}	Decreases Δp^{-}	Average Δp	Absolute Changes $\lvert\Delta p\rvert$	Increases Changes Δp^{+}	Decreases Δp^{-}
Food	12.8	0.1	8.9	8.7	-9.1	0.2	7.6	6.8	-7.1
Unprocessed food	3.3	-0.0	11.0	10.7	-10.7	0.1	9.3	9.0	-9.1
Processed food	9.5	0.1	8.1	7.9	-8.5	0.2	6.8	5.8	-6.2
NEIG	18.6	-0.4	15.8	15.1	-15.3	-0.2	13.3	11.2	-12.2
Durable goods	8.6	-0.5	11.9	11.8	-12.0	-0.3	9.9	8.3	-9.0
Semi-durable goods	7.6	-0.3	21.5	20.0	-20.0	-0.0	20.0	16.4	-17.5
Non-durable goods	2.4	0.0	12.0	11.5	-12.5	0.1	9.9	8.8	-9.9
Energy	3.8	-0.1	2.7	2.3	-2.4	0.1	2.2	1.8	-1.7
Services	21.0	-0.0	12.6	11.7	-13.3	0.5	10.8	9.3	-11.4
Housing	1.6	1.2	4.9	4.7	-5.3	1.4	4.3	4.1	-4.8
Transport	1.8	0.8	17.7	17.3	-17.9	1.0	17.6	17.2	-18.6
Communication	2.7	-1.0	13.1	13.1	-13.7	-0.8	13.5	10.7	-7.9
Recreation	14.0	-0.2	12.1	11.0	-12.9	0.3	10.2	8.7	-10.9

Notes: The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions. "Coverage" indicates the average CPI expenditure weight of the sector over the sample period. The size of "average" price changes, "absolute" price changes, price "increases," and "decreases" refer to the weighted averages (medians) of the average size of price changes, the absolute size of price changes, size of price increases and size of price decreases, respectively. The mean (median) size of average price changes is calculated by first computing the average size of price changes for each variety and then taking a weighted mean (median) across all varieties by sector using CPI expenditure weights. Price changes are reported in percent per month. Sectors correspond to the COICOP-HICP special aggregates by Eurostat. Food includes alcohol and tobacco. Services correspond to the overall index excluding goods (i.e., food, non-energy industrial goods, and energy). Services related to recreation also include repairs and personal care.

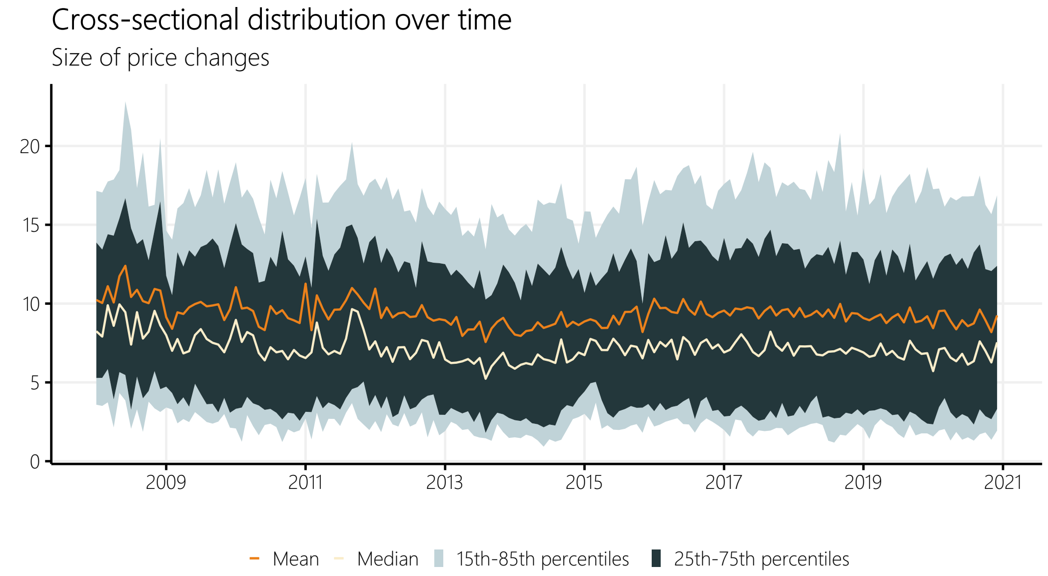

Figure 10: Distribution of the absolute size of price changes across varieties in Swiss CPI microdata. The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions. The figure depicts the mean, the median, the interquartile range (dark-shaded areas), and the 15th-85th percentile range (light-shaded areas). Price changes are reported in percent per month.

to be due to macroeconomic or idiosyncratic shocks.

Figure 11 shows the weighted distribution of the absolute size of price changes with the contributions of the various sectors for the periods 2008 to 2010 and 2017 to 2019.[29] We observe that the sizes of price adjustments changed across sectors. The size of price adjustments decreased from 9.9 percent to 6.6 percent for food items and from 12.0 percent to 11.2 percent for NEIG items (Table 9). By contrast, it increased from 7.6 percent to 10.7 percent for services.

[29]We omit 2020 to exclude the effect of the COVID-19 pandemic on the result.

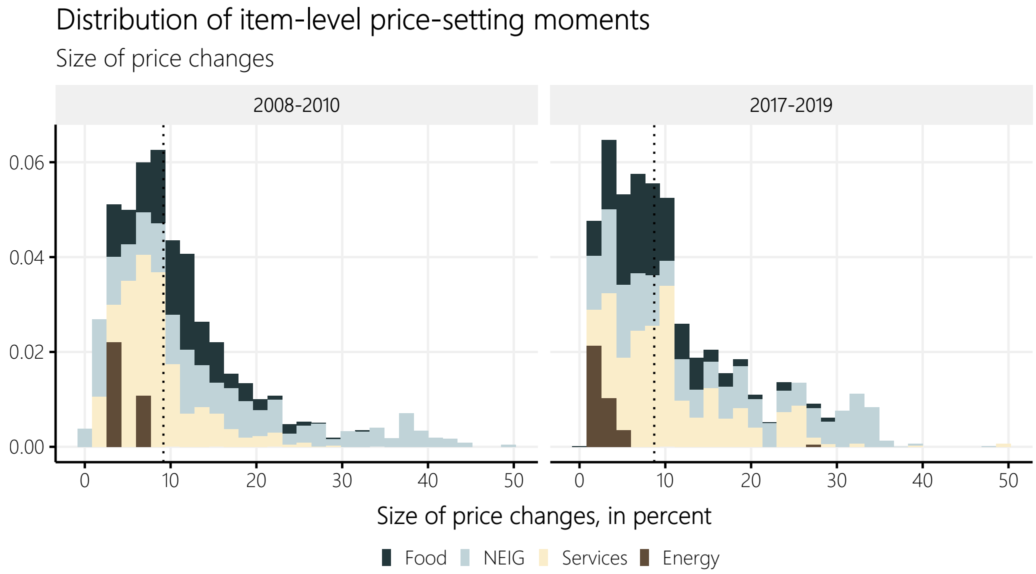

Figure 11: Distribution of the absolute size of price changes across expenditure items from January 2008 to December 2010 (left panel) and from January 2017 to December 2019 (right panel). The samples include price changes due to temporary sales and product substitutions. Contributions of sectors (food, goods, services, and energy) are weighted by constant CPI expenditure weights across periods. The vertical dotted lines show the median absolute size of price changes.

Table 9: Size of price adjustments by sector: 2008–2010 and 2017–2019

	N	Size of price adjustments			CPI weight
		Median	IQR	Kurtosis	
2008–2010					
Food	66	9.9	8.4	2.4	12.9
NEIG	79	12.0	8.3	2.2	20.4
Services	35	7.6	4.2	2.3	20.6
Energy	4	3.5	1.8	2.9	4.5
2017–2019					
Food	79	6.6	6.1	3.7	13.5
NEIG	95	11.2	9.9	2.9	17.5
Services	45	10.7	8.0	2.9	21.2
Energy	5	2.2	1.6	3.4	3.3

Notes: The samples range from January 2008 to December 2010 and from January 2017 to December 2019 and include price changes due to temporary sales and product substitutions. “N” denotes the number of expenditure items. Moments are calculated at the variety level and aggregated using CPI expenditure weights. The median price change is calculated using absolute log-price changes, while the interquartile range is based on log-price changes. The kurtosis uses standardized price changes. Price changes are reported in percent per month.

3.3 Comparison with evidence on price setting in the United States and the euro area

In this section, we compare our findings on the frequency and size of price changes in Switzerland with evidence for the United States (based on Nakamura and Steinsson, 2008) and the euro area (based on Gautier et al., 2021). Comparing results with studies for other countries is inherently difficult because of differences in the composition of the consumption baskets. To make our two comparisons as consistent as possible, we attempt to restrict the samples in each comparison to the same equivalent products.[30]

Comparison with evidence for the United States

To compare results for Switzerland with evidence for the United States, we use the disaggregated results on the frequency and size of price changes that are part of the supplementary material provided by Nakamura and Steinsson (2010). These results are available from 1998 to 2005 based on samples including and excluding temporary sales (product substitutions are excluded in both samples). To determine the sample of comparable products, we create a correspondence table between the Entry Level Items (ELIs) classification of the US CPI and the COICOP classification of the Swiss CPI. The sample of products represented in both countries covers 55.5 percent of the 2020 Swiss consumption basket. We use US CPI weights to calculate aggregate statistics for both economies.

For the sample including sales, we find that prices are on average more flexible in the United States than in Switzerland. The average frequency of price adjustments is 25.8 percent in the US, whereas it is 20.6 percent for comparable goods and services in Switzerland (see Table B.9). However, when we exclude temporary sales, the frequencies of price changes are about the same in both countries: 20.2 percent in the US and 19.1 percent in Switzerland. The same pattern applies to the median frequencies of price changes. Examining the sectoral differences, we observe that the frequency of food price changes is significantly higher in Switzerland than in the US (+9 percentage points excluding temporary sales). This difference could partly be due to the fact that in Switzerland, the prices of most food items have been collected as scanner data since 2008, which leads to more frequent price changes (Cavallo, 2018b). In all other sectors, the price adjustment frequency in the US exceeds that in Switzerland by 2 to 3 percentage

[30] We provide further details on the comparison methods and the results in Appendix B.7 for the comparison with the United States and in Appendix B.8 for the comparison with the euro area.

points.

Turning to the size of price changes, we find that price changes in the US are, on average, significantly larger than in Switzerland. For the sample including temporary sales, the average absolute price change is 15.3 percent in the US and 10.9 percent in Switzerland (see Table B.10). When we exclude price changes due to temporary sales, we find that the size of price changes in both countries is a bit closer: 10.7 percent in the United States versus 7.9 percent in Switzerland. Price changes in the food and energy sector are more than twice as large in the US than in Switzerland. For food items, this could again be related to the use of scanner data, which usually are associated with smaller price changes (Cavallo, 2018b). For NEIG and services, the size of price changes in the US exceeds that in Switzerland by about 2 percentage points.

Comparison with evidence for the euro area

Gautier et al. (2021) examine CPI microdata from eleven euro area countries over varying periods and a harmonized sample of 166 common products at the five-digit COICOP level over the period 2011 to 2017. To compare our results with their findings, we restrict our sample to 155 of the 166 common products, which are also represented in our Swiss data. The sample of products represented in both economic areas covers 53.0 percent of the 2020 Swiss CPI basket. We set the sample period to 2011–2017 to compare price-setting moments over the same period. Furthermore, we use the same euro area HICP weights averaged over the period 2017–2020 to calculate aggregate statistics for Switzerland.

The comparison shows that prices are more flexible in Switzerland than in the euro area. The average frequency of price adjustments including temporary sales is 15.2 percent in Switzerland, whereas it is 11.9 percent in the euro area (see Table B.11). The results for Switzerland are comparable to Latvia (15.9 percent), Lithuania (13.3 percent), and Greece (12.7 percent), the countries for which Gautier et al. (2021) find the highest frequencies of price changes in the euro area. When temporary sales are excluded, the respective adjustment frequencies are 12.9 percent for Switzerland and 8.3 percent for the euro area. These findings also apply to the median frequencies of price changes.

Furthermore, while we observe a considerable increase in the frequency of price changes from 2008 to 2019 in Switzerland, the results for the euro area do not show any strong upward trend over the period from 2005 to 2019.

With respect to the size of price changes, we find that price changes in Switzerland are, on average, slightly larger than in the euro area. For the sample including temporary sales, the median absolute size of price increases (decreases) is 11.8 percent (12.9 percent) in Switzerland, compared to 9.0 percent (12.0 percent) in the euro area (see Table B.12). When we exclude price changes due to temporary sales, the difference is smaller for price increases (7.9 percent in Switzerland versus 6.4 percent in the euro area) but larger for absolute price decreases (9.3 percent versus 8.0 percent). Examining the sectoral differences, we note that while price changes for NEIG and services are larger in Switzerland, price changes for food are larger in the euro area.

4 Contributions of the frequency and size of price changes to variations in inflation

Inflation is the result of individual decisions on price adjustments: inflation may change because more firms change their prices or because firms change their prices by a larger amount. In this section, we analyze how the frequency of price changes and the size of price changes contribute to variations in inflation. Following Klenow and Kryvtsov (2008)[31], we express the monthly item-level inflation rate as,

$$\hat{\pi}_{i,t} = f_{i,t} \cdot \Delta p_{i,t}, \tag{3}$$

where $f_{i,t}$ is the frequency of price changes of expenditure item i in month t, and $\Delta p_{i,t}$ is the size of non-zero monthly price changes of item i. The variable $\hat{\pi}_t$ is an approximation and not an exact representation of the monthly CPI inflation rate π_t for mainly two reasons. First, our sample is restricted and does not include administered prices and unit value indices. Second, the CPI uses a stratified aggregation at the level of regions and distribution channels (FSO, 2016).

Using the decomposition in Equation (3), we construct two counterfactual estimates of CPI inflation to assess the contributions of the frequency and size of price changes to variations in inflation. The two estimates differ in that we allow either the frequency or the sizes of price changes to vary over time while holding the other constant at their item-specific mean. The frequency-related inflation rate, holding the sizes of price changes

[31] More recent examples are Berardi et al. (2015), Wulfsberg (2016), and Gautier et al. (2021).

constant at Δp_i, is:

$$\hat{\pi}_{i,t}|_f = f_{i,t} \cdot \Delta p_i. \tag{4}$$

All variation in $\hat{\pi}_t|_f$ is due to variation in the frequencies of price changes. This case is consistent with predictions of a state-dependent model in which firms respond to shocks through the probability (but not the size) of price adjustments.

Similarly, holding the frequencies of price changes constant at f_i, the size-related inflation rate is:

$$\hat{\pi}_{i,t}|_{\Delta p} = f_i \cdot \Delta p_{i,t}. \tag{5}$$

All variation in $\hat{\pi}_t|_{\Delta p}$ is due to variation in the size of price changes. This case is consistent with predictions of a pure Calvo (1983) model in which the probability of price changes is constant over time, and variation in inflation comes only from fluctuations in the size of price changes.

Table 10: Cross-correlations between inflation and counterfactual inflation rates

	$\hat{\pi}_t\|_f$	$\hat{\pi}_t\|_{\Delta p}$	$\hat{\pi}_t\|_{f^+,f^-}$	$\hat{\pi}_t\|_{\Delta p^+,\Delta p^-}$
$\hat{\pi}_{i,t}$	0.107	0.853	0.767	0.580
Food	0.103	0.867	0.730	0.613
NEIG	0.030	0.846	0.808	0.591
Energy	0.016	0.985	0.858	0.668
Services	0.246	0.817	0.724	0.456

Notes: The table shows cross-correlations between inflation, as in Equation (6), and counterfactual inflation rates as in Equation (4), Equation (5), Equation (7), and Equation (8). Statistics are calculated by expenditure item i and month t, and aggregated using CPI expenditure weights. The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions.

Table 10 shows the correlation coefficients between monthly item-level inflation rates calculated from CPI microdata and the counterfactual inflation rates calculated based on Equation (5) and Equation (4). The table shows that the correlation coefficient between inflation and the size-related inflation rates, $\hat{\pi}_{i,t}|_{\Delta p}$, is 0.85, with sectoral coefficients ranging between 0.82 and 0.99. This correlation is much stronger than the correlation between inflation and the frequency-related inflation rates, $\hat{\pi}_{i,t}|_f$, for which we obtain a correlation coefficient of 0.11, ranging from 0.02 to 0.25 at the sectoral level.

Figure 12 visualizes these results. The top-left panel shows the frequency-related inflation, $\hat{\pi}_{i,t}|_f$, of each item i and month t plotted against the corresponding month-on-

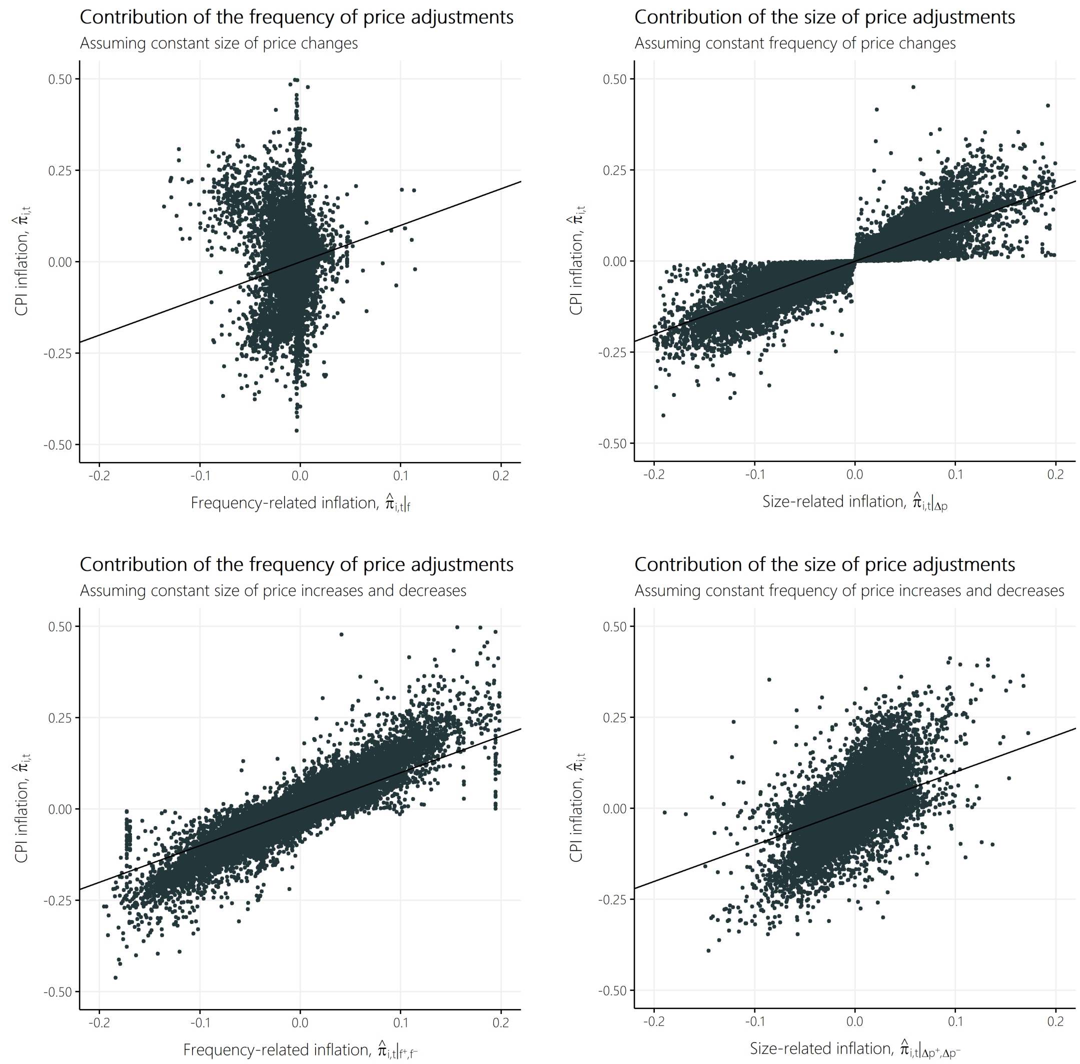

Figure 12: The figure shows scatter plots between inflation, as in Equation (6), and counterfactual inflation rates as in Equation (4), Equation (5), Equation (7), and Equation (8). The straight lines indicate the 45-degree line. The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions.

month inflation rate, while the top-right panel presents a plot of the size-related inflation, $\hat{\pi}_{i,t}|_{\Delta p}$, against the corresponding month-on-month inflation rate. The straight lines indicate the 45-degree lines in both graphs. When we hold the frequencies of price changes constant at their item-specific means (top-right panel), the counterfactual estimates of inflation more closely align with the 45-degree line than when we hold the size of price changes constant (top-left panel).

Overall, our results suggest that variations in inflation are dominated by variations in the size of price changes. This lends some support to the Calvo (1983) model. However, the Calvo model predicts that price adjustment frequencies are constant over time and thus cannot contribute to the variation in inflation at all. In state-dependent pricing models, by contrast, variations in the frequency of price changes do account for some of the variations in inflation. Variations in the frequency of price changes appear to be a modest source of inflation variability in Swiss CPI microdata. This result is in line with findings obtained by Klenow and Kryvtsov (2008) for the US and Gautier et al. (2021) for the euro area but contrasts with findings by Gagnon (2009) for Mexico.

We can further investigate the contributions of the frequency and size of price changes to inflation variations by distinguishing between price increases (+) and price decreases (−). In this case, the inflation rate can be written as

$$\hat{\pi}_{i,t} = f^{+}_{i,t} \cdot \Delta p^{+}_{i,t} + f^{-}_{i,t} \cdot \Delta p^{-}_{i,t}, \tag{6}$$

where $f^{+}_{i,t}$ and $f^{-}_{i,t}$ are, respectively, the frequency of price increases and the frequency of price decreases, and $\Delta p^{+}_{i,t}$ and $\Delta p^{-}_{i,t}$ are the average size of price increases and the average size of price decreases of item i in month t. We consider two counterfactual inflation rates, which are based on Equation (6). The first, $\hat{\pi}_{i,t}|_{f^{+},f^{-}}$, is similar to the frequency-related inflation, but instead of holding the size of price changes constant, both the size of price increases and the size of price decreases are held constant over time:

$$\hat{\pi}_{i,t}|_{f^{+},f^{-}} = f^{+}_{i,t} \cdot \Delta p^{+}_{i} + f^{-}_{i,t} \cdot \Delta p^{-}_{i}. \tag{7}$$

The second counterfactual inflation rate, $\hat{\pi}_{i,t}|_{\Delta p^{+},\Delta p^{-}}$, assumes that the frequency of both price increases and decreases is constant over time:

$$\hat{\pi}_{i,t}|_{\Delta p^{+},\Delta p^{-}} = f^{+}_{i} \cdot \Delta p^{+}_{i,t} + f^{-}_{i} \cdot \Delta p^{-}_{i,t}. \tag{8}$$

That is, variation in $\hat{\pi}_{i,t}|_{f^{+},f^{-}}$ is due to variation in the frequencies of price increases and price decreases, while variation in $\hat{\pi}_{i,t}|_{\Delta p^{+},\Delta p^{-}}$ is due to variation in the size of price increases and price decreases.

The results based on Equation (7) and Equation (8) are summarized in Table 10. The correlation coefficient between inflation and counterfactual inflation assuming constant sizes of price increases and decreases is 0.77, with a range of 0.72 to 0.86 for the sectors. This correlation is slightly stronger than the correlation between inflation and counterfactual inflation assuming constant frequencies of price increases and price decreases. In the latter case, the correlation coefficient is 0.58, with a range of 0.46 to 0.67 for the sectors. Figure 12 presents a graphical representation of the results. The scatterplots indicate a positive relationship between time variations in inflation and the contributions of both the time variations in the frequency of price increases and decreases (bottom-left panel) and the time variations in the size of price increases and decreases (bottom-right panel).

What stands out in Figure 12 is the stark contrast between the upper-left panel and the bottom-left panel. Time variations in the frequency of price increases and decreases contribute significantly to the time variations in inflation (bottom-left panel), while time variations in the frequency of all price changes do not. This is because the frequency of price increases tends to go up when the frequency of price decreases goes down, and vice versa. As a result, the frequency of all price changes is fairly stable, which keeps the contribution from time variations in the frequency of price changes low.

Thus, when considering positive and negative price changes separately, the analysis suggests that variation in inflation is slightly more strongly driven by changes in the frequencies of price increases and decreases than by changes in the sizes of price increases and decreases. Gautier et al. (2021) for the euro area and Wulfsberg (2016) for Norway obtain similar results for micro prices underlying the respective CPIs.

5 The synchronization of price changes

The synchronization of price changes across firms is another aspect of price setting that can have important macroeconomic consequences. Whether all firms change their prices simultaneously (synchronization) or only a fraction of firms adjust prices in every period (staggering) has implications for the propagation of nominal shocks and the persistence of their effects. Staggered price setting creates price level inertia and leads to the misallocation of goods and services (Taylor, 1979, 1980).

Most empirical studies of the synchronization of price changes are based on producer prices (e.g., Bhattarai and Schoenle, 2014; Nilsen et al., 2021; Dedola et al., 2021). Microdata underlying the CPI allow us to examine the synchronization of price changes for individual outlets rather than for entire firms. We distinguish between two types of synchronization: synchronization across varieties within a given outlet and synchronization across outlets for a given variety. Synchronization across varieties measures the extent to which an individual outlet coordinates price changes across its assortment. Synchronization across outlets measures the extent to which stores change prices simultaneously.

Earlier empirical evidence points to little or no synchronization of consumer prices across stores. Lach and Tsiddon (1992) find that prices are not synchronized across stores even during periods of high inflation in a study of CPI microdata of 26 food products from Israel. Studies of CPI microdata from different countries in the euro area generally find a low degree of synchronization (Aucremanne and Dhyne, 2004; Veronese et al., 2005; Baumgartner et al., 2005; Hoffmann and Kurz-Kim, 2006). Similarly, Gorodnichenko et al. (2018a) find little synchronization of price changes across stores in daily US and UK online prices. By contrast, several studies find strong evidence for the synchronization of price changes across varieties within a given store. Focusing on grocery stores selling wines and meat products in Israel, Lach and Tsiddon (1996) find that price changes tend to be staggered across stores but synchronized within stores. Midrigan (2011) finds evidence of within-store synchronization in weekly data from a US retail chain.

This section examines the relevance of both types of synchronization for price adjustment decisions in Swiss CPI microdata. For this purpose, we use a discrete choice model similar to the one used by Bhattarai and Schoenle (2014) for estimating synchronization in US producer prices. Discrete choice models are suitable for explaining how the choice between two or more discrete courses of action (such as price changes in our case) depends on selected factors. To measure synchronization, we use two indicator variables, $I^{+}_{p,i,s,t}$ and $I^{-}_{p,i,s,t}$, where p denotes the product of variety i and s denotes the outlet where the price is collected in month t. The indicator variables take the value one for a positive or negative price change, respectively, and zero otherwise. Varieties constitute the lowest level of product identification in our data. We follow Nilsen et al. (2021) and define our measures for the synchronization of positive and negative price changes across varieties as the fractions of within-outlet positive and negative price changes:

$$f^{s,+}_{p,i,s,t} = \frac{(\sum_{i=1}^{I} \sum_{p=1}^{P} I^{+}_{p,i,s,t}) - I^{+}_{p,i,s,t}}{\sum_{i=1}^{I} N_{i,s,t} - 1} \tag{9}$$

$$f^{s,-}_{p,i,s,t} = \frac{(\sum_{i=1}^{I} \sum_{p=1}^{P} I^{-}_{p,i,s,t}) - I^{-}_{p,i,s,t}}{\sum_{i=1}^{I} N_{i,s,t} - 1} \tag{10}$$

where $I_{(t)}$ denotes the number of varieties in outlet s in month t, $P_{(t)}$ denotes the number of products in each variety i, and $N_{i,s,t}$ is the observed total number of products within outlet s in month t. The within-variety fractions, $f^{i,+}_{p,i,s,t}$ and $f^{i,-}_{p,i,s,t}$, are calculated analogously by summing the number of price increases (or price decreases) over all products and outlets for each variety in a given month, excluding the price observation whose synchronization we are trying to explain.

The model is a standard multinomial logit model with three discrete outcomes: negative, zero, and positive price changes. Specifically, we estimate a model of the form:

$$\Pr(Y_{p,i,s,t} = 1, 0, -1 | X_{p,i,s,t} = x) = F(\beta X_{p,i,s,t}) = \frac{\exp(\beta X_{p,i,s,t})}{1 + \sum \exp(\beta X_{p,i,s,t})}, \qquad (11)$$

where $Y_{p,s,t}$ is an indicator variable for positive, zero, or negative price changes of product p of variety i sold in outlet s at time t. Within this model, our definition of synchronization is qualified in the sense that price changes must have the same sign to qualify as synchronous. The explanatory variables $X_{p,i,s,t}$ include the fraction of within-outlet positive and negative price changes, $f^{s,+}_{p,i,s,t}$ and $f^{s,-}_{p,i,s,t}$, and the fraction of within-variety positive and negative price changes, $f^{i,+}_{p,i,s,t}$ and $f^{i,-}_{p,i,s,t}$. Further, we include five-digit COICOP-level inflation rates to control for exogenous shocks at the item level, and we account for the time that has elapsed since the last price change. At the product level, we use dummies to control for imports, temporary sales and product substitutions, and we include the average price change of competitors' prices. We further control for sector-fixed effects (two-digit COICOP level) and the size of outlets (as measured by the number of varieties surveyed in an outlet) to account for differences in assortment size across sectors. For example, supermarkets tend to offer a large number of varieties, while the prices of hairdressers are concentrated in one item only. Finally, we include monthly dummies to control for seasonal effects and yearly dummies to control for the overall increase in the frequencies of price changes over time.

Table 11: Synchronization of price changes by sectors

	Food	NEIG	Energy	Services
Positive price change				
Fraction up outlet	1.074	1.073	1.036	1.068
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction down outlet	1.042	1.049	1.023	1.045
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction up variety	1.049	1.041	1.07	1.037
	(0.000)	(0.000)	(0.001)	(0.001)
Fraction down variety	1.018	1.018	1.04	1.005
	(0.000)	(0.000)	(0.001)	(0.001)
Negative price change				
Fraction up outlet	1.046	1.05	1.022	1.048
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction down outlet	1.071	1.072	1.041	1.073
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction up variety	1.019	1.018	1.035	1.033
	(0.000)	(0.000)	(0.001)	(0.001)
Fraction down variety	1.05	1.041	1.058	1.023
	(0.000)	(0.000)	(0.001)	(0.001)
Positive price change				
Fraction change outlet	1.058	1.064	1.031	1.057
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction change variety	1.034	1.026	1.058	1.021
	(0.000)	(0.000)	(0.001)	(0.000)
Negative price change				
Fraction change outlet	1.059	1.061	1.035	1.056
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction change variety	1.035	1.035	1.055	1.025
	(0.000)	(0.000)	(0.001)	(0.000)

Notes: Multinomial logit estimation of the synchronization of Swiss consumer price changes across sectors. The sample ranges from January 2008 to December 2020, excludes price changes due to temporary sales but includes price changes due to product substitutions. The table shows the relative risk ratios for a positive (negative) price change compared to no price change. The fractions of positive (negative) price changes within outlets and within varieties are included in percent. Standard errors in parentheses. Controls are included but not reported.

We estimate the model on monthly data from January 2008 to December 2020. The sample includes price changes due to product substitutions but excludes price changes due to temporary sales.[32] Table 11 shows the results for the multinomial logit estimation of the synchronization of Swiss consumer price changes in four sectors (food, NEIG, energy, and services). The parameters in vector β give the estimated coefficients in log-odds form. To allow for an easier interpretation, we report relative risk ratios, which

[32] Table C.1 in the appendix shows the results of our multinomial logit model for the samples including and excluding temporary sales and product substitutions. Temporary sales (and to a lesser extent product substitutions) tend to increase synchronization within varieties and decrease synchronization within outlets.

are the exponentiated values of the estimated logit coefficients. The relative risk ratio of a coefficient compares the risk of a positive (negative) price change with the risk of no price change for the variable in question.

Starting with the within-outlet synchronization, the results reported in the upper panel of Table 11 indicate a strong degree of synchronization of price changes within individual outlets. They show significant relationships between the fraction of both positive and negative price changes within the outlet and the probability of positive and negative price changes. The relative risk ratios are smallest for energy items but similar for food, NEIG, and services. In these sectors, and keeping all other variables constant, an increase in the within-outlet fraction of positive (negative) price changes by one percentage point makes a positive (negative) price change around 1.07 times more likely than no price change. That is, the odds of a price change in the same direction are 7 percent higher. The odds of a price increase rise similarly with the share of positive price changes as the odds of a price decrease with the share of negative price changes within outlets. This suggests no asymmetry between price increases and decreases in synchronization within outlets.

Interestingly, an increasing share of positive price changes within the outlet not only increases the odds of a price increase but also (to a smaller degree) the odds of a price decrease. The same is true for an increasing share of within-outlet price decreases. Hence, the synchronization of price changes within outlets tends to be largely independent of the direction of price changes. This observation is at odds with the idea that synchronization of price changes is driven by firm- or sector-specific shocks because these types of shocks would likely affect the prices of all products within a firm in the same direction. However, it supports the theory of scope economies in menu costs. Firms may well choose to lower the price of one product while raising the price of most others.

Turning to the synchronization across outlets, we see that the relative risk ratios of the fraction of positive and negative price changes within varieties are also significant. However, the economic effects are smaller than for within-outlet synchronization. This applies to all sectors except energy. The synchronization across outlets is particularly low for services. Furthermore, price increases are marginally more synchronized across outlets than price reductions.

We repeat the estimation for groups of outlets defined by the total number of varieties for which prices are collected in them. Table 12 summarizes the results. They suggest that the degree of within-outlet synchronization of individual price adjustment decisions does not depend on the number of varieties sold by the outlet. The relative risk ratios (for both price increases and decreases) are similar to the ones found in Table 11 and do not change systematically as the number of varieties sold by the outlets increases from less than three varieties to more than ten varieties.

However, the multi-product dimension of price setting is important when we consider synchronization for a given variety across outlets. We find that the degree of synchronization across outlets depends strongly on the number of varieties sold by the outlets. For outlets offering one or two varieties, the odds of a positive (negative) price change is 3.7 percent (3.0 percent) higher when the fraction of within-variety positive (negative) price changes increases by one percentage point. For outlets offering between six and ten varieties, these odds increase to 5.6 percent (5.5 percent).

Table 12: Synchronization of price changes by outlet size

	1–2 varieties	3–5 varieties	6–10 varieties	> 10 varieties
Positive price change				
Fraction up outlet	1.067	1.054	1.083	1.083
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction down outlet	1.044	1.036	1.053	1.034
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction up variety	1.037	1.043	1.056	1.042
	(0.001)	(0.001)	(0.001)	(0.000)
Fraction down variety	1.018	1.012	1.039	1.014
	(0.001)	(0.001)	(0.001)	(0.000)
Negative price change				
Fraction up outlet	1.044	1.039	1.054	1.057
	(0.000)	(0.001)	(0.001)	(0.000)
Fraction down outlet	1.07	1.054	1.083	1.059
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction up variety	1.028	1.016	1.045	1.013
	(0.001)	(0.001)	(0.001)	(0.000)
Fraction down variety	1.03	1.041	1.055	1.041
	(0.001)	(0.001)	(0.001)	(0.000)
Positive price change				
Fraction change outlet	1.06	1.046	1.079	1.06
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction change variety	1.028	1.03	1.046	1.029
	(0.000)	(0.000)	(0.001)	(0.000)
Negative price change				
Fraction change outlet	1.061	1.047	1.074	1.061
	(0.000)	(0.000)	(0.001)	(0.000)
Fraction change variety	1.024	1.029	1.047	1.036
	(0.001)	(0.000)	(0.001)	(0.000)

Notes: Multinomial logit estimation of the synchronization of Swiss consumer price changes across outlet size (as measured by the number of varieties for which prices are collected in these outlets). The sample ranges from January 2008 to December 2020, excludes price changes due to temporary sales but includes price changes due to product substitutions. The table shows the relative risk ratios for a positive (negative) price change compared to no price change. The fractions of positive (negative) price changes within outlets and within varieties are included in percent. Standard errors in parentheses. Controls are included but not reported.

6 Price setting during the COVID-19 pandemic

The spread of the coronavirus disease (COVID-19) in early 2020 triggered an economic crisis that affected all countries, including Switzerland.[33] To contain the pandemic, the

[33] The virus was confirmed to have spread to Switzerland on 25 February 2020 when a person tested positive for COVID-19 for the first time. Faced with a rapidly deteriorating epidemiological situation, the federal government decreed a partial lockdown and introduced nationwide measures to protect the public on 16 March. These measures were gradually removed in late April and June 2020. However, as COVID-19 cases surged again in October 2020, the authorities reimposed some measures towards the end of the year.

federal government imposed a range of containment measures such as temporary lock-downs, travel restrictions, and social distancing rules. These measures severely restricted business operations and consumer spending. Figure 13 shows the year-on-year changes in Swiss debit card transaction volumes, which can be viewed as an approximation of consumer spending.[34]

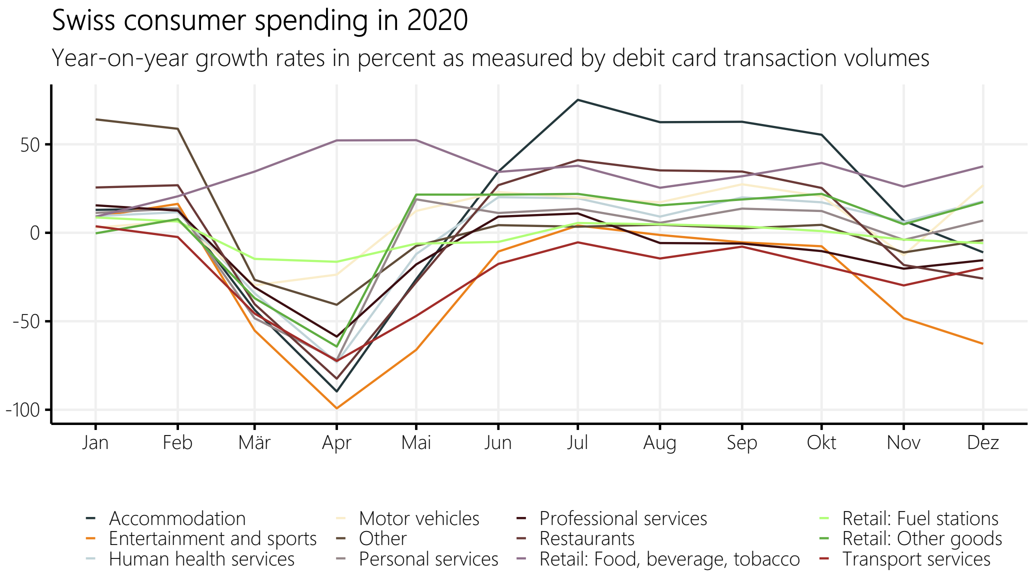

Figure 13: Year-on-year percentage changes in Swiss consumer spending in 2020 as measured by debit card transaction volumes.

According to these data, private consumption declined sharply in spring 2020 and, to a lesser extent, in late autumn 2020. However, the effect of the pandemic varied widely across sectors. Spending in service sectors such as entertainment and sports, accommodation, or restaurants took the largest hit and recovered only slowly thereafter. By contrast, spending on food, beverages and tobacco recorded higher sales throughout 2020 than in the previous year. In most other categories, consumption spending declined significantly in spring 2020 but recovered or even increased above previous levels in the following months.

In this section, we document the effect of the COVID-19 pandemic on price-setting be-

[34] These data are based on transactions of debit cards issued by banks to their customers in Switzerland and include debit card payments at points of sale. They are taken from "Monitoring Consumption Switzerland" (see https://monitoringconsumption.com). Baker et al. (2020) for the US or Carvalho et al. (2020) for Spain use similar data to assess the impact of the containment measures on consumer demand.

havior in Switzerland. We compare the frequency and size of price changes with their pre-crisis values (Section 6.1), and we analyze the behavior of temporary sales (Section 6.2). The analysis focuses on CPI microdata, where we exclude price observations related to product substitutions and COVID imputations (see Section 2). These observations are excluded to base our analysis on prices that were actually collected in stores or online during the pandemic.

6.1 The frequency and size of price changes during the pandemic

We begin by analyzing how price setting characteristics changed in 2020, the first year of the pandemic. Figure 14 shows the frequency and the size of price changes from January 2018 to December 2020, first for all prices changes and then separately for price increases and price decreases. The dashed lines show the respective average values calculated from January 2018 to December 2019. The shaded areas indicate the dispersion measured as the standard deviation around the mean over the same period. We focus our analysis on the sample including temporary sales but excluding product substitutions and COVID imputations.

After the outbreak of the pandemic in early 2020, the frequency of price changes fell slightly below its 2018/2019 level. In the first half of the year, the difference to the 2018/2019 level amounted to 0.4 percentage points. The frequency of price decreases, in particular, contributed to the overall slowdown in the frequency of price changes. Even after most shops reopened in June and July of 2020, the frequency of price decreases remained mostly below the average level of the previous two years. However, the adjustment frequencies for price increases rose slightly above their 2018/2019 level in the summer of 2020. This may be due to the temporary improvement of the epidemiological situation. Consumer demand recovered in several sectors, creating a favorable environment for firms to increase prices.

The absolute size of price changes was smaller in almost every month of 2020 compared to the previous years. The average absolute size of price changes was 9.9 percent in 2020, 0.6 percentage points lower than in 2018/2019. Both the size of price increases and the size of price decreases got smaller. Indeed, the average absolute size of price changes had already decreased in previous years. However, the decline was particularly large in April and May and towards the end of 2020, largely in line with the number of COVID-19 cases.

To gain insight into the heterogeneity of the response of price-setting behavior to the

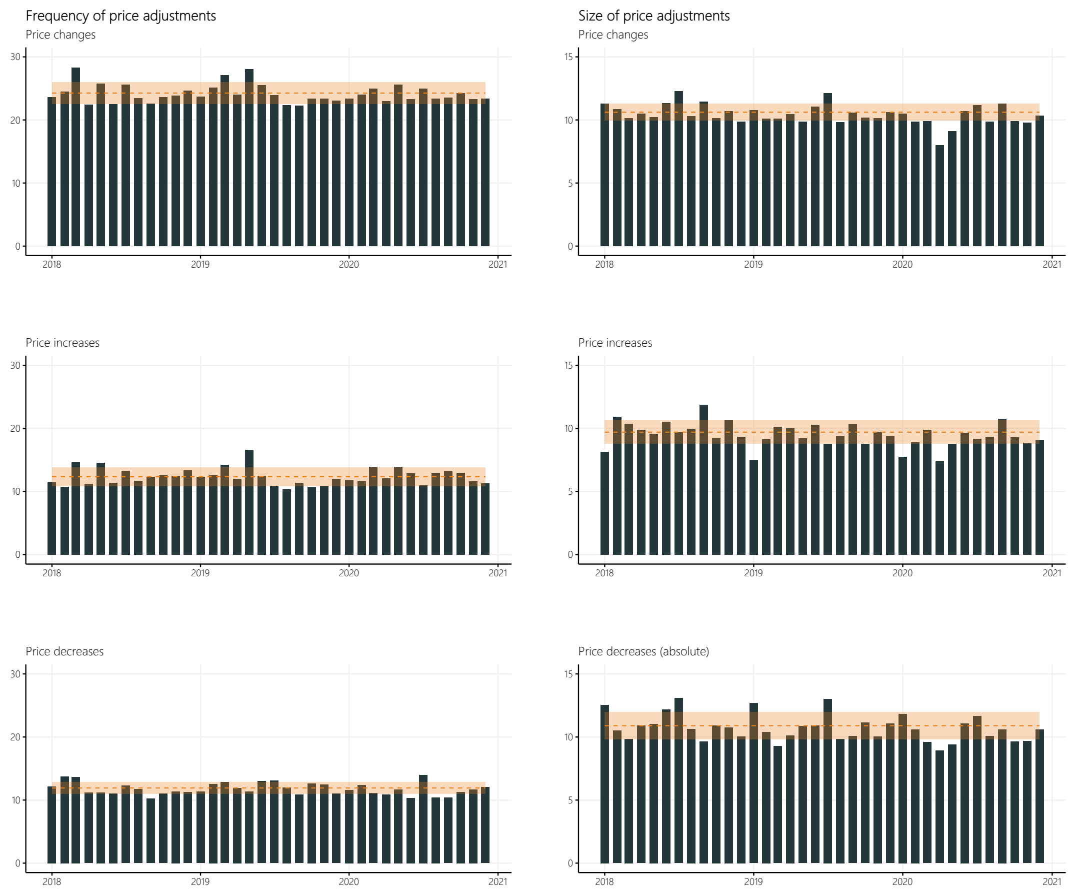

Figure 14: This figure shows the frequency of price changes (top left panel), price increases (middle left panel), and price decreases (bottom left panel), and the size of absolute price changes (top right panel), price increases (middle right panel) and absolute price decreases (bottom right panel). The shaded area shows the mean of the respective measures from January 2018 to December 2019 and one standard deviation thereof. The sample includes price changes due to temporary sales but excludes product substitutions and COVID imputations.

COVID-19 shock, we examine the frequency and the size of price changes across sectors. Figure 15 shows the frequency of price changes for food, NEIG, and services, again first for all price changes and then separately for price increases and price decreases.

For food, the frequency of price changes in 2020 did not deviate much from the average value of the previous two years. However, the distinction between price increases and decreases exposes clear changes in price-setting behavior related to the pandemic. As a result of supply constraints and higher demand in the food sector following the outbreak of the pandemic, the frequency of price increases increased, and the frequency of price decreases decreased. Overall, these adjustments suggest that retail food pricing responded strongly to excess demand in the spring of 2020 (Figure 13).

In the case of NEIG, retailers reduced prices more frequently and increased prices less frequently following the outbreak of the pandemic compared with the previous years. This development was mainly driven by price adjustments for transport goods (e.g., used cars, motorcycles, or bicycles), electronic goods (e.g., game consoles and electronic games, computer software), and furnishings. Overall, sellers in these markets have sought to offset the decline in demand by cutting prices. From August to October 2020, when demand was back at or above pre-pandemic levels, the frequency of price increases also grew significantly and exceeded 2018/2019 levels. Price adjustments for used cars and furniture once again contributed disproportionately to this development.

In services, where the decline in demand resulting from the various containment measures was most severe and prolonged, it is difficult to detect a systematic response in the frequency of price changes. Even before the pandemic, the frequency of price adjustments usually was very small and fluctuated rather erratically. This was also the case during the pandemic in 2020.

Looking at the same set of graphs for the size of price changes in Figure 16, we notice the significant decline in the size of absolute price changes for NEIG throughout 2020. The absolute size of price changes for NEIG was smaller in almost every month of 2020 than in 2018/2019. When we distinguish between price increases and price decreases, we find that both price increases and decreases were smaller on average compared to previous years.

The evaluation of changes in the frequency and the absolute size of price changes since the outbreak of the pandemic has shown that the reactions varied greatly between the three sectors. Two main factors are likely to be important. For one, the pandemic and the various containment measures taken by the government affected supply and

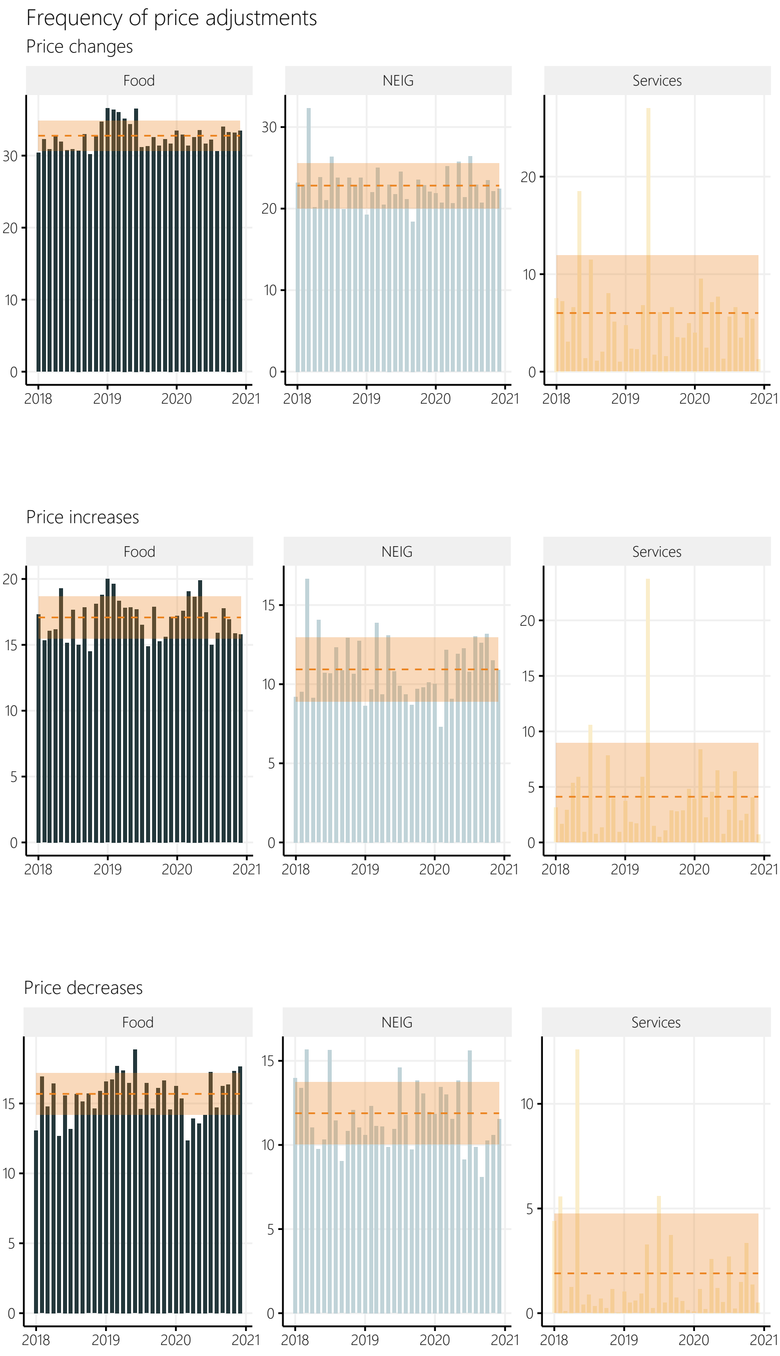

Figure 15: This figure shows the frequency of price changes (top row), price increases (middle row), and price decreases (bottom row) across sectors. The shaded area shows the mean of the respective measures from January 2018 to December 2019 and one standard deviation thereof. The sample includes price changes due to temporary sales but excludes product substitutions and COVID imputations.

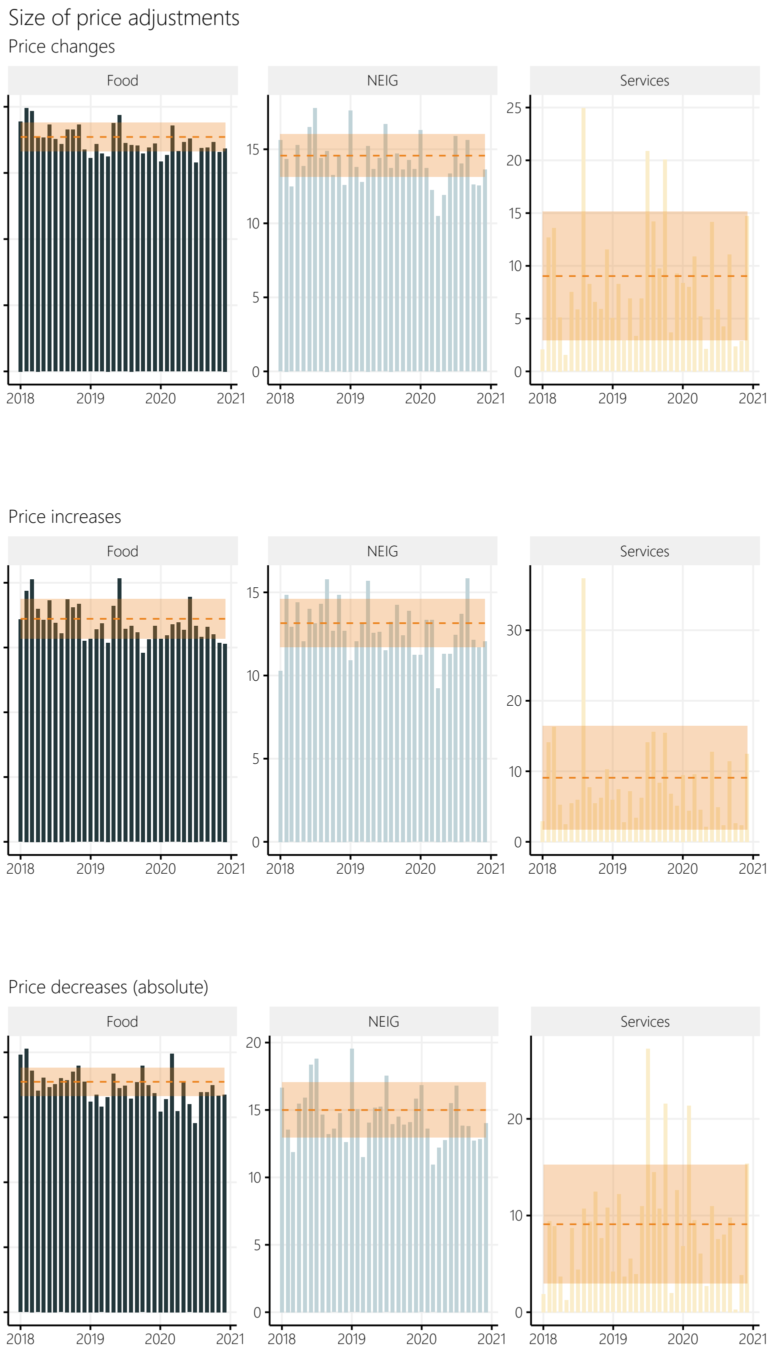

Figure 16: This figure shows the size of absolute price changes (top row), price increases (middle row), and price decreases (bottom row) across sectors. The shaded area shows the mean of the respective measures from January 2018 to December 2019 and one standard deviation thereof. The sample includes price changes due to temporary sales but excludes product substitutions and COVID imputations.

demand conditions differ in the various sectors. For another, uncertainty about future supply and demand conditions in the context of the pandemic varied across sectors. In a recent paper, Ilut et al. (2020) set out a theory of price stickiness, according to which uncertainty creates endogenous costs of price adjustment, which in turn lead to real price stickiness. Firms prefer maintaining their current price rather than changing it. Thus, the differences in the response of price adjustment frequencies following the outbreak of the pandemic may reflect different degrees of uncertainty that retailers were facing in the various sectors.

6.2 The frequency and size of sales during the pandemic

To examine the behavior of temporary sales during the COVID-19 pandemic, we consider the frequency and size of sales from January 2018 to December 2020. There is a long and ongoing debate about whether firms use temporary sales to adjust to aggregate shocks. On the one hand, Eichenbaum et al. (2011) show that a menu cost model calibrated to match the frequency of reference price changes does better at reproducing the effects of a monetary policy shock than a version of the same model in which the size of the menu cost is fitted to the frequency of posted price changes. They conclude that high-frequency price movements should be filtered out of the data when analyzing the responsiveness of firms to monetary policy shocks. In support of this view, Anderson et al. (2017) find that sales are insensitive to wholesale cost shocks in data from a US retailer selling general merchandise and groceries. On the other hand, Klenow and Willis (2007) find evidence in US CPI microdata that sales-related price changes and regular price changes respond similarly to macro shocks. Moreover, Kryvtsov and Vincent (2021) demonstrate that the frequency of sales is strongly countercyclical and that the share of sale prices more than doubled during the Great Recession.

We calculate the frequency of sales for each variety and aggregate the sale frequencies using CPI expenditure weights. Similarly, we aggregate the size of the sale-related discounts for each variety in any given month. Figure 17 illustrates the frequency of sales and the size of sales across sectors. The dashed lines show the respective average values over the sample from January 2018 to December 2019. The shaded areas represent the values within one standard deviation of the mean.

The results show that discount policies vary widely across sectors. While an average of 5.8 percent of all NEIG prices was temporarily discounted between January 2018 and December 2019, temporary sales play virtually no role in services (0.3 percent) and

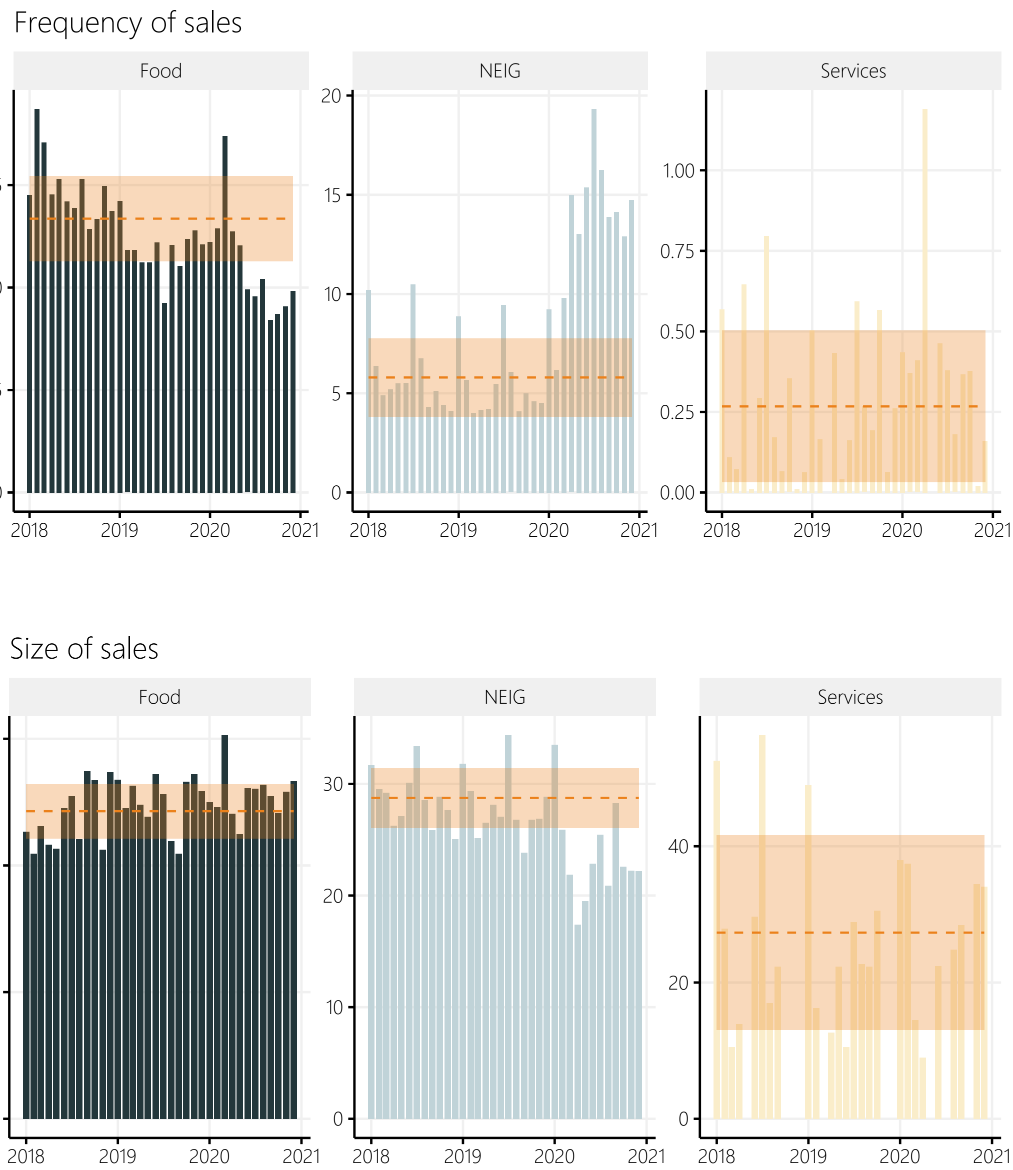

Figure 17: The frequency of sales (upper panel) and the (absolute) size of sales (lower panel) across sectors. The shaded area shows the mean of the respective measures from January 2018 to December 2019 and one standard deviation thereof. The sample includes price changes due to temporary sales but excludes product substitutions and COVID imputations.

account for only a small share of food prices (1.0 percent). Following the outbreak of the pandemic, the frequency of temporary sales increased significantly for NEIG. It amounted to 14.4 percent on average from March to December 2020, which is more than double the pre-crisis level. In July 2020, almost 20 percent of all NEIG micro prices were sale prices. For services, we find that the frequency of sales increased by a factor of 4 to 1.2 percent (April 2020). By contrast, the frequency of sales decreased for food items, where demand increased with the pandemic. While it was relatively stable at an average of 1.4 percent in 2018/2019, it dropped to 1.0 percent from April to December 2020.

Most of the increase in the frequency of sales in the NEIG sector is attributable to new cars, whose sale prices were up to 50 percentage points more frequent than in 2018/2019. The frequency of sales was also significantly higher for many items of furniture or clothing and footwear. Companies managing their inventories and compensating for the lower demand during the lockdown can explain these more frequent discounts. In some areas of the NEIG sector, the frequency of sales decreased. In particular, promotions for various electronic items (e.g., photographic equipment, game consoles and electronic games, and personal computers) were less frequent in 2020. This may be attributable to the high demand for these products due to home office duty and stay-at-home requests.

The lower panel of Figure 17 shows the size of temporary price discounts across sectors. Interestingly, discounts were smaller than in the previous two years in the NEIG sectors. From March to December 2020, the size of sales was 22.3 percent on average and thus 7.4 percentage points smaller than in 2018/2019. NEIG retailers appear to have cushioned the large losses of revenues during the lockdown with smaller but more frequent temporary sales. For food and services, we find no significant change in the size of temporary discounts.

Taken together, the evidence on the frequency and size of temporary sales during the COVID-19 pandemic suggests that retailers use temporary sales to respond to macroeconomic shocks. In particular, the frequency of sales was strongly countercyclical in response to the respective demand conditions across sectors. Therefore, our analysis of sale prices during the pandemic adds to the strand of literature that emphasizes the responsiveness of temporary sales to aggregate shocks (e.g., Klenow and Willis, 2007; Kryvtsov and Vincent, 2021).

7 Conclusion

Empirical findings on price-setting behavior allow us to better understand price rigidity at the product level. Estimates of price-setting characteristics are often relevant for calibrating macroeconomic models with nominal price stickiness. In this paper, we have reconsidered price-setting behavior in Switzerland, focusing on changes in price-setting characteristics over time. The data are microdata underlying the CPI from January 2008 to December 2020.

The main findings can be summarized as follows. First, the frequency of price changes has increased significantly over the last decade. We find that this increase is partly the result of the rise of e-commerce. Because prices on online platforms are adjusted considerably more frequently than prices at stationary retailers, the increasing share of online prices in the CPI has a direct impact on the total frequency of price changes. Second, time variation in the frequency of price changes contributes little to variations in inflation. However, distinguishing between price increases and price decreases shows that the frequency of price increases and the frequency of price decreases taken separately contribute substantially to variations in inflation. The contribution even exceeds that of the size of price increases and decreases. Third, price changes are synchronized within rather than across stores, and both types of synchronization are weaker for smaller outlets. Fourth, on average, price-setting characteristics changed little during the COVID-19 pandemic in 2020. However, the response varied by sector, reflecting the fact that the pandemic hit the economy unevenly. Furthermore, temporary sales responded countercyclically to the respective sectoral demand conditions.

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Appendix

Price Setting Before and During the Pandemic: Evidence from Swiss Consumer Prices

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In this appendix, we present additional figures, tables and analyses that are not featured in the main body of the paper. The appendices refer to the corresponding sections in the main text.

A Data

This appendix refers to Section 2 in the main body of the paper and presents additional figures, tables, and analyses that are not featured in the main text.

A.1 Price quotes

The FSO introduced scanner data in July 2008 and broadened the range of product categories for which prices are collected as scanner data in April 2010, April 2012, and December 2016. Figure A.1 shows the percentage of price quotes collected as scanner data for each main group in our sample from January 2008 to December 2020.

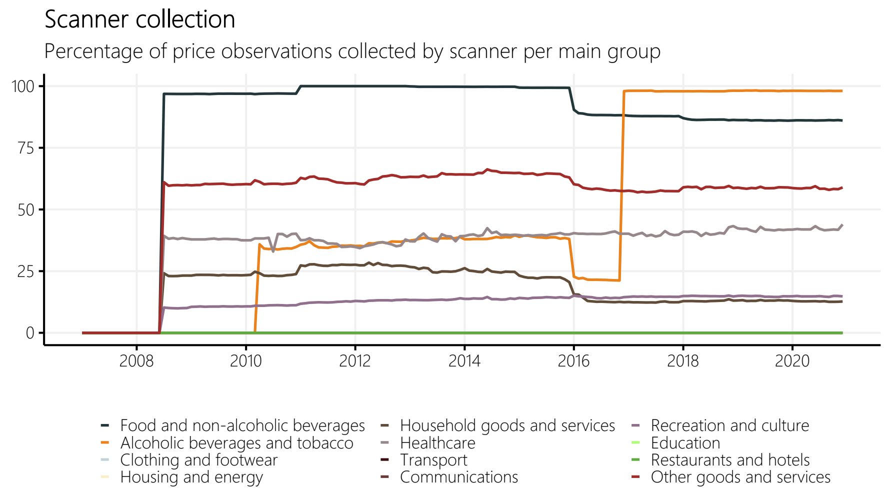


Figure A.1: Share of price quotes collected as scanner data from January 2008 to December 2020 for each main group.

A.2 Product substitutions and price imputations

The COVID-19 pandemic and the measures taken to contain it affected price surveys for the CPI in 2020. The FSO could only field a partial price collection in many areas. Therefore, it had to impute many prices. Table A.1 lists the expenditure items whose prices were (fully or partially) imputed each month during the COVID-19 pandemic in 2020.

Table A.1: COVID imputations

Month	Expenditure item
March 2020	Air transport; International package holidays
April 2020	Jackets for men; Men's suits; Men's trousers; Men's shirts; Men's knitwear; Men's underwear; Women's coats and jackets; Women's skirts and dresses; Women's trousers; Women's blouses; Women's jumpers; Women's underwear; Children's jackets; Children's trousers and skirts; Children's knitwear; Babies' clothing; Children's underwear; Summer/year-round sportswear; Other clothing accessories; Men's footwear; Women's footwear; Children's footwear; Air transport; International package holidays; Meals taken in restaurants and cafés; Wine; Beer; Spirits, other alcoholic drinks; Coffee and tea; Mineral water and soft drinks; Self-service restaurants; Hotels
May 2020	Air transport; International package holidays; Hotels
June 2020	Air transport; International package holidays; Hotels
July 2020	Air transport
August 2020	Air transport; Sporting events; Admission to sport facilities
September 2020	Air transport; Sporting events; Admission to sport facilities
October 2020	Air transport
November 2020	Air transport; International package holidays; Meals taken in restaurants and cafés; Wine; Beer; Spirits, other alcoholic drinks; Coffee and tea; Mineral water and soft drinks; Self-service restaurants; Fast food meals; Men's and children's hairdressers; Women's hairdressers
December 2020	Air transport; International package holidays; Meals taken in restaurants and cafés; Wine; Beer; Spirits, other alcoholic drinks; Coffee and tea; Mineral water and soft drinks; Self-service restaurants; Fast food meals

Notes: This table lists the expenditure items whose prices were (fully or partially) imputed in 2020 during the COVID-19 pandemic. Source: Monthly press releases on the Swiss CPI by the FSO.

Table A.2 quantifies the extent of product substitutions and COVID imputations for each month in 2020. During the lockdown in April 2020, 7.1 percent of all price observations (2.5 percent by CPI weight) were related to product substitutions, and 16.3 percent of all prices (11.4 percent by CPI weight) were imputed prices. The shares of product substitutions and COVID imputations temporarily increased in spring 2020 and again towards the end of the year, reflecting the course of the pandemic and the associated lockdown measures.

Table A.2: Product substitutions and COVID imputations in 2020

	Product substitutions		COVID imputations	
	Share	Weight	Share	Weight
Jan	2.9	1.7	0.0	0.0
Feb	3.9	1.3	0.0	0.0
Mar	5.1	2.0	0.8	2.7
Apr	7.1	2.5	16.3	11.4
May	4.7	2.5	1.9	3.3
Jun	3.6	1.5	2.2	3.6
Jul	2.2	1.0	0.3	0.7
Aug	3.7	1.7	0.9	0.7
Sep	5.1	1.8	0.9	0.7
Oct	5.1	2.5	0.3	0.7
Nov	3.5	1.8	6.2	9.8
Dec	4.0	1.3	5.7	9.5

Notes: This table lists the share ("Share") of product substitutions and COVID imputations as well as their CPI coverage ("Weight") for every month in 2020. Numbers are in percent.

B Evidence on the frequency and size of price changes

This appendix refers to Section 3 in the main body of the paper and presents additional figures, tables, and analyses that are not featured in the main text.

B.1 Alternative sale filters

In the main text, we rely on the sale flags provided by the FSO to identify temporary sales. In this appendix, we assess the robustness of our sale-filtered results by employing two alternative sale filters to identify and remove temporary sales from our data. For one, we employ a symmetric V-shaped sale filter proposed by Nakamura and Steinsson (2008), which aims at removing price patterns in which the price returns to the same price within 1 or 3 months. If the price does not return to the original price within the chosen window, we consider the price change as a regular price change. For another, we create monthly reference prices as 3-month running modal prices, which we iteratively update to align the reference-price change with the actual price change as in Kehoe and Midrigan (2015).

Table B.1 and Table B.2 present the frequency and size of price adjustments, respectively, for the two versions of the symmetric V-shaped sale filter and the running mode filter.

Table B.1: Frequency of price adjustments, alternative sale filters

	Frequency of price adjustments			
	Changes f	Increases f^+	Decreases f^-	Share Increases
V-shaped filter (1-month window)				
Mean	25.1	12.7	12.4	55.3
Median	12.5	4.9	4.0	
Std. dev.	30.2	19.8	21.0	
V-shaped filter (3-month window)				
Mean	20.1	10.7	9.4	57.3
Median	8.6	3.8	2.5	
Std. dev.	26.5	17.8	17.3	
Running mode filter (3-month window)				
Mean	24.1	12.0	12.0	54.4
Median	10.7	4.2	3.6	
Std. dev.	30.5	19.5	20.8	

Notes: The sample ranges from January 2008 to December 2020 and includes price changes due to product substitutions. The V-shaped filter removes symmetric V-shaped price changes, following the algorithm of Nakamura and Steinsson (2008). We consider 1-month and 3-month windows. The running mode filter removes price changes following the algorithm of Kehoe and Midrigan (2015). The frequency of price "changes," "increases," and "decreases" refer to the weighted averages of the share of price changes, increases, and decreases, respectively. The mean frequency of price changes is calculated by first computing the frequency of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Median statistics and statistics of standard deviations are calculated analogously. "Share of increases" refers to the share of price increases in all price changes. Frequencies of price adjustments are reported in percent per month.

Table B.2: Size of price adjustments, alternative sale filters

	Size of price adjustments			
	Average Changes Δp	Absolute Changes $\lvert\Delta p\rvert$	Increases Δp^{+}	Decreases Δp^{-}
V-shaped filter (1-month window)				
Mean	0.0	10.6	9.8	-11.1
Median	0.5	7.4	6.5	-7.8
Std. dev.	11.5	10.2	10.3	11.2
V-shaped filter (3-month window)				
Mean	-0.1	10.3	9.4	-11.1
Median	0.5	7.3	6.3	-7.8
Std. dev.	11.3	10.0	9.9	11.1
Running mode filter (3-month window)				
Mean	0.0	9.1	8.5	-9.5
Median	0.4	6.1	5.5	-6.4
Std. dev.	10.0	9.2	9.1	9.9

Notes: The sample ranges from January 2008 to December 2020 and includes price changes due to product substitutions. The V-shaped filter removes symmetric V-shaped price changes, following the algorithm of Nakamura and Steinsson (2008). We consider 1-month and 3-month windows. The running mode filter removes price changes following the algorithm of Kehoe and Midrigan (2015). The size of "absolute" price changes, price "increases," and "decreases" refer to the weighted averages of the absolute size of price changes, size of price increases and size of price decreases, respectively. The mean size of average price changes is calculated by first computing the average size of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Median statistics and statistics of standard deviations are calculated analogously. Price changes are reported in percent per month.

B.2 Mismeasurement issues raised by Eichenbaum et al. (2014)

As discussed in Section 2.4, we discard the following prices from our data set to obtain our baseline sample: price imputations (as far as they can be identified), prices derived from auxiliary indices, and prices of administered or semi-administered prices. In addition, we exclude price changes greater than the 99th percentile of absolute log price changes and smaller than the 1st percentile for every variety.

Eichenbaum et al. (2014) have raised various concerns with respect to mismeasurement in the context of CPI microdata. In what follows, we examine to what extent these concerns apply to our data. Eichenbaum et al. (2014) identify 27 problematic items in the US CPI. By problematic, they mean that spurious small price changes arise because of the method used to measure prices. The problematic prices are prices that are non-transactional or are computed as auxiliary indices or pertain to bundles of goods. We are able to match 20 of the 27 items with their counterparts in our Swiss data set. Out of these 20 problematic items, 11 are excluded by our sampling decisions summarized above. The 9 items that remain in the data set are arguably all single-good transaction prices and not computed as a unit value index. Nevertheless, we recalculate our results on the frequency and the size of price changes after excluding all items identified as problematic by Eichenbaum et al. (2014). The results are reported in Table B.3 to Table B.5. Comparing these results with Table 2, Table 6, and Table 7 in the main text, we find that differences are small. None of our conclusions on price-setting behavior is affected.

Table B.3: Frequency of price adjustments

	Frequency of price adjustments			
	Changes f	Increases f^+	Decreases f^-	Share Increases
Mean	27.7	14.3	13.4	56.2
Median	14.3	5.8	4.4	
Std. dev.	31.9	22.3	23.0	

Notes: The sample ranges from January 2008 to December 2020, includes price changes due to temporary sales and product substitutions but excludes all items identified as problematic by Eichenbaum et al. (2014). The frequency of price "changes," "increases," and "decreases" refer to the weighted averages of the share of price changes, increases, and decreases, respectively. The mean frequency of price changes is calculated by first computing the frequency of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Median statistics and statistics of standard deviations are calculated analogously. "Share of increases" refers to the share of price increases in all price changes. Frequencies of price adjustments are reported in percent per month.

Table B.4: Size of price adjustments

	Size of price adjustments			
	Average Changes Δp	Absolute Changes $\|\Delta p\|$	Increases Δp^+	Decreases Δp^-
Mean	0.4	11.7	11.0	-12.4
Median	0.8	8.5	7.6	-9.1
Std. dev.	12.3	11.1	11.0	12.2

Notes: The sample ranges from January 2008 to December 2020, includes price changes due to temporary sales and product substitutions but excludes all items identified as problematic by Eichenbaum et al. (2014). The size of "absolute" price changes, price "increases," and "decreases" refer to the weighted averages of the absolute size of price changes, size of price increases and size of price decreases, respectively. The mean size of average price changes is calculated by first computing the average size of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Median statistics and statistics of standard deviations are calculated analogously. Price changes are reported in percent per month.

Table B.5: Distribution of the size of price adjustments

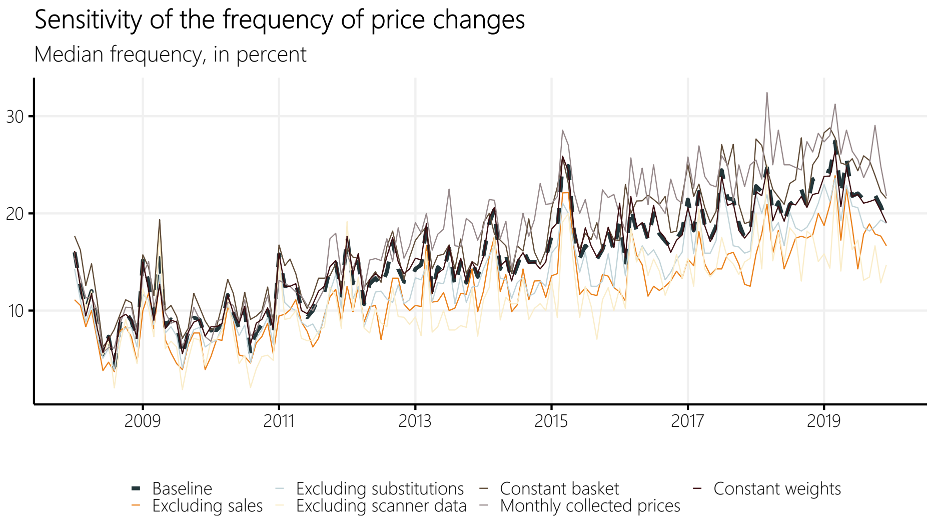
	Size of price adjustments				
	Changes Δp	Abs. changes $\|\Delta p\|$	Increases Δp^+	Decreases Δp^-	Stand. changes z
Mean	0.3	9.8	9.4	-10.3	0.7
10th percentile	-15.1	0.7	0.7	-35.7	0.1
25th percentile	-3.7	1.7	2.6	-22.3	0.2
50th percentile	0.6	4.3	7.3	-9.4	0.5
75th percentile	4.7	11.4	18.3	-2.6	1.0
90th percentile	14.4	25.9	34.8	-0.6	1.5
Standard deviation	21.8	16.9	16.9	16.9	0.6
Skewness	0.2				-0.0
Kurtosis	9.1				4.5

Notes: The sample ranges from January 2008 to December 2020, includes price changes due to temporary sales and product substitutions but excludes all items identified as problematic by Eichenbaum et al. (2014). The size of average price "changes," "absolute" price changes, price "increases," "decreases," and "standardized" price changes refer to the weighted averages of the average size of price changes, absolute size of price changes, size of price increases, size of price decreases, and size of standardized price changes, respectively. The mean size of average price changes is calculated by first computing the average size of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Statistics of other moments are calculated analogously. Median statistics and statistics of standard deviations are calculated analogously. Price changes are reported in percent per month.

B.3 The frequency and size of price changes over time

The variation in the frequency and the size of price changes over time are shown in Figure 5 and Figure 10 in the main text. In what follows, we examine whether the results shown in these figures are robust to alternative data sets, i.e., the exclusion of temporary sales or product substitutions, the exclusion of scanner data, the exclusion of goods and services that were not in the basket over the whole period, the exclusion of prices collected at a non-monthly frequency, and the use of constant instead of time-varying basket weights.

Figure B.1 plots the median frequency (top panel) and the median absolute size (bottom panel) of price changes in CPI microdata from January 2008 to December 2020 for these alternative data sets. The lines in the top panel show an upward trend, whereas the lines in the lower panel are mostly flat. Therefore, our conclusions on the trends in the frequency and absolute size of price changes are robust to the alternative data sets considered here.



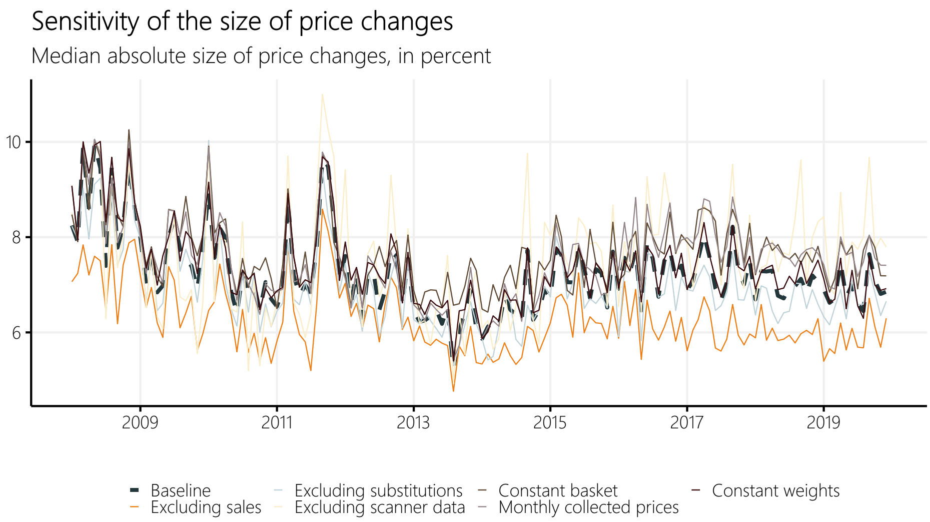


Figure B.1: Sensitivity of the median frequency (top panel) and absolute size of price changes (bottom panel) in Swiss CPI microdata from January 2008 to December 2020 across different sample compositions. "Baseline" refers to the sample including temporary sales and product substitutions used in Figure 5 and Figure 10. "Excluding sales" refers to the sample excluding price changes related to temporary sales. "Excluding substitutions" refers to the sample excluding price changes related to product substitutions. "Excluding scanner data" refers to the sample excluding items collected by scanner. Scanner data was continuously introduced in 2008, 2010, 2012, and 2016. The price of an item collected via scanner data is calculated as the unit value price during the first 14 days of the month, i.e., the ratio of sales revenue from a product to the quantity sold. To the extent that there are temporary discounts, this generates spurious price changes. "Constant basket" is based on items that are consistently part of the basket of goods and services from 2008 to 2020 (and accordingly neglects items that are introduced or discontinued during the period). "Monthly collected prices" is based on prices that have only been collected at a monthly frequency since 2008. "Constant weights" uses time-invariant CPI weights (averaged over the sample period) in the aggregation.

Furthermore, we examine whether the upward trend in the frequency of price changes is related to an increase in the number of goods per outlet. Figure B.2 shows the average number of prices collected per outlet and month and the average frequency of price changes. We observe that the average number of prices collected per outlet varies little over time, while the frequency of price changes shows an upward trend. The correlation between the two series is positive but very low (Pearson correlation coefficient of +0.146). The correlation coefficient stays close to zero when calculating correlations at the level of main groups (not reported in Figure B.2).

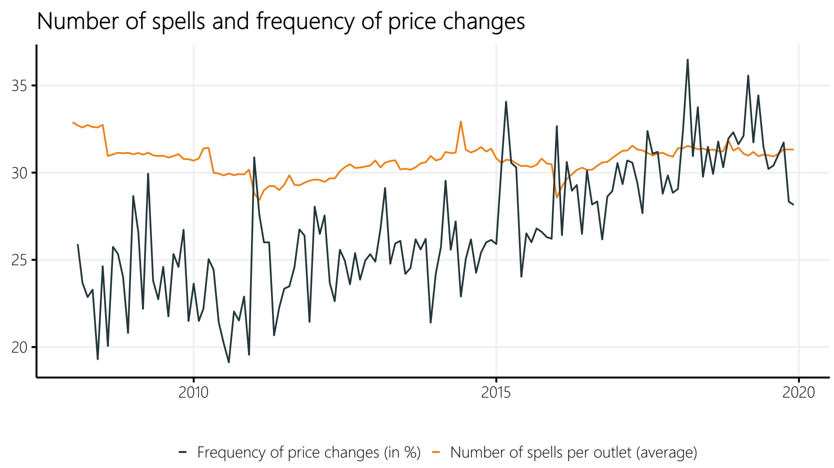


Figure B.2: The figure shows the average frequency of price changes together with the number of spells per outlet for the sample including temporary sales and product substitutions over the period from 2008 to 2019.

B.4 Determinants of the size of price changes

In the main text, we estimate a fixed-effects model to examine the effect of profit margins, inflation, and other variables on the frequency of price changes (Table 5). To complement this analysis, we show the analogous estimation results for the absolute size of price changes in Table B.6. Profit margins have a statistically significant negative effect on the size of price changes. However, the significance is only at the 10 percent level, and the coefficients on profit margins in the sectoral samples are not significant.

Table B.6: Factors affecting the size of price changes

	Dependent variable:			
	Absolute size of price changes			
	All sectors	Food	NEIG	Services
$\text{Profit}_{j,t}$	-0.014^{*}	0.0002	-0.005	0.008
	(0.008)	(0.003)	(0.006)	(0.016)
Core_t	-0.122	-0.075	-0.319^{***}	0.106
	(0.136)	(0.113)	(0.095)	(0.340)
P_t^*	0.009^{*}	0.012^{**}	0.006	0.0003
	(0.005)	(0.005)	(0.004)	(0.012)
$\lvert Y_t \rvert$	-0.017^{**}	0.005	-0.055^{***}	0.011
	(0.007)	(0.008)	(0.006)	(0.026)
$\lvert \Delta\text{EURCHF}_t \rvert$	0.040	0.043^{**}	0.046^{*}	0.012
	(0.025)	(0.021)	(0.027)	(0.065)
Month	Yes	Yes	Yes	Yes
VAT	Yes	Yes	Yes	Yes
Scanner	Yes	Yes	Yes	No
Observations	16,546	9,284	6,346	916
R^2	0.015	0.038	0.025	0.035
Adjusted R^2	0.001	0.027	0.009	-0.006
F Statistic	13.108^{***}	18.903^{***}	9.000^{***}	1.878^{**}

Notes: Fixed-effects estimation in monthly data from January 2008 to December 2020, excluding energy items and price changes due to temporary sales and product substitutions. Absolute sizes of price changes at the expenditure item level ($|\Delta p_{j,t}|$) are calculated based on CPI prices for food, NEIG, and services. Profit margins ($\text{Profit}_{j,t}$) are annual profit margins approximated from the NACE division level. Core inflation (Core_t) is the year-on-year inflation rate of the CPI excluding fresh and seasonal products, energy, and fuel. Growth in commodity prices (P_t^*) is year-on-year percentage change in the Thomson Reuters Core Commodity CRB Index. Output gap ($|Y_t|$) is the percentage deviation of real GDP from HP-filtered real GDP. Exchange rate fluctuations ($|\Delta\text{EURCHF}_t|$) are the cumulative absolute percentage changes in EURCHF exchange rate over the last three months. SCC-adjusted standard errors reported in parentheses: *p<0.1; **p<0.05; ***p<0.01

B.5 The distribution of price changes

In the main text, we summarize various statistics on the distribution of non-zero price changes including temporary sales and product substitutions (Table 7). In Table B.7, we provide the corresponding set of results for the sample excluding sales.

Table B.7: Distribution of the size of price adjustments, excluding sales

	Size of price adjustments				
	Changes Δp	Abs. changes $\|\Delta p\|$	Increases Δp^{+}	Decreases Δp^{-}	Stand. changes z
Mean	0.1	9.2	8.9	-9.5	0.6
10th percentile	-14.1	0.6	0.5	-28.6	0.1
25th percentile	-3.9	1.6	2.1	-16.3	0.2
50th percentile	0.3	4.1	6.7	-7.8	0.5
75th percentile	4.3	11.0	15.2	-2.3	0.9
90th percentile	13.8	23.9	28.5	-0.5	1.5
Standard deviation	15.4	12.3	12.3	12.3	0.6
Skewness	0.2				-0.1
Kurtosis	14.8				5.2

Notes: The sample ranges from January 2008 to December 2020 and includes price changes due to product substitutions but excludes price changes due to temporary sales. The size of average price “changes,” “absolute” price changes, price “increases,” “decreases,” and ”standardized” price changes refer to the weighted averages of the average size of price changes, the absolute size of price changes, size of price increases, size of price decreases, and size of standardized price changes, respectively. The mean size of average price changes is calculated by first computing the average size of price changes for each variety and then taking a weighted mean across all varieties using CPI expenditure weights. Statistics of other moments are calculated analogously. Price changes are reported in percent per month.

B.6 Alternative trimming of the data

The sampling decisions described in Section 2.4 restrict price changes in the data sample to price changes between the 1st percentile and the 99th percentile of the distribution of absolute log price changes. Table B.8 summarizes statistics for the baseline (Case 0) and three alternative trimming thresholds. Statistics are given for the frequency and absolute size of price changes, the standard deviation, and the kurtosis. The kurtosis values reported in the table become smaller when the lower threshold is more stringent.

Table B.8: Robustness of price-setting moments to trimming

Case	Type of trimming	Obs.	f	$\lvert\Delta p\rvert$	sd($\lvert\Delta p\rvert$)	Kur(z)
0	$P1 < \lvert\Delta p\rvert < P99$	1,446,132	26.93	11.13	10.83	4.80
1	$0.5\% < \lvert\Delta p\rvert < P99$	1,296,814	24.18	11.88	10.85	4.32
2	$1.0\% < \lvert\Delta p\rvert < P99$	1,191,857	21.84	12.55	10.88	3.99
3	$P1 < \lvert\Delta p\rvert < 100\%$	1,443,124	26.89	11.02	10.51	4.76

Notes: Robustness of price-setting moments to outlier treatment. The sample ranges from January 2008 to December 2020 and includes price changes due to temporary sales and product substitutions. Case 0 corresponds to the trimming applied in the baseline sample in the main text. "Obs." denotes the number of price changes, f denotes the monthly frequency of price changes in percent, $|\Delta p|$ is the absolute size of price changes, sd($|\Delta p|$) is the standard deviation of the absolute size of price changes, and Kur(z) denotes the kurtosis of standardized price changes. Moments are aggregated using CPI expenditure weights.

B.7 Comparison with evidence on price setting in the United States

This section provides more details on the methodology and the results of the comparison of our findings on price rigidity in Switzerland with evidence for the United States provided by Nakamura and Steinsson (2008) for the period 1998–2005.

To secure a consistent comparison and control for possible differences in the composition of the consumption baskets, we perform the comparison based on a restricted sample of products represented in both countries. Furthermore, we use US CPI expenditure weights to calculate aggregate statistics for both economies. We start from the disaggregated results on the frequency and size of price changes that are part of the supplementary material by Nakamura and Steinsson (2010). To match the underlying product groups with the data for Switzerland, we create a correspondence table between the Entry Level Items (ELIs) classification of the US CPI and the COICOP classification of the Swiss CPI and map them into the five-digit COICOP categories.

We exclude 16 ELIs (accounting for 3.1 percent of the US consumption basket), for which we do not find an appropriate correspondence in the five-digit COICOP categories. These ELIs are: dogs (RB012), automobile service clubs (TF032), housing at school, excluding board (HB011), replacement of setting for women's rings (GD043), calculators and adding machines (EE042), gardening or lawn care services (HP021), reupholstery of furniture (HP042), Spanish/Mexican foods (FT062), rental of video tapes and discs (RA042), peanut butter (FS031), moving, storage, freight express (HP031), appliance repair (HP041), motor oil (TC022), alternative automotive fuels (TB022), vehicle leasing (TA031) and automobile rental (TA041).

Furthermore, we exclude 5 five-digit COICOP categories (accounting for 8.2 percent of the US consumption basket) for which underlying prices are collected using a different method in one country (e.g., as unit-value index or administered prices) than in the other. These COICOP categories are: electricity (04.5.1), gas (04.5.2), other health related incurred costs (06.6.1), recording media (09.1.4), and books (09.5.1).

Table B.9 and the upper panels of Figure B.3 present the comparison results for the frequency of price changes. Results are given for the mean and median frequency of price changes and samples including and excluding temporary sales. Price changes due to product substitutions are excluded in all samples. The corresponding results for the absolute size of price changes are presented in Table B.10 and in the lower panels of Figure B.3.

Table B.9: Frequency of price adjustments: Switzerland versus United States

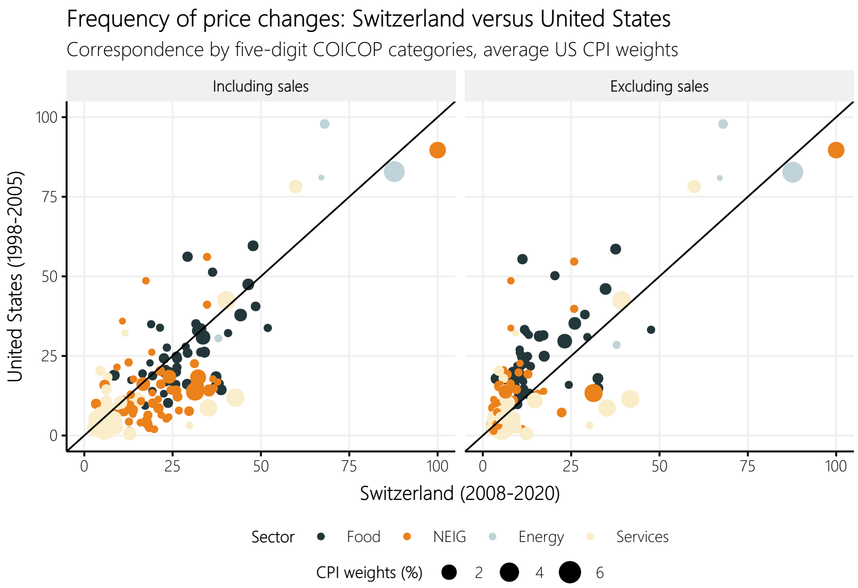
	Including sales				Excluding sales			
	Mean		Median		Mean		Median	
	CH	US	CH	US	CH	US	CH	US
Total	20.6	25.8	11.9	20.4	19.1	20.2	8.7	8.4
Food	28.0	31.3	25.9	32.9	26.6	17.7	24.8	13.1
NEIG	19.9	28.6	13.8	25.9	15.5	17.7	5.0	6.4
Energy	82.7	85.4	82.9	87.6	82.5	85.4	82.7	87.6
Services	11.1	15.2	5.6	7.8	11.0	14.9	5.6	7.8

Notes: The table shows the mean and median frequencies of price adjustments in percent per month for Switzerland and the United States. The results for Switzerland are based on the period from January 2008 to December 2020. The results for the US are taken from Nakamura and Steinsson (2010) calculated on the period 1998–2005. To control for possible differences in the composition of the consumption basket across economic areas, the comparison uses the same equivalent products and US CPI expenditure weights to calculate aggregate statistics. Both samples exclude price changes due to product substitution. Temporary sales are excluded using sale flags by the respective national statistical office.

Table B.10: Absolute size of price adjustments: Switzerland versus United States

	Including sales						Excluding sales					
	Changes		Increases		Decreases		Changes		Increases		Decreases	
	CH	US	CH	US	CH	US	CH	US	CH	US	CH	US
Total	10.9	15.3	10.6	14.2	10.9	17.3	7.9	10.7	7.5	10.1	8.5	12.5
Food	7.8	24.8	7.6	23.4	7.9	26.6	6.4	13.7	6.2	12.6	6.4	16.0
NEIG	15.8	18.4	14.4	16.6	15.8	19.7	8.0	9.7	7.4	9.3	8.8	10.7
Energy	2.4	6.6	2.1	7.0	2.2	6.0	2.3	6.6	2.0	7.0	2.1	6.0
Services	10.0	11.1	10.5	10.4	10.0	13.7	9.1	10.6	8.8	10.0	10.0	13.0

Notes: The table shows the average absolute size of price changes, increases and decreases in percent per month for Switzerland and the United States. The results for Switzerland are based on the period from January 2008 to December 2020. The results for the US are taken from Nakamura and Steinsson (2010) calculated on the period 1998–2005. To control for possible differences in the composition of the consumption basket across economic areas, the comparison uses the same equivalent products and US CPI expenditure weights to calculate aggregate statistics. Both samples exclude price changes due to product substitution. Temporary sales are excluded using sale flags by the respective national statistical office.



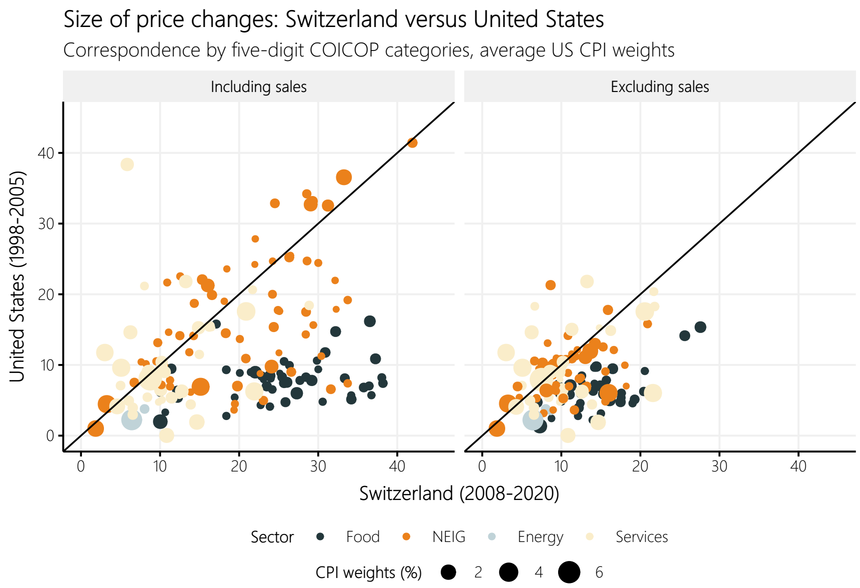


Figure B.3: These figures plot the frequency (upper panels) and size of price changes (lower panels) for the samples including and excluding temporary sales for Switzerland and the United States. The results for Switzerland are based on the period from January 2008 to December 2020. The results for the US are taken from Nakamura and Steinsson (2010) calculated on the period 1998–2005. To control for possible differences in the composition of the consumption basket across economic areas, the comparison uses the same equivalent products and US CPI expenditure weights to calculate aggregate statistics. Both samples exclude price changes due to product substitution. Temporary sales are excluded using sale flags by the respective national statistical office.

B.8 Comparison with evidence on price setting in the euro area

This section provides more details on the methodology and the results of comparing our findings on price rigidity in Switzerland with evidence for the euro area provided by Gautier et al. (2021).

Gautier et al. (2021) use CPI microdata from eleven euro area countries and build a harmonized sample of 166 common products at the five-digit COICOP level. The 166 common products are items for which data are available in at least three of the four largest euro area countries (Germany, France, Italy, and Spain). They calculate results on the frequency and size of price changes over the common period from 2011 to 2017 across all countries, except for Belgium (2011–2015) and Latvia (2017).

Gautier et al. (2021) do not publish disaggregated results on the frequency and size of price changes. Therefore, we restrict our sample to 155 of the 166 common products, which are also represented in our Swiss data.[35] The 11 five-digit COICOP categories missing from the Swiss data account for only 1.8 percent of the 166 common products in the euro area by expenditure weight, which leaves our comparison broadly representative. We further restrict the sample period to 2011–2017 to compare moments of price rigidity on a common period in all euro area countries (except Belgium: 2011–2015; Latvia: 2017) and Switzerland. Beyond, we use the same euro area HICP weights averaged over 2017–2020 to aggregate our five-digit COICOP-level results for Switzerland.

The 11 COICOP categories missing in our data for Switzerland are: Fresh or chilled seafood (01.1.3.3), frozen seafood (01.1.3.4), other preserved or processed fish and seafood-based preparations (01.1.3.6), milk, preserved (01.1.4.3), repair of furniture, furnishings and floor coverings (05.1.3.0), repair of household appliances (05.3.3.0), thermal-baths, corrective-gymnastic therapy, ambulance services and hire of therapeutic equipment (06.2.3.2), lubricants (07.2.2.4), removal and storage services (07.3.6.2), museums, libraries, zoological gardens (09.4.2.2), and accommodation services of other establishments (11.2.0.3).

Table B.11 presents the comparison results for the frequency of price changes. Results are given for the mean and median frequency of price changes and samples including and excluding temporary sales. Price changes due to product substitutions are excluded in all samples. The corresponding results for the size of price changes are presented in Table B.12.

[35] We thank the authors for providing us the list of 166 common products covered in Gautier et al. (2021).

Table B.11: Frequency of price adjustments: Switzerland versus euro area

	Including sales				Excluding sales			
	Mean		Median		Mean		Median	
	CH	EA	CH	EA	CH	EA	CH	EA
Total	15.2	11.9	12.8	9.6	12.9	8.3	7.4	5.7
Processed food	48.4	31.1	50.4	29.3	46.9	23.4	49.3	20.2
Unprocessed food	21.4	14.9	21.6	14.4	20.2	10.2	19.9	8.5
NEIG	12.6	12.4	14.5	12.0	6.5	6.3	3.3	5.1
Services	7.1	5.6	4.3	3.2	7.0	5.4	4.1	3.0

Notes: The table shows the mean and median frequencies of price adjustments in percent per month for Switzerland and the euro area. The results for the euro area are taken from Gautier et al. (2021) calculated on the period 2011–2017 (Belgium: 2011–2015; Latvia: 2017) and using a harmonized sample of 166 common products. The results for Switzerland are based on the same period and 155 of the 166 common products, representing 98.2% of their expenditure. Results for both economic areas use euro area HICP weights averaged over the period 2017–2020 to aggregate five-digit COICOP-level results to control for possible differences in consumption patterns. Both samples exclude price changes due to product substitution. Temporary sales are excluded using sale flags by the respective national statistical office.

Table B.12: Absolute size of price adjustments: Switzerland versus euro area

	Including sales				Excluding sales			
	Increases		Decreases		Increases		Decreases	
	CH	EA	CH	EA	CH	EA	CH	EA
Total	11.8	9.0	12.9	12.0	7.9	6.4	9.3	8.0
Processed food	9.8	12.3	9.7	14.5	8.8	10.0	8.6	10.6
Unprocessed food	6.9	8.3	7.2	10.4	5.3	5.7	5.6	6.1
NEIG	20.2	13.5	21.1	18.4	9.2	7.8	11.9	10.2
Services	8.1	5.0	10.0	6.5	7.9	5.0	9.5	6.2

Notes: The table shows the median absolute size of price increases and decreases in percent per month for Switzerland and the euro area. The results for the euro area are taken from Gautier et al. (2021) calculated on the period 2011–2017 (Belgium: 2011–2015; Latvia: 2017) and using a harmonized sample of 166 common products. The results for Switzerland are based on the same period and 155 of the 166 common products, representing 98.2% of their expenditure. Results for both economic areas use euro area HICP weights averaged over the period 2017–2020 to aggregate five-digit COICOP-level results to control for possible differences in consumption patterns. Both samples exclude price changes due to product substitution. Temporary sales are excluded using sale flags by the respective national statistical office.

C The synchronization of price changes

This appendix refers to Section 5 in the main body of the paper, where we show results on the synchronization of price changes in four sectors (Table 11). Table C.1 shows the results for the samples including and excluding temporary sales and product substitutions. Temporary sales (and to a lesser extent product substitutions) tend to increase synchronization within varieties and decrease synchronization within outlets.

Table C.1: Synchronization of price changes across samples including and excluding temporary sales and product substitutions

	Incl. sales Incl. subst.	Excl. sales Incl. subst.	Incl. sales Excl. subst.	Excl. sales Excl. subst.
Positive price change				
Fraction up outlet	1.067	1.07	1.067	1.069
	(0.000)	(0.000)	(0.000)	(0.000)
Fraction down outlet	1.036	1.045	1.033	1.045
	(0.000)	(0.000)	(0.000)	(0.000)
Fraction up variety	1.043	1.039	1.04	1.038
	(0.000)	(0.000)	(0.000)	(0.000)
Fraction down variety	1.018	1.012	1.014	1.01
	(0.000)	(0.000)	(0.000)	(0.000)
Negative price change				
Fraction up outlet	1.048	1.049	1.049	1.047
	(0.000)	(0.000)	(0.000)	(0.000)
Fraction down outlet	1.065	1.069	1.063	1.067
	(0.000)	(0.000)	(0.000)	(0.000)
Fraction up variety	1.025	1.015	1.019	1.015
	(0.000)	(0.000)	(0.000)	(0.000)
Fraction down variety	1.048	1.038	1.043	1.035
	(0.000)	(0.000)	(0.000)	(0.000)
Positive price change				
Fraction change outlet	1.053	1.059	1.053	1.059
	(0.000)	(0.000)	(0.000)	(0.000)
Fraction change variety	1.032	1.026	1.028	1.026
	(0.000)	(0.000)	(0.000)	(0.000)
Negative price change				
Fraction change outlet	1.058	1.06	1.058	1.059
	(0.000)	(0.000)	(0.000)	(0.000)
Fraction change variety	1.039	1.03	1.035	1.029
	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Multinomial logit estimation of the synchronization of Swiss consumer price changes from 2008 to 2020 across samples (including and excluding temporary sales and product substitutions). The table shows the relative risk ratios for a positive (negative) price change compared to no price change. The fractions of positive (negative) price changes within outlets and within varieties are included in percent. Standard errors in parentheses. Controls are included but not reported.