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CURRENCY APPRECIATION, DISTANCE TO BORDER AND PRICE CHANGES: EVIDENCE FROM SWISS RETAIL PRICES

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JEL Classification: E30, E31

Keywords: Price Setting Behavior of Firms, Exchange rate, Distance to Border

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Currency appreciation, distance to border and price changes: Evidence from Swiss retail prices

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July 3, 2020

Abstract

How does the exchange rate affect the way that firms adjust their prices? We use quarterly firm and product price data, underlying the Swiss sectoral consumer price index. The data allows us to trace the pricing decisions of the identified firm over time and as a function of the distance to the border distance. The appreciation of the Swiss franc results in an increase in the probability of both positive and negative price changes. When a firm is more closely located to the border, the probability of a negative price change is higher. On the intensive margin, we document that an appreciation of the Swiss Franc leads to price reductions, and that this effect is stronger the closer a firm is located to the nearest border. However, for firms located far away from the border, an appreciation of the Swiss Franc leads to no price reductions or even increases. We rationalise this by the relative strengths of income and substitution effects. The substitution effect dominates for firms close to the border, while the income effect dominates for firms located further away from the border.

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1 Introduction

The pass-through of exchange rate movements is a crucial element to analyzing macroeconomic policies in open economies. The way how exchange rates affect the price level depends on how firms actually adjust their prices. The change in the price level is a function of the frequency of price adjustments, the extensive margin and the extent to which a firm adjusts its prices, the intensive margin.

This paper wants to analyze how the exchange rate affects the price decision of retail firms both at the intensive and extensive margin. In particular, we want to investigate whether this depends on the distance to the border of the location of the store. To this end, we use a panel data set of product prices underlying the Swiss sectoral CPI data series. A unique feature compared to other datasets is that the price series of individual firms do not interrupt on a regular basis as this is the case, for example, for US CPI data.[1] Furthermore, for each observation (that is, a certain product sold in a certain store at a certain point in time) we also observe the location of the store where the good is sold, along with an ID for that store. This allows us to track one particular good of one store over time, and relate its price movements to changes in the exchange rate as well as the distance to the border of its point of sale. Our main finding is that appreciations of the Swiss Franc induce Swiss retailers to lower prices. For stores located far away from the border, this effect vanishes, we obtain even evidence for price increases. We interpret the latter result as a dominating income effect resulting from a higher purchasing power due to appreciation.

We investigate the observable factors that influence price setting behavior at both the extensive and intensive margins, i.e., the frequency and the (average) size of price changes. Following the literature, we distinguish between time-dependent and state-dependent variables. In accordance with previous findings, our results show that time-dependent variables are of less importance, with the exception of seasonality components, i.e., we observe more and, on average, stronger price adjustments during the first quarter of a year. State-dependent factors are of larger importance. The position of the firm's price relative to the average of its competitors is particularly relevant. Both the probability and the size of a price change

[1] See Klenow and Kryvtsov (2008).

increase to a greater extent the further away a price is from the average price of competitors.

This paper addresses two strands of the literature. The first one aims to understand firms' price setting behavior at the microeconomic level. As mentioned, it is empirically well acknowledged that prices are not fully flexible. Indeed, price stickiness is a theoretical key factor of all New Keynesian models in the macroeconomic literature. On the one hand, *time-dependent* models consider the timing of price changes as exogenously given, meaning that only the size of the price change is chosen by the respective firm. There exists a traditional literature concerning theoretical modelling of this kind of price setting behavior (e.g., Calvo (1983), Taylor (1980), Mankiw and Reis (2002)). Following this literature, several contributions tried to analyze empirically the timing patterns of price adjustments.[2] Kashyap (1995) states that prices are normally fixed for more than one year; however, he also clearly emphasizes that the time between price changes is irregular, i.e., there is likely no stable frequency. It is therefore not surprising that other authors report different frequencies. Bils and Klenow (2004), for example, who consider more than 350 categories of consumer goods, examine a frequency of approximately five months. Nakamura and Steinsson (2008) propose that 9-12% of prices change every month, but the price adjustments are highly seasonal, i.e., most prices change at the beginning of a year - a finding that we can also support with our data. [3]

On the other hand, *state-dependent* pricing, in the theoretical literature generally referred to as "menu cost models", assumes that firms react to idiosyncratic shocks, i.e., that firms' pricing decisions are made independent of timing (Rotemberg, 1982; Dotsey, King and Wolman, 1999; Gertler and Leahy, 2008; Golosov and Lucas, 2007). The empirical literature concerned with state-dependent pricing is rather small. An important contribution is made by Klenow and Kryvtsov (2008) who work with a similar dataset to ours for the U.S. They compare pricing patterns with the predictions of the most important theoretical models and find that especially time-dependent pricing models are not in line with real data, especially regarding the size of price changes. Using a different econometric approach, however, our findings cannot support

[2]There is also a literature trying to relate inflation and the frequency of price adjustments. A well known example is the contribution by Cecchetti (1986) who uses data on the newsstand prices of American magazines for this purpose.

[3]More recently, Hong et al. (2020) and Balleer and Zorn (2019) analyze the real effects of monetary policy on U.S. and German producer prices, respectively. The find monetary non-neutrality over longer time horizons.

this result for Swiss data. Lein (2010) uses a survey across industrial firms in Switzerland which allows her to consider the impact of individual cost structures and expectations. However, the survey does not contain information about the sizes of price changes. Honoré, Kaufmann and Lein (2012) use smiliar data to ours from subindices of the Swiss CPI to investigate the contribution of general inflation to the share of positive price changes in Switzerland.[4]

The second strand of the literature we address focuses on the functioning of the exchange rate pass-through. Most literature asks how fast the general price level reacts to exchange rate movements, for example by distinguishing between high and low inflation environments or emerging and industrialized countries (see, e.g., Menon (1995), Choudhri, Faruqee and Hakura (2005), Mishkin (2008), Ha, Stocker and Yilmazkuday (2019), Jašová, Moessner and Takáts (2019)). Closer to our paper are studies that focus on the impact of the exchange rate movements on prices at the micro-level, finding factors as firm size, share of imported inputs, product quality, distribution costs and the strength of competition to be specific determinants of the pass-through (see Bonadio, Fischer and Sauré (2019) and Casas (2019) for an overview)[5]. We add to this literature as we use the distance to the border as additional explanatory factor while using the prices of all sectors present in CPI[6].

The remainder of the paper is organized as follows. Section 2 describes the data and provides descriptive statistics. Section 3 presents the results of the econometric estimations regarding the price setting behavior. Finally, section 4 concludes.

[4]Certain studies investigate the reaction of sectoral price indices (instead of prices in a narrow sense) to macroeconomic disturbances. See, e.g., Boivin, Giannoni and Mihov (2009), Maćkowiak, Moench and Wiederholt (2009), Kaufmann and Lein (2013), and Altissimo, Mojon and Zaffaroni (2009).

[5]For the case of Switzerland, especially the termination of the exchange rate minimum in 2015 is often used as a case study (e.g., Bonadio, Fischer and Sauré (2019) and Auer, Burstein and Lein (2018)).

[6]Baggs et al. (2016) document the adverse impact of exchange rate appreciation on sales and profits (but not prices) of retailers in relation to their distance to the US/Canadian border. The strength of the negative effect is decreasing in the distance of the border. In contrast, our focus lies on the reaction of prices. In addition, we consider all goods and services.

2 Data description and descriptive statistics

2.1 Data

Our analysis is based on quarterly firm and product price data. The data are provided by the Swiss Federal Statistical Office (SFSO) and are available for the years 1993 to 2017. The data set allows us to track the development of a single price for a given product charged by a given firm over time.

The data appear on a quarterly basis from 1993Q2 to 2017Q4. Firms and products enter and exit the data set on an irregular basis, but these changes are documented. Thus, a few prices can be tracked over the entire sample, which is a central advantage of the data set over others (e.g., Klenow and Kryvtsov (2008), in which products always drop out the data set after at most five years). Furthermore, only 1.8% of all the recorded price changes in the data set are due to temporary sales, which largely eliminate a critical source of disturbances in the estimation. A disadvantage of the data is that we could not observe any additional information about the tracked firms, except for the location of that firm. We will use this information to calculate the distance to border of that firm.[7] As the distance to the border is a crucial variable in our analysis, we exclude all observations for which the recorded location is either "Switzerland" or missing (2,581,669 observations).[8] In addition, we exclude observations for which different locations within the same store are recorded (41,553 observations). This leaves us with a panel of 4,351,105 observations.

In the second quarter of 2000, we observe a disproportionately large number of firms and products that are replaced, because the method for calculating the CPI in Switzerland changed at this point in time.[9] A limited number of substantial price jumps indicate potential measurement errors at this time; however, we retain these observations in the data because they have little impact on the results.

[7]The location of the firm is available for firms in 11 Swiss cities: Basel, Berne, Chur, Geneva, Lausanne, Lucerne, Lugano, Neuchatel, Sion, St. Gallen, and Zurich.

[8]Note that the observations referring for the term "Switzerland" consist of different types of data points, e.g., those observations record price changes on a more aggregate level (such as the general price development of the tourism sector in a particular region, as opposed to individual items sold in a restaurant or hotel).

[9]See Kaufmann (2009) for a broader discussion.

The data set records, based on the statistical criteria of the SFSO, whether a certain product is replaced by a new one, e.g., because of a substantial quality improvement. If we observe such a replacement, we consider the given price series as terminated and begin a new one.

Table 1 provides an overview of the data structure. Note that the total number of observations refers to the number of observed prices and not to the number of price changes.

Table 1: Overview data

Specification	Number
Producers (or firms)	3,079
Products	1,502
Price Series	297,697
Quarters	97
Observations	4,351,105
Time span	1993q2-2017q2

The table shows that we have information on more than 3000 producers, producing 1502 distinct products. The sample spans 97 quarters, and we have more than four million observations. The large number of producers justifies the assumption in the empirics that prices are set independently. If prices were set centrally, this would drive the estimate of the border effect, our main result of interest, to zero.[10]

To these firm level data, we match a series of macroeconomic variables, which serve as control variables in our regressions. These macroeconomic variables include the Swiss CPI and its subindices, provided by the SFSO. On the highest level of aggregation, there are 12 subindices or sectors. For the econometric analysis and the calculation of sectoral inflation, as explained in section 2.2 below, we use the fourth level of aggregation, which are 95 subindices. Furthermore, we collect data on GDP and key interest rates from Datastream, and we add

[10] One potential obstacle for our empirical analysis could arise from the fact that Switzerland's two largest retailers, Migros and Coop, set their prices centrally for all their stores across Switzerland. Due to the concentration in the retail sector, this could be problematic as these two entities might account for a significant share of the data points in our sample. However, the two companies are organised as cooperatives, and the regional cooperatives are responsible for the price setting in their according region, although there are no official statements on their price setting strategy. Table 11 in the appendix shows the cooperatives for Migros and the cities in our data set belonging to each of the cooperatives. Coop has a similar structure: there are ten cooperatives, and for each of them we have one city in our dataset (except for one cooperative we have two cities). This alleviates the threat that prices for these stores are set centrally. And even if there exists some degree of central price setting for these retailers, this would rather drive our result towards zero.

information on changes in the value added tax (VAT) to the dataset.

The explanatory variable of interest is the real effective exchange rate for the Swiss Franc and its interaction with the distance to border. To calculate the distance to border, we take the stores' locations and calculate the distance to the next border post either in kilometers or in minutes by car.

2.2 Constructed variables

Three variables are constructed from the data. The first reflects, at each point in time and for each price series, the number of periods since the last non-zero price change. Let $p(i_n, j, t)$ be the price of product i_n (where n is the number of the product, if the same product type, i, is sold more than once by the same firm), charged by firm j in period t; then, $\hat{p}(i_n, j, t) := \frac{p(i_n,j,t)-p(i_n,j,t-1)}{p(i_n,j,t-1)}$ subsequently defines the respective relative change in this price. Furthermore, we denote $k_1(i_n, j), k_2(i_n, j), \ldots, k_m(i_n, j), \ldots, k_M(i_n, j)$ as those periods during which we observe a change in the price, $p(i_n, j, t)$. In formal terms:

$$t = \begin{cases} k_m(i_n, j), & \text{if } \hat{p}(i_n, j, t) \neq 0 \\ k_m(i_n, j) + z(i_n, j, t), & \text{otherwise} \end{cases}, \tag{1}$$

where $z(i_n, j, t,) := \min_{k_m(i_n,j)<t} (t - k_m(i_n, j)) \; \forall \, t, m$ therefore represents the desired number of periods since the last price change. In constructing the variable $z(i_n, j, t,)$, we were forced to omit the data before the first price change in every price series, i.e., all data points at $t < k_1(i_n, j)$. This procedure follows Klenow and Kryvtsov (2008), who also note that the estimations would be biased otherwise.

Second, we are interested in the accumulated sectoral inflation after the last price change occurred. We measure sectoral inflation on the fourth level of aggregate, thus there are 95 sectors. $\text{CPI}_{\Omega(i)}(t)$ represents the subindex to which product i belongs (in period t). Given this notation, the inflation accumulated since the last price change, denoted $\pi(i_n, j, t)$, is defined as follows:

$$\pi(i_n, j, t) := \min_{k_m(i_n,j)<t} \frac{\text{CPI}_{\Omega(i)}(t-1) - \text{CPI}_{\Omega(i)}(k_m(i_n, j))}{\text{CPI}_{\Omega(i)}(k_m(i_n, j))}. \tag{2}$$

Note that equation (2) implies that accumulated inflation is measured as the inflation occurring between the last price change and period $t-1$, which is assumed for the following reason: A firm that is deciding whether it wishes to change one of its prices in period t only knows the inflation rate prior to period $t-1$, because the inflation rate of period t remains unknown until all the firms have made their pricing decisions in period t. Moreover, the construction of the variable also prevents a potential endogeneity problem. We create a similar measure for accumulated exchange rate changes for a given product since its last price change.

Third and as a particular feature of our dataset, we are able to calculate each price relative to the mean price of its product category, i, at each point in time, t. For this purpose, we define $A(i,t) := \sum_{n,j} 1_t[p(i_n,j,t)]$ as the total (unweighted) number of observed prices of product i in period t. Thus, $1_t[.]$ is an indicator function taking a value equal to one if $p(i_n,j,t) > 0$ in period t and zero otherwise. Denoting the individual deviation from the mean price as $\rho(i_n,j,t)$, we can define

$$\rho(i_n,j,t) := \frac{p(i_n,j,t)}{\frac{1}{A(i,t)}\sum_{n,j} p(i_n,j,t)} - 1. \tag{3}$$

Note that, by construction, it holds that $\frac{1}{A(i,t)}\sum_{n,j} \rho(i_n,j,t) = 0 \; \forall\, i,t$. The variable $\rho(i_n,j,t)$ provides us with a measurement of the competitive standing of the respective price. It is clear that this measurement is only an approximation, because we cannot observe other important factors, such as distance to the nearest competitor or other cost factors.

2.3 Descriptive statistics

Table 2 presents the frequency of price changes (positive and negative) disaggregated by each individual product sector, Ω, where we use the first level of aggregation (i.e. there are twelve sectors). In the full sample, the prices are changed in 20% of all the observations. Compared to the literature, the firms in our data set change prices relatively infrequently.

Table 2: Share of price changes

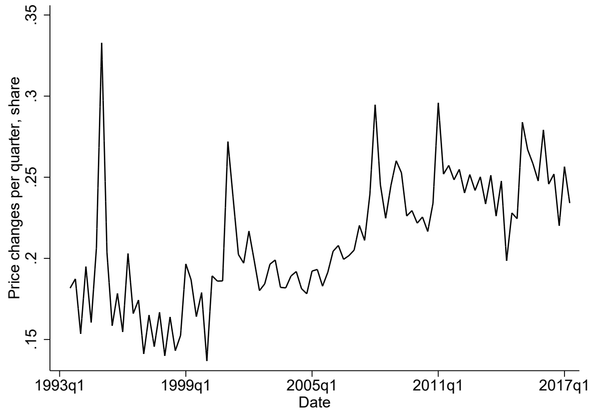
Sector	Price changes	Positive	Negative	N Firms	N Obs
All	20.46%	11.39%	9.08%	3,079	4,053,087
1	29.64%	16.06%	13.58%	324	1,437,476
2	14.76%	9.04%	5.72%	148	196,130
3	16.02%	8.28%	7.74%	370	608,698
4	49.65%	25.92%	23.74%	238	96,782
5	12.91%	7.72%	5.18%	298	308,314
6	8.32%	6.26%	2.06%	243	64,813
7	25.98%	13.60%	12.38%	440	163,029
8	39.64%	13.82%	25.82%	16	2,858
9	14.10%	7.46%	6.64%	742	532,071
10	8.41%	7.18%	1.22%	142	33,153
11	8.56%	7.02%	1.55%	374	297,206
12	11.38%	7.50%	3.88%	481	302,872

The sectors are 1 – Food and non-alcoholic beverages, 2 – Alcoholic beverages and tobacco, 3 – Clothing and footwear, 4 – Housing and energy, 5 – Household goods and services, 6 – Healthcare, 7 – Transport, 8 – Communications, 9 – Recreation and culture, 10 – Education, 11 – Restaurants and hotels, 12 – Other goods and services.

The data also suggest downward price rigidity, in line with the findings provided by Kaufmann (2009), which can to some extent be explained by the nominal downward rigidity of wages, as described by Fehr and Goette (2005) for the case of Switzerland.

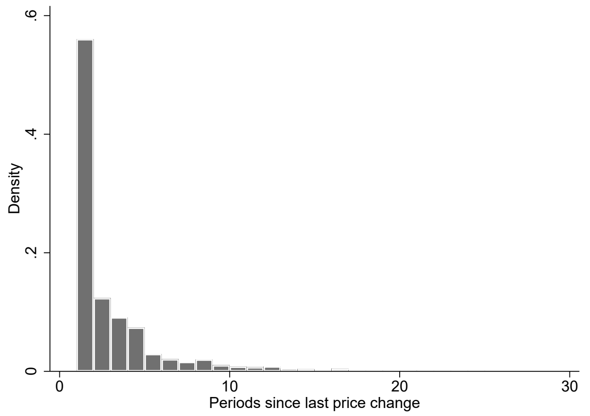
Figure 1 graphically illustrates the (unweighted) frequency of price changes over time, measured as a share of all the observations in each quarter. The graph indicates that the frequency of price changes is seasonal, with a peak in the first quarter of the year and a decrease thereafter. However, some spikes stand out by visual inspection. These spikes coincide with the introduction and further raises in the VAT, the first time in January 1995 and subsequently in January 2001 and 2008. Furthermore, there occurs a spike in the first quarter of 2015, when 17.3% of the prices are lowered (note that, in comparison, figure 3 shows negative and positive price changes). In January 2015 the minimum exchange rate was lifted which led to an appreciation of the Swiss Franc by around 10% leading many firms to lower their prices.

Figure 1: Frequency of price changes, on a quarterly basis



As with most models, the distribution in figure 2 is right skewed. We observe a strong drop in the frequency of price changes between the fourth and fifth quarter, indicating yearly frequency of price setting.

Figure 2: Frequency of price changes, on a quarterly basis



Our dataset allows us to calculate not only the frequency but also the size of price changes. Table 3 and Figure 3 describe how the size of non-zero price changes are distributed. For this purpose, we normalize the data in the sense that we subtract the accumulated sectoral inflation at every non-zero price change (data points without a price change, constituting the majority, are excluded), i.e., the statistics refer to data of the following form:

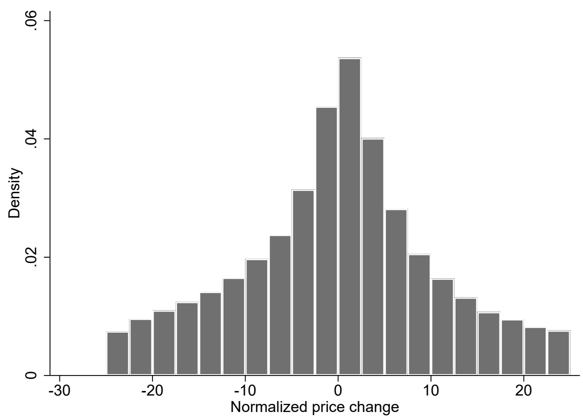
$$\hat{p}_{norm}(i_n, j, t) := \begin{cases} \hat{p}(i_n, j, t) - \pi(i_n, j, t), & \text{if } \hat{p}(i_n, j, t) \neq 0 \\ \emptyset, & \text{otherwise} \end{cases}. \tag{4}$$

The normalization allows us to interpret the size of a price change while abstracting from the potential "distortion" of the general price development. Consequently, the average normalized price change is therefore not statistically different from zero. We can observe a relatively broad distribution of price changes, implying that other factors might also be important in the price setting process.

Table 3: Statistics for normalized price changes

	Mean	St.Dev.	Min.	Max.
Normalized price change	3.44%	26.33%	-103.82%	1034.02%

Figure 3: Histogram of normalized price changes



3 Econometric results

3.1 Methodology

We are interested how appreciations (or depreciations) in the real effective exchange rate of the Swiss Franc affect pricing decisions of Swiss retailers. In particular, we want to investigate whether this decision depends on the distance to the border to neighbouring countries.

To answer this question we focus both on the frequency and the size of the price changes. First, we focus on the extensive margin. Controlling for other factors, we estimate how the real effective exchange rate in combination with the distance to border of the store influences the probability of a (positive or negative) price change. A conditional logit model is employed for this purpose. The conditional form is appropriate because we are unable to observe any individual attributes of firms or price series within the data set. In the second part, we focus on the intensive margin. We estimate how the exchange rate and other factors influence the size of price adjustments on average (i.e., we also consider the data points with no price changes because these represent also pricing decisions) by relying on a standard OLS framework.

In each of the two models, we estimate three regression specifications, but the specifications differ in the numbers of variables included. In the first specification, we only include the variables of interest along with dummy variables for quarter. In the second model, we add accumulated sectoral inflation (on the fourth level of aggregation) as well as the relative price of the product compared to the mean price of the same product. In the third specification, we add macroeconomic variables: Growth in GDP and its lags, the LIBOR and its lags, as well as information about changes in the value added tax (VAT).

A dummy for the second quarter of 2000 is also included in each estimation, and the same holds for starting and ending points of temporary sales.[11] All the estimations also include product-series-specific fixed effects to control for series-specific shocks. Because the firm is the relevant pricing decision unit, standard errors are clustered at the firm level, as proposed by Lein (2010).

3.2 Pricing at the extensive margin

This section analyzes the factors that influence individual pricing decisions at the extensive margin (i.e., whether a firm changes its price), using a conditional logit probability model. The estimations for the three specifications are performed twice: once for positive price changes and once for negative price changes. Table 4 reports the parameter estimates from the conditional logit model.

[11] The dummy for the second quarter of 2000 is included because of the relatively high proportion of product replacements during this period due to a change in the method for calculating the CPI. See section 2.1.

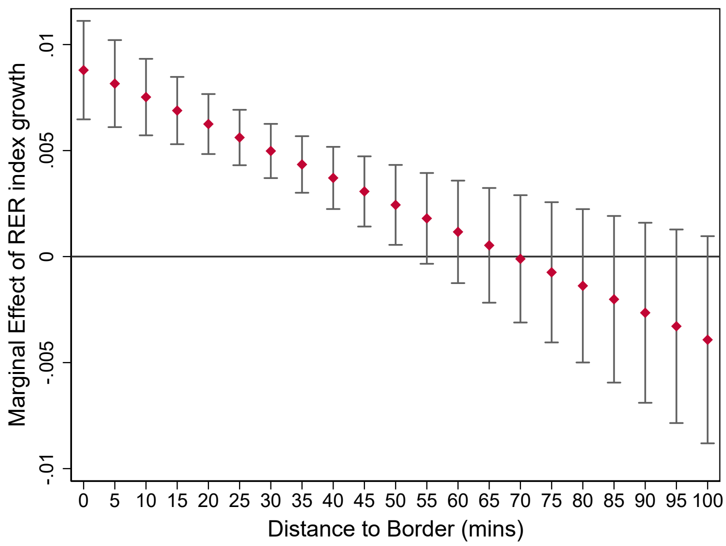
Table 4: Conditional Logit probability model

Dependent Variable:	Positive Price Changes			Negative Price Changes		
	(1)	(2)	(3)	(4)	(5)	(6)
RER index growth, qoq	1.09**	1.94***	0.83*	3.56***	2.65***	2.32***
	(0.52)	(0.51)	(0.49)	(0.48)	(0.48)	(0.55)
RER index growth, qoq × Minutes to border	0.02	0.00	0.01	-0.05***	-0.03*	-0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Periods since last price change, $z(i_n, j, t)$	2.29***	2.83***	3.13***	5.36***	5.39***	5.85***
	(0.57)	(0.60)	(0.63)	(0.62)	(0.64)	(0.65)
$z(i_n, j, t)^2$	0.02	-0.05***	-0.05***	-0.13***	-0.10***	-0.11***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Acc.sec.infl., $\pi(i_n, j, t)$		11.30***	11.15***		-10.33***	-10.16***
		(0.42)	(0.41)		(0.51)	(0.50)
L.Price relative to mean price, $\rho(i_n, j, t)$		-4.11***	-4.13***		3.96***	3.97***
		(0.21)	(0.21)		(0.13)	(0.13)
L.$\rho(i_n, j, t)^2$		0.00**	0.00**		-0.00***	-0.00***
		(0.00)	(0.00)		(0.00)	(0.00)
RER lags	No	No	Yes	No	No	Yes
Period controls	Yes	Yes	Yes	Yes	Yes	Yes
Macro controls	No	No	Yes	No	No	Yes
Observations	2,305,571	2,297,377	2,297,172	1,885,163	1,881,348	1,881,208

Standard errors are clustered at the firm level and are displayed in brackets. All estimates include a price series fixed effect. RER lags includes lags 1–4 for the RER index growth variable. Period controls include quarter dummies, sales (and sales end) dummies, as well as a dummy for the second quarter of the year 2000. Macro controls include GDP growth (and its first 4 lags), the change in the 3m LIBOR (and its first 4 lags), the change in the VAT (and its first 2 lags), and a variable on whether the increase in the VAR was known in advance (and its first 4 lags). All coefficients are multiplied by 100 for better readability.

Interestingly, an appreciation to the real effective exchange rate of the Swiss Franc increases both the probability of a positive as well as of a negative price change. Firms seem to check their pricing strategy when the value of the Swiss Franc changes. Our robustness checks show that this result does not change when we consider non-linear specifications of the exchange rate. The distance to the nearest border, however, only seems to matter for negative price changes: The further away from the border a store is located, the lower is the probability that a store will decrease its price for a given product when faced with an appreciation of the exchange rate. The sign of the remaining controls is intuitive: the probability to change the price increases the longer the price has been fixed and the higher sectoral inflation has accumulated since the last price change. As we would expect, an increase of the latter decreases negative price changes. Furthermore, firms tend to correct their relative price position, high-price firms are more likely to lower their price and vice versa. To check whether the size of the estimates makes sense, we calculated the marginal effects in figure 4. If we calculate the marginal effects, a 10% appreciation of the real exchange rate amounts increases the probability of a price change by almost 7 percentage points in the same quarter. This estimate seems to be in line with the spike of price changes in the first quarter of 2015 when an appreciation of similiar size occurred. Among the remaining controls, sectoral inflation has a large quantitative effect on the probability of a price change.

Figure 4: Marginal effects of exchange rate: Extensive margin



The figure shows the change in the probability of a negative price change for a marginal change in the exchange rate growth for different levels of distance to border. To calculate the marginal effects, the same specification as in column (4) of table 4 is used.

3.3 Pricing at the intensive margin

Exchange rate appreciations lead to more price changes, both positive and negative. This opens up the question how large the net effect is. Consequently, this section analyzes the pricing decisions of firms at the intensive margin. In this context, the intensive margin refers to the unconditional impact of our explanatory variables on the sizes of price changes. Thus, we perform OLS estimations, treating the size of price changes, $\hat{p}(i_n, j, t)$, as the dependent variable including data points with no price changes because these represent also relevant pricing decisions. Note that all the relative changes are expressed in percentages, allowing for a direct interpretation of the coefficients. Table 5 presents the results of the three specifications.[12]

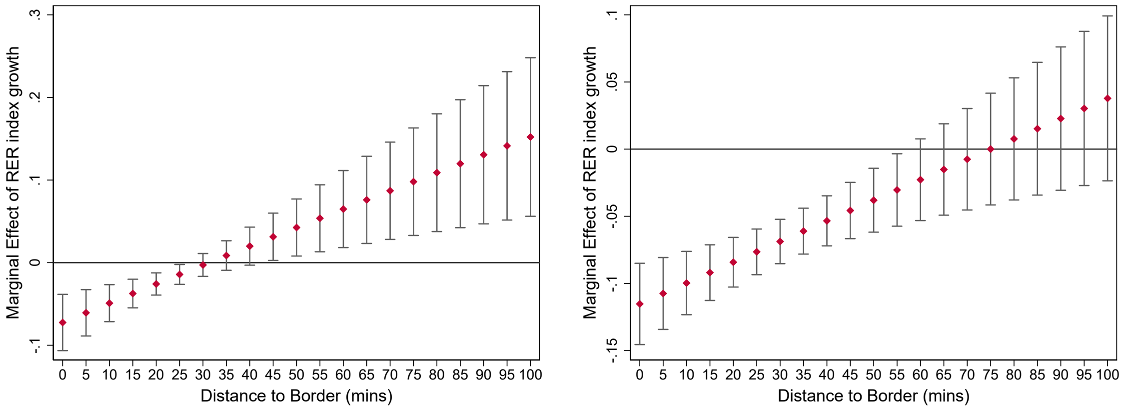
Table 5: Estimation Results: Size of relative price changes

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-7.24***	-7.20***	-11.53***
	(1.74)	(1.13)	(1.54)
RER index growth, qoq × Minutes to border	0.24***	0.08**	0.16***
	(0.07)	(0.04)	(0.04)
Squared interaction	-0.00***	-0.00**	-0.00*
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	-2.19***	-4.23***	-4.27***
	(0.82)	(1.21)	(1.24)
$z(i_n, j, t)^2$	0.06***	-0.25***	-0.25***
	(0.02)	(0.04)	(0.04)
Acc.sec.infl., $\pi(i_n, j, t)$		69.38***	69.12***
		(3.86)	(3.81)
L.Price relative to mean price, $\rho(i_n, j, t)$		-22.42***	-22.46***
		(1.34)	(1.35)
L.$\rho(i_n, j, t)^2$		0.01***	0.01***
		(0.00)	(0.00)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	2,728,116	2,716,926	2,716,641

Standard errors are clustered at the firm level and are displayed in brackets. All estimates include a price series fixed effect. Squared interaction is the square of the second regressor. RER lags includes lags 1–4 for the RER index growth variable. Period controls include quarter dummies, sales (and sales end) dummies, as well as a dummy for the second quarter of the year 2000. Macro controls include GDP growth (and its first 4 lags), the change in the 3m LIBOR (and its first 4 lags), the change in the VAT (and its first 2 lags), and a variable on whether the increase in the VAR was known in advance (and its first 4 lags). All coefficients are multiplied by 100 for better readability.

[12] Table 12 in the appendix presents the estimates with a linear specification of the exchange rate.

Figure 5: Marginal effects of exchange rate: Intensive margin



The figure shows the change in the price for a marginal change in the exchange rate growth for different levels of distance to border. The left hand side shows the marginal effects using the specification of column (1) in table 5, while the right hand side uses the specification of column (3) of table 5 with additional controls.

The results show that in all specifications, an appreciation of the Swiss Franc leads to firms lowering their prices, on average. The interaction of the change in the exchange rate with the distance to border shows that this effect is alleviated for firms that are located further away from the border. This result is robust over all three specifications. Taking lagged exchange rate changes into account, the total exchange rate pass through at the border lies between 0.08% and 0.22%, according to the specifications, which is line with the values in the literature.[13] Similar to the results on the extensive margin, the other controls have the expected sign. Accumulated sectoral inflation has a strong impact and prices exhibit regression to the mean: If the price of a good is 10% above the sectoral average, the price will decrease on average by 2.2% –4.3% on a quarterly basis. Perhaps surprisingly, the size of price changes decreases until around eight quarters when the price has been fixed for a longer time. This is due to seasonal product and commodities that exhibit frequent and large price changes. Figure 5, based on the non-linear specification (1) in table 5, shows our main result. At the border, an appreciation of 10% leads to a decrease of average prices by 0.72% on impact. This is the expected result, firms situated at the border lower their prices because of increased competition from across the border on, potentially, lower input costs. However, the farther away a firm is located from the border, the smaller the impact of the exchange rates becomes. Depending on

[13]See, e.g., the values documented in Bonadio, Fischer and Sauré (2019)

the specification, firms that are more than 30 to 70 minutes away form the border even increase their prices in the first quarter when the exchange rate appreciates. However, this increase is mostly insignificant. A potential mechanism why firms lower their prices less lies in income effects. An appreciation increases the purchasing power of domestic consumers. Recall from table 4 that appreciations lead to more positive price changes, irrespective from the distance to the border. The increase in negative price changes, however, is stronger the closer to the border a firm is located. Summing up, this results in a net price increase with appreciations and a dominance of income effects for firms that are situated in the interior of the country.

3.4 Discussion

To understand the mechanism behind the impact of border distance on price setting, we analyze factors that influence the cost of arbitrage, i.e., the cost to buy a product at a store on the other side of the border. For this aim, we check how our results depend on the price and the perishability of the items.

3.4.1 Goods with high prices vs. goods with low prices

The simplest form to differ cheap and expensive goods is to classify a good as cheap if it its price is below the median price, pooled over all goods and all years. Tables 6 and 7 show the results for cheap and expensive goods, respectively. If we order goods prices in quartiles, the same effects remain, see tables 13 to 18 in appendix A.1. While the distance to the nearest border does not seem to be relevant for cheaper goods, for more expensive goods the distance to border does affect the pricing decisions of Swiss retailers. This suggests that the effects discovered in the last section are driven by higher priced goods. Arguably, for cheaper goods the cost of going over the border to shop outweigh the potential savings of the goods bought. For more expensive goods, however, the potential savings are higher, such that it makes more sense to buy the goods abroad, given the cost of getting to a shopping center abroad is not too high (i.e., the distance to the border matters). Additionally, the direct effect of the exchange rate on the pricing decisions is also higher (and significant in more specifications) for goods with higher prices compared to cheaper goods.

Table 6: Estimation Results: Goods with below median price

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-1.56	-5.38***	-9.11***
	(1.45)	(1.38)	(1.64)
RER index growth, qoq × Minutes to border	0.03	0.02	0.05
	(0.04)	(0.04)	(0.04)
Squared interaction	-0.00*	0.00**	0.00**
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	-6.29***	-11.09***	-11.65***
	(1.05)	(1.26)	(1.29)
$z(i_n, j, t)^2$	0.16***	-0.16***	-0.14***
	(0.02)	(0.04)	(0.04)
Acc.sec.infl., $\pi(i_n, j, t)$		59.03***	58.46***
		(2.36)	(2.31)
L.Price relative to mean price, $\rho(i_n, j, t)$		-39.15***	-39.32***
		(1.89)	(1.89)
L.$\rho(i_n, j, t)^2$		0.03***	0.03***
		(0.01)	(0.01)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	1,412,687	1,406,661	1,406,555

The specifications are identical to those in table 5, but the sample is restricted to goods with a below (or equal to) median price (CHF 11.9).

Table 7: Estimation Results: Goods with above median price

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-9.17***	-8.00***	-11.76***
	(2.09)	(1.45)	(1.85)
RER index growth, qoq × Minutes to border	0.33***	0.11**	0.18***
	(0.08)	(0.05)	(0.05)
Squared interaction	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	-0.05	-0.10	0.11
	(0.75)	(1.29)	(1.32)
$z(i_n, j, t)^2$	0.02	-0.28***	-0.28***
	(0.01)	(0.04)	(0.04)
Acc.sec.infl., $\pi(i_n, j, t)$		59.68***	59.35***
		(3.93)	(3.89)
L.Price relative to mean price, $\rho(i_n, j, t)$		-14.17***	-14.19***
		(1.03)	(1.03)
L.$\rho(i_n, j, t)^2$		0.00***	0.00***
		(0.00)	(0.00)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	1,314,129	1,308,965	1,308,785

The specifications are identical to those in table 5, but the sample is restricted to goods with an above median price (CHF 11.9).

3.4.2 Perishable vs. durable goods

An alternative check for the cost of arbitrage channel is to classify the goods as perishable or durable. We classify goods as perishable if they belong to product sectors 1, 10, or 11 (see table 2 for the description of the sectors). The goods belonging to any of the other 9 sectors are classified as durable.[14] The results for the single sectors are reported in tables 19 to 29 in appendix A.2. Similar to our argumentation above, we expect that the distance to border effect will be larger for durable goods. For perishable goods, the fixed cost of shopping abroad (e.g.,

[14]Obviously, the classification of the goods into perishable and durable is to some degree arbitrary. However, the results are similar if we classify as perishable goods those in sector 1 (food and non-alcoholic beverages) and as durable goods those in sectors 3 and 5 (clothing and footwear; household goods and services).

daily purchases or customs limit) are too high. However, for more expensive goods, buyers tend to shop abroad as long as the cost of doing so (i.e., shorter distance to the next border) are not too high. Tables 8 and 9 show some evidence for this. Again, the raw effect of the exchange rate on the pricing decisions is also higher (and significant in more specifications) for durable goods, compared to perishable goods. Also note that durable goods tend to be more expensive, which is in line that the results of the two exercises yield similar results.

Table 8: Estimation Results: Perishable goods

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-2.91*	-5.80***	-7.42***
	(1.48)	(1.46)	(1.74)
RER index growth, qoq × Minutes to border	0.02	0.03	0.05
	(0.04)	(0.04)	(0.05)
Squared interaction	-0.00	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	-6.94***	-16.21***	-17.11***
	(1.34)	(1.53)	(1.54)
$z(i_n, j, t)^2$	0.18***	-0.05	-0.03
	(0.03)	(0.03)	(0.03)
Acc.sec.infl., $\pi(i_n, j, t)$		61.21***	60.44***
		(2.72)	(2.65)
L.Price relative to mean price, $\rho(i_n, j, t)$		-38.03***	-38.16***
		(2.17)	(2.18)
L.$\rho(i_n, j, t)^2$		0.01***	0.01***
		(0.00)	(0.00)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	1,320,319	1,316,306	1,316,250

The specifications are identical to those in table 5, but the sample is restricted to perishable goods (i.e. goods in sectors 1, 10, and 11).

Table 9: Estimation Results: Durable goods

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-8.46***	-7.57***	-11.80***
	(1.91)	(1.40)	(1.78)
RER index growth, qoq × Minutes to border	0.30***	0.10**	0.16***
	(0.07)	(0.05)	(0.05)
Squared interaction	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	1.98***	3.77***	4.16***
	(0.56)	(1.06)	(1.09)
$z(i_n, j, t)^2$	-0.02*	-0.31***	-0.32***
	(0.01)	(0.04)	(0.04)
Acc.sec.infl., $\pi(i_n, j, t)$		54.45***	54.25***
		(3.55)	(3.52)
L.Price relative to mean price, $\rho(i_n, j, t)$		-11.65***	-11.68***
		(0.84)	(0.84)
L.$\rho(i_n, j, t)^2$		0.00***	0.00***
		(0.00)	(0.00)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	1,407,797	1,400,620	1,400,391

The specifications are identical to those in table 5, but the sample is restricted to durable goods (i.e. goods in sectors 2, 3, 4, 5, 6, 7, 8, 9, and 12).

3.4.3 Robustness for the sample selection

As our analysis is based on observations for which we know the location only, we want to establish that these observations do not significantly differ from observations for which we do not observe the location (see section 2 for a discussion). Table 10 repeats the exercise carried out in table 5 but using all observations (i.e., including the observations without the location information) as a comparison to the selected sample. Obviously, the distance to border effect is omitted. The results highlight that there are no significant differences between the full sample and the sample selected on those observations with the information about location.

Table 10: Estimation Results: Different Samples

Dependent Variable:	Price change in %					
	Obs. with location info			All obs. (whole sample)		
	(1)	(2)	(3)	(4)	(5)	(6)
RER index growth, qoq	-0.45 (0.70)	-4.95*** (0.57)	-6.92*** (0.82)	0.91 (1.07)	-1.99 (1.39)	-4.15*** (1.61)
Periods since last price change, $z(i_n, j, t)$	-2.16*** (0.83)	-4.22*** (1.21)	-4.24*** (1.24)	-1.82 (1.13)	-5.08*** (1.13)	-4.63*** (1.11)
$z(i_n, j, t)^2$	0.06*** (0.02)	-0.25*** (0.04)	-0.25*** (0.04)	0.05** (0.02)	-0.24*** (0.04)	-0.25*** (0.04)
Acc.sec.infl., $\pi(i_n, j, t)$		69.43*** (3.87)	69.19*** (3.86)		69.36*** (3.24)	69.31*** (3.23)
L.Price relative to mean price, $\rho(i_n, j, t)$		-22.42*** (1.34)	-22.46*** (1.35)		-23.90*** (1.27)	-23.92*** (1.27)
L.$\rho(i_n, j, t)^2$		0.01*** (0.00)	0.01*** (0.00)		0.01*** (0.00)	0.01*** (0.00)
RER lags	No	No	Yes	No	No	Yes
Period controls	Yes	Yes	Yes	Yes	Yes	Yes
Macro controls	No	No	Yes	No	No	Yes
Observations	2,728,116	2,716,926	2,716,641	4,362,180	4,338,437	4,338,019

The specifications are identical to those in table 5, but without the distance to border effect. The first three columns use the same sample as table 5 (i.e. the observations for which a location exists), while columns (4) to (6) use all observations. The table shows that the determinants of price changes are not fundamentally different for the two samples – and hence we do not select certain observation types by excluding observations without location information.

4 Conclusion

Using a large data set of retail prices in Switzerland, we analyzed the factors that influence the price setting behavior of firms within a small open economy. Our data set allowed us to investigate the factors that influence the frequency (i.e., the extensive margin) as well as the (average) size of price changes (i.e., the intensive margin). Our prime interest is in how exchange rate fluctuations influence pricing decisions, and how these decisions depend on the distance to the nearest border post.

We find that an appreciation of the real effective exchange rate of the Swiss Franc increases the probability of positive as well as negative price changes for Swiss retailers. However, we also find that the distance to the nearest border point only matters for negative price changes.

The further away from the border a store is located, the lower is the probability that a store will decrease its price for a given product when faced with an appreciation of the exchange rate.

On the intensive margin, our results show that an appreciation of the Swiss Franc induces Swiss retailers to reduce their prices. Similar to the findings at the extensive margin, this effect weakens the further away a store is located from the nearest border to a neighbouring country. Both effects are statistically significant and robust across different specifications. In fact, for firms located relatively far away from the nearest border, an appreciation of the Swiss Franc leads to price increases. We rationalise this by the relative strengths of income and substitution effects. The substitution effect dominates for firms close to the border, while the income effect dominates for firms located further away from the border.

To corroborate our findings, we divide our sample into goods with relatively low and relatively high prices. As expected, the distance to the nearest border only matters for goods with higher prices. We explain this by arguing that for cheaper goods the cost of going over the border to shop outweigh the potential savings of the goods bought. For more expensive goods, however, the potential savings are higher, such that it makes more sense to buy the goods abroad, given the cost of getting to a shopping center abroad is not too high (i.e. the distance to the border matters). The results hold for several different specifications for the division between cheap and expensive goods. Furthermore, with a similar reasoning, we also divide the goods into perishable and durable goods and document that our results remain robust as well (i.e. the effect of the border distance in combination with exchange rate movements is an important determinant for price setting for durable but not for perishable goods).

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A Appendix

Table 11: Migros' cooperatives overview

Cooperative	Cities
Geneva	Geneva
Wallis	Sion
Neuchatel	Neuchatel
Aare	Berne
Basel	Basel
Lucerne	Lucerne
Ticino	Lugano
Eastern Switzerland	Chur, St. Gallen
Vaud	Lausanne
Zurich	Zurich

Source:
https://www.migros.ch/de/genossenschaften.html

Table 12: **Estimation Results: Size of relative price changes**

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-6.80***	-7.08***	-11.20***
	(1.66)	(1.12)	(1.53)
RER index growth, qoq × Minutes to border	0.20***	0.07*	0.13***
	(0.06)	(0.04)	(0.04)
Periods since last price change, $z(i_n, j, t)$	-2.17***	-4.22***	-4.25***
	(0.82)	(1.21)	(1.24)
$z(i_n, j, t)^2$	0.06***	-0.25***	-0.25***
	(0.02)	(0.04)	(0.04)
Acc.sec.infl., $\pi(i_n, j, t)$		69.42***	69.09***
		(3.87)	(3.82)
L.Price relative to mean price, $\rho(i_n, j, t)$		-22.42***	-22.46***
		(1.34)	(1.35)
L.$\rho(i_n, j, t)^2$		0.01***	0.01***
		(0.00)	(0.00)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	2,728,116	2,716,926	2,716,641

Standard errors are clustered at the firm level and are displayed in brackets. All estimates include a price series fixed effect. RER lags includes lags 1–4 for the RER index growth variable. Period controls include quarter dummies, sales (and sales end) dummies, as well as a dummy for the second quarter of the year 2000. Macro controls include GDP growth (and its first 4 lags), the change in the 3m LIBOR (and its first 4 lags), the change in the VAT (and its first 2 lags), and a variable on whether the increase in the VAR was known in advance (and its first 4 lags). All coefficients are multiplied by 100 for better readability.

A.1 Results for goods by quartile of their price

When dividing the individual prices into four quartiles, a similar pattern as in section 3.4.1 emerges. As tables 13 to 16 show, the point estimate for the interaction term between currency appreciation and distance to border generally increases with the price of the products considered. Furthermore, we only observe statistically significant effects for products with an above median price.

Table 13: Estimation Results: Goods prices below below first quartile

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-1.74	-7.30***	-11.83***
	(1.71)	(1.59)	(1.75)
RER index growth, qoq × Minutes to border	0.01	0.05	0.05
	(0.05)	(0.04)	(0.04)
Squared interaction	-0.00	0.00	0.00*
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	-9.74***	-11.46***	-11.83***
	(1.34)	(1.26)	(1.27)
$z(i_n, j, t)^2$	0.24***	-0.11***	-0.09***
	(0.03)	(0.03)	(0.03)
Acc.sec.infl., $\pi(i_n, j, t)$		47.77***	46.85***
		(2.06)	(1.98)
L.Price relative to mean price, $\rho(i_n, j, t)$		-47.57***	-47.86***
		(2.32)	(2.32)
L.$\rho(i_n, j, t)^2$		0.13***	0.13***
		(0.02)	(0.02)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	716,637	714,974	714,941

The specifications are identical to those in table 5, but the sample is restricted to goods with a below (or equal to) first quartile price (CHF 3.65).

Table 14: Estimation Results: Goods prices between first and second quartile

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-1.40	-4.38**	-12.29***
	(1.93)	(1.92)	(2.26)
RER index growth, qoq × Minutes to border	0.05	0.00	0.07
	(0.05)	(0.05)	(0.05)
Squared interaction	0.00	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	-3.33***	-12.41***	-11.77***
	(1.00)	(1.82)	(1.83)
$z(i_n, j, t)^2$	0.09***	-0.20***	-0.20***
	(0.02)	(0.07)	(0.07)
Acc.sec.infl., $\pi(i_n, j, t)$		53.61***	53.56***
		(2.18)	(2.17)
L.Price relative to mean price, $\rho(i_n, j, t)$		-42.26***	-42.45***
		(2.03)	(2.04)
L.$\rho(i_n, j, t)^2$		0.03***	0.03***
		(0.01)	(0.01)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	693,887	689,527	689,454

The specifications are identical to those in table 5, but the sample is restricted to goods with a below (or equal to) second quartile price (CHF 11.9) but above first quartile price (CHF 3.65).

Table 15: Estimation Results: Goods prices between second and third quartile

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-7.78***	-7.80***	-11.62***
	(2.21)	(1.65)	(2.10)
RER index growth, qoq × Minutes to border	0.24***	0.04	0.12*
	(0.09)	(0.06)	(0.06)
Squared interaction	-0.00***	-0.00**	-0.00
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	-4.26***	-11.22***	-11.17***
	(1.01)	(1.45)	(1.43)
$z(i_n, j, t)^2$	0.10***	-0.14***	-0.13***
	(0.02)	(0.04)	(0.04)
Acc.sec.infl., $\pi(i_n, j, t)$		66.35***	65.93***
		(6.40)	(6.34)
L.Price relative to mean price, $\rho(i_n, j, t)$		-28.99***	-29.07***
		(2.15)	(2.15)
L.$\rho(i_n, j, t)^2$		0.03***	0.03***
		(0.01)	(0.01)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	677,403	677,299	677,227

The specifications are identical to those in table 5, but the sample is restricted to goods with a below (or equal to) third quartile price (CHF 55) but above second quartile price (CHF 11.9).

Table 16: Estimation Results: Goods price above third quartile

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-8.72***	-7.97***	-11.27***
	(2.45)	(1.92)	(2.27)
RER index growth, qoq × Minutes to border	0.28***	0.11	0.14*
	(0.08)	(0.07)	(0.07)
Squared interaction	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	1.86***	6.66***	7.14***
	(0.67)	(1.51)	(1.53)
$z(i_n, j, t)^2$	-0.02*	-0.34***	-0.34***
	(0.01)	(0.05)	(0.05)
Acc.sec.infl., $\pi(i_n, j, t)$		46.43***	46.31***
		(3.41)	(3.37)
L.Price relative to mean price, $\rho(i_n, j, t)$		-10.60***	-10.61***
		(0.95)	(0.95)
L.$\rho(i_n, j, t)^2$		0.00***	0.00***
		(0.00)	(0.00)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	635,726	630,666	630,559

The specifications are identical to those in table 5, but the sample is restricted to goods with an above third quartile price (CHF 55).

Alternatively, we can define the median-split of the product prices at one given point in time (in this case, the second quarter of 2017, our last time period). We define a good as having a below median price if all observations of that product had a below median price in the second quarter of 2017. The definition for goods with an above median price are defined in the same manner. Therefore, only goods that existed in the second quarter of 2017 and where all observed prices are either below or above median in the second quarter of 2017 are included. Tables 17 and 18 show the results. The findings show similar results to the different specification of cheap versus expensive goods above.

Table 17: Estimation Results: Goods prices below median in 2017q2

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-4.10**	-6.46***	-8.69***
	(1.79)	(1.74)	(1.96)
RER index growth, qoq × Minutes to border	0.07	0.07	0.10*
	(0.05)	(0.05)	(0.05)
Squared interaction	-0.00	0.00**	0.00**
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	-3.66***	-10.31***	-11.18***
	(1.17)	(1.31)	(1.33)
$z(i_n, j, t)^2$	0.10***	-0.18***	-0.15***
	(0.03)	(0.04)	(0.04)
Acc.sec.infl., $\pi(i_n, j, t)$		67.67***	66.50***
		(2.58)	(2.51)
L.Price relative to mean price, $\rho(i_n, j, t)$		-44.49***	-44.69***
		(2.13)	(2.14)
L.$\rho(i_n, j, t)^2$		0.07***	0.07***
		(0.01)	(0.01)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	852,964	848,479	848,417

The specifications are identical to those in table 5, but the sample is restricted to goods with a below median price in 2017q2 (CHF 23.9).

Table 18: Estimation Results: Goods above above median in 2017q2

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-12.22***	-7.02***	-7.71**
	(3.71)	(2.71)	(3.05)
RER index growth, qoq × Minutes to border	0.31***	0.08	0.08
	(0.12)	(0.09)	(0.10)
Squared interaction	-0.00***	-0.00***	-0.00**
	(0.00)	(0.00)	(0.00)
Periods since last price change, $z(i_n, j, t)$	1.43*	4.02*	4.16*
	(0.79)	(2.23)	(2.24)
$z(i_n, j, t)^2$	-0.01	-0.31***	-0.31***
	(0.01)	(0.06)	(0.06)
Acc.sec.infl., $\pi(i_n, j, t)$		61.63***	61.46***
		(3.58)	(3.56)
L.Price relative to mean price, $\rho(i_n, j, t)$		-12.66***	-12.67***
		(1.21)	(1.21)
L.$\rho(i_n, j, t)^2$		0.01***	0.01***
		(0.00)	(0.00)
RER lags	No	No	Yes
Period controls	Yes	Yes	Yes
Macro controls	No	No	Yes
Observations	398,413	393,471	393,421

The specifications are identical to those in table 5, but the sample is restricted to goods with an above median price in 2017q2 (CHF 23.9).

A.2 Results on the sectoral level

Table 19: Sector 1 – Food and non-alcoholic beverages

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-4.17**	-6.10***	-8.75***
	(1.76)	(1.89)	(2.22)
RER index growth, qoq × Minutes to border	0.03	0.04	0.06
	(0.05)	(0.06)	(0.06)
Squared interaction	-0.00	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
Observations	1,102,663	1,102,663	1,102,621

Specification is as in table 5 but only the two main coefficients are displayed.

Table 20: Sector 2 – Alcoholic beverages and tobacco

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-2.49	-4.32**	-5.37**
	(2.03)	(2.01)	(2.59)
RER index growth, qoq × Minutes to border	0.10	0.09	0.08
	(0.07)	(0.06)	(0.07)
Squared interaction	-0.00	-0.00***	-0.00
	(0.00)	(0.00)	(0.00)
Observations	126,934	126,934	126,920

Specification is as in table 5 but only the two main coefficients are displayed.

Table 21: Sector 3 – Clothing and footwear

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-4.36	-6.22**	-13.46**
	(3.08)	(3.10)	(5.44)
RER index growth, qoq × Minutes to border	0.19*	0.13	0.17
	(0.11)	(0.10)	(0.14)
Squared interaction	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)
Observations	345,503	345,503	345,497

Specification is as in table 5 but only the two main coefficients are displayed.

Table 22: Sector 4 – Housing and energy

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-37.95***	-0.91	1.19
	(10.15)	(2.27)	(2.57)
RER index growth, qoq × Minutes to border	-0.21	-0.19***	-0.21***
	(0.27)	(0.06)	(0.06)
Squared interaction	-0.00*	-0.00	0.00
	(0.00)	(0.00)	(0.00)
Observations	73,034	72,440	72,440

Specification is as in table 5 but only the two main coefficients are displayed.

Table 23: Sector 5 – Household goods and services

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-1.28	-1.86	-5.53*
	(2.50)	(2.50)	(2.97)
RER index growth, qoq × Minutes to border	0.04	0.01	0.03
	(0.08)	(0.08)	(0.08)
Squared interaction	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)
Observations	175,801	175,801	175,698

Specification is as in table 5 but only the two main coefficients are displayed.

Table 24: Sector 6 – Healthcare

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	2.08*	0.97	1.69
	(1.14)	(1.42)	(1.63)
RER index growth, qoq × Minutes to border	-0.04	-0.03	-0.07*
	(0.03)	(0.04)	(0.04)
Squared interaction	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)
Observations	45,602	39,147	39,144

Specification is as in table 5 but only the two main coefficients are displayed.

Table 25: Sector 7 – Transport

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-13.07***	-12.31***	-9.61***
	(2.66)	(2.44)	(2.18)
RER index growth, qoq × Minutes to border	0.14*	0.12*	0.08
	(0.07)	(0.07)	(0.07)
Squared interaction	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)
Observations	117,556	117,556	117,556

Specification is as in table 5 but only the two main coefficients are displayed.

Table 26: Sector 9 – Recreation and culture

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-3.21	-2.69	-4.51*
	(2.28)	(2.26)	(2.38)
RER index growth, qoq × Minutes to border	0.10	0.07	0.09
	(0.07)	(0.07)	(0.07)
Squared interaction	-0.00***	-0.00*	-0.00
	(0.00)	(0.00)	(0.00)
Observations	338,622	338,622	338,529

Specification is as in table 5 but only the two main coefficients are displayed.

Table 27: Sector 10 – Education

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	0.44	0.88	-0.08
	(2.44)	(2.69)	(2.79)
RER index growth, qoq × Minutes to border	-0.08	-0.06	-0.04
	(0.07)	(0.07)	(0.08)
Squared interaction	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Observations	21,857	17,844	17,843

Specification is as in table 5 but only the two main coefficients are displayed.

Table 28: Sector 11 – Restaurants and hotels

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	4.49***	2.33**	1.53*
	(1.09)	(0.91)	(0.87)
RER index growth, qoq × Minutes to border	-0.00	0.00	0.01
	(0.03)	(0.02)	(0.02)
Squared interaction	-0.00**	-0.00***	-0.00
	(0.00)	(0.00)	(0.00)
Observations	195,799	195,799	195,786

Specification is as in table 5 but only the two main coefficients are displayed.

Table 29: Sector 12 – Other goods and services

Dependent Variable:	Price change in %		
	(1)	(2)	(3)
RER index growth, qoq	-0.13	-0.75	-4.88**
	(1.94)	(1.92)	(2.29)
RER index growth, qoq × Minutes to border	0.07	0.05	0.09*
	(0.05)	(0.05)	(0.05)
Squared interaction	-0.00*	-0.00	-0.00
	(0.00)	(0.00)	(0.00)
Observations	182,551	182,551	182,541

Specification is as in table 5 but only the two main coefficients are displayed.