2.2 CONSUMER PRICE BEHAVIOUR IN LUXEMBOURG: NEW EVIDENCE FROM MICRO PRICE DATA FOR 2005-2017[74]

2.2.1 Introduction

How prices are set affects the behaviour of inflation and its response to monetary policy and to economic shocks, including changes in demand and supply. For instance, if all price-setters were perfectly informed and adjusted prices instantaneously, inflation would be more volatile because prices would adjust to all incoming shocks. The assumption of perfect price flexibility, which was common in classical economics implies that monetary policy cannot affect output, consumption and investment, not even in the short run. However, empirical evidence shows that prices only respond to shocks gradually. New Keynesian economists attribute this phenomenon to nominal and real rigidities, which prevent prices from adjusting in the short run, thus allowing monetary policy to have real effects. A detailed understanding of price dynamics is crucial for economists who study general equilibrium models, but also for policymakers, especially central bankers. For instance, the distributional consequences of indirect taxes or wage indexation cannot be grasped without an understanding of micro price dynamics. Therefore, the appropriate setting of monetary policy[75] requires detailed knowledge of firms' price setting behaviour and how it influences price rigidity and inflation persistence.

This analysis studies individual price data from Luxembourg at monthly frequency from 2005 to 2017. The national statistical institute (NSI) of Luxembourg, the *Service Central des Statistiques et des Études Économiques* (STATEC), used this data to calculate both the national and harmonised consumer price indexes. The results presented below are part of the research conducted within the Price-setting Microdata Analysis Network (PRISMA) set up by the European System of Central Banks (ESCB). This network analyses the price rigidity of individual product prices in several countries of the European Union. The PRISMA network also provides a much needed update to the findings of the Eurosystem Inflation Persistence Network (IPN) more than 15 years ago (see Dhyne et al., 2006 for a summary of the IPN results). We characterise the price-setting process across five broad product types and 12 detailed product categories. Following previous work on Luxembourg by Lünnemann and Mathä (2005), we assess changes in the setting of consumer prices over almost two decades.

This analysis provides a first assessment of key characteristics of the price setting behaviour in Luxembourg using recent micro price data. At this point, we do not distinguish whether changes in the frequency and size of price changes are caused by differences in the occurrence of shocks or constraints faced by firms when reacting to shocks. Future research will further explore possible changes in price setting behaviour over time, e.g. following the global financial crisis or during the low inflation period in the euro area.

74 Written by Thomas Y. Mathä, Moritz Osterhuber and Ladislav Wintr. Thomas Y. Mathä and Ladislav Wintr are economists Economics and Research Department. The article was written while Moritz Osterhuber was an intern in the department. We would like to thank STATEC for granting us access to their data, and in particular Marc Ferring for clarifying the methodological issues related to the price collection.

75 Levin and Moessner (2005) review the implications of inflation persistence for the design of monetary policy.

2.2.2 Framing the debate

The increase in computer power and the availability of micro price data collected by NSIs allow researchers today to analyse very large datasets. Bils and Klenow (2004) used US micro consumer price data to show that prices change more frequently than commonly assumed. Nakamura and Steinsson (2008) systematically studied the role of temporary price cuts (sales) on consumer prices in the US, as well as the relation between consumer and producer prices. In Europe, the IPN mentioned above provided comparable evidence on price rigidities and the distribution of price changes across ten euro area countries.[76]

Since then, micro price studies have been carried out in many different countries. These studies generally find a broad spectrum of price-setting regimes, which may be due to substantially different inflation environments, differences in the relative importance of individual product types or cross-country variation in data collection, aggregation and study methodology.[77]

Despite these differences, European countries share some discernible regularities in price dynamics with most advanced economies. First, apart from seasonal sales, prices tend to remain quite stable. Second, when prices change, they tend to do so by a substantial amount, typically 7% to 16% depending on the study. Third, price increases are more common than price decreases, which is not surprising since most studies focus on positive inflation environments. However, despite these common empirical findings, the debate on theoretical pricing models remains unsettled. In fact, empirical studies find evidence in favour of both state-dependent pricing and time-dependent pricing. State-dependent pricing models assume that price-setters face non-trivial adjustment costs and do not change prices until they have moved far from their target level. Instead, time-dependent pricing models assume periodic adjustment, with prices reviewed at fixed intervals.[78]

New euro area evidence from the PRISMA network finds that the average frequency of price changes decreased to 12-15% since the IPN results (Gautier et al., 2022). Compared to the United States, euro area prices are considerably less flexible and average changes are relatively small. However, because temporary price cuts (sales) are more prevalent in the US than in the euro area, the difference in price change frequency shrinks when sales are excluded. Gautier et al. (2022) find that cross-sectoral variation in the price change frequency plays a much more important role than variation across countries. Price changes are less frequent in services, and most frequent for unprocessed food. Across countries, price increases tend to be more frequent than price decreases and increases tend to be smaller than decreases.

2.2.3 Data and methodology

We use the individual price data collected by STATEC to calculate the monthly National Index of Consumer Prices (NICP) in Luxembourg.[79] In total, the dataset consists of more than 1.2 million individual price quotes. This allows us to trace the price of individual products sold through a particular outlet.[80] Following standard practice in the literature, we define a price trajectory as a series of price observations for a given

76 See Altissimo, Ehrmann and Smets (2006).

77 For a summary of micro-price studies across countries, see Klenow and Malin (2010).

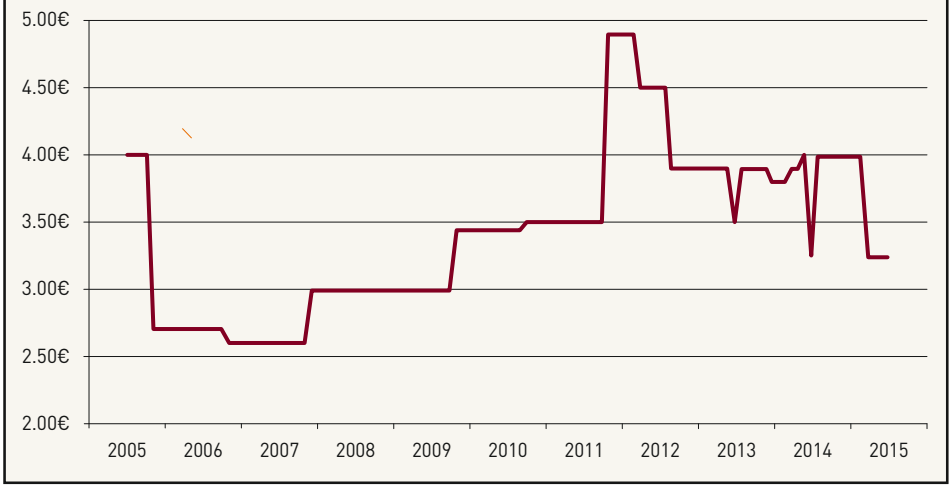
78 See Barro (1972), Sheshinski and Weiss (1977), Rotemberg (1982) and Mankiw (1985) for state-dependent pricing models and Calvo (1983) and Taylor (1999) for time-dependent models.

79 These data are also used to calculate the Luxembourg Harmonised Index of Consumer Prices (HICP). Price quotes are collected once per month. Hence, if prices change more than once between price collection dates, only one price change will be recorded. This means that if prices were observed in continuous time, we would observe more price changes. This could be particularly important for products that change prices very often (e.g. petrol or e-commerce). Prices from online sellers are not included in the dataset with few notable exceptions (travel-related services).

80 STATEC provided anonymised data to prevent identification of the products and outlets.

product sold in a specific outlet. The trajectory usually ends if the product changes in size, quality or is no longer recorded.[81] A price trajectory may include several price spells, i.e. periods in which the price remains unchanged. Figure 1 presents an example of a price trajectory with 17 different price spells between January 2005 and December 2017, including two one-month price reversions in 2013 and 2014.

Figure 1
Example of a price trajectory with multiple price spells



Sources: own calculations

Such micro price datasets compress complex real-world pricing dynamics into relatively simple formats, so the interpretation of results is not always straightforward. In particular, findings may be sensitive to different definitions of what constitutes an individual product and a price change, as well as the statistical treatment of missing observations on certain prices (e.g. seasonal products, such as skiing equipment) or attrition (i.e. termination of products or closure of outlets). For instance, the NSI may decide to collect price data on digital video discs (DVD) to replace price data on video cassettes (VHS), reflecting technological progress and shifting consumer preferences. If one is willing to assume that consumers see these products as close substitutes, one could interpret this switch as a price change. However, researchers might wish to limit such assumptions and focus only on price changes recorded for exactly the same product.

In this analysis, we eliminate price quotes that are subject to attrition, i.e. that have changed in quality or quantity (e.g. temporary changes in packaging sizes) or have switched to a different outlet. This includes seasonal products like fresh fruit, whose trajectory continues although they may disappear from the supermarket shelves for parts of the year. Although sellers typically advertise their promotions and temporary sales, NSIs do not always record such information. In Luxembourg, STATEC only introduced identifiers for temporary sales in 2015, so we cannot rely on this information over the entire sample. Therefore, we apply predefined sales filters that identify temporary sales from the shape of the price trajectory. To maintain a consistent definition of temporary sales over the whole sample, we adopt the sales filter used in Gautier et al. (2022), whose performance has been checked against temporary sales flags set by the NSI in selected countries.[82] To limit the influence of extreme and possibly unreliably large price swings on the results, we also remove outliers, meaning price changes in absolute value smaller than 0.1% or larger than three times the interquartile range of price changes in the given product category.

Unless stated otherwise, the statistics reported below include temporary sales but exclude attrition, which is similar to the approach in Dhyne et al. (2006) and Gautier et al. (2022). We assess the influence of temporary sales by recalculating the statistics after excluding such price changes. We calculate statistics at the most detailed level (309 different ECOICOP categories[83]) and aggregate them using the 2017 consumer

81 Products may no longer be recorded because they follow seasonal patterns in demand and/or supply, because they become obsolete or because they reach the end of their lifecycle. Outlets may also close or relocate, terminating price trajectories.

82 Our estimates of the share of temporary sales should be considered a lower bound of the actual share of sales since short temporary sales between collection dates are not recorded in the dataset.

83 ECOICOP stands for European Classification of Individual Consumption by Purpose; it groups individual products into categories, of which 309 are included in our dataset.

expenditure weights in Luxembourg. While the results for Luxembourg reported in Gautier et al. (2022) rely on a smaller sample of product categories (for reasons of comparability to other countries), these authors use the same weighting and aggregation procedure.

2.2.4 Results

Below, we present five stylised facts characterising price behaviour in Luxembourg. The first stylised fact is based on the aggregate NICP published by STATEC, as well as its sub-indices for twelve product categories. Stylised facts 2-5 are based on our micro price dataset.

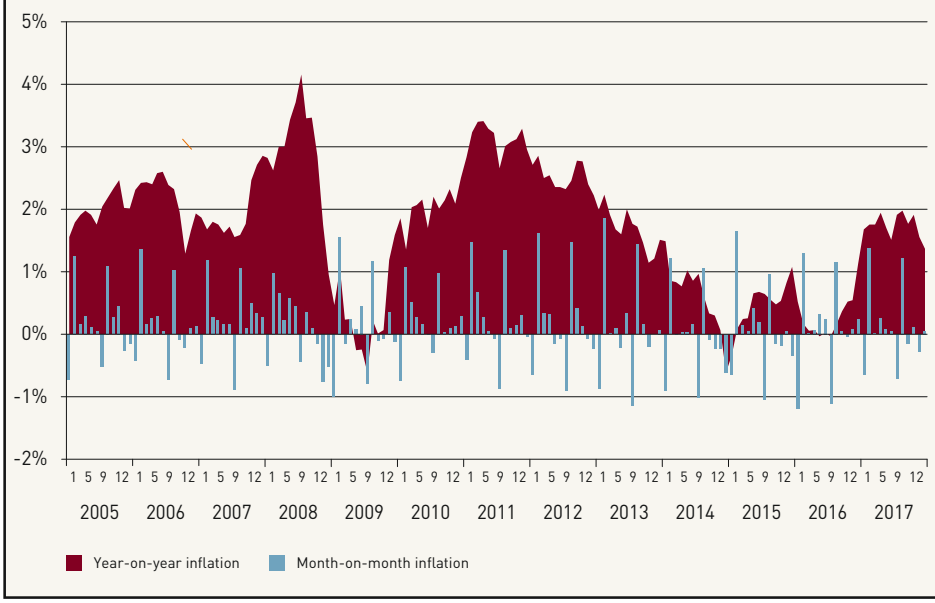
Stylised Fact 1: *From 2005 to 2017, the average year-on-year inflation of 1.9% masked substantial heterogeneity across product types and intertemporal variation in inflation rates.*

Between 2005 and 2017, the Luxembourg NICP rose 1.9% per year. Figure 2 reports year-on-year and month-on-month inflation rates over the sample period. The most notable feature is the precipitous decline in inflation following the 2008 global financial crisis. Late in 2009, year-on-year inflation accelerated to reach a peak in 2011 before declining steadily between 2012 and 2014.

Year-on-year changes in inflation were mostly positive between 2005 and 2017. Exceptions were the unravelling of the financial crisis in late 2008 and the end of 2014. Seasonal sales periods in Luxembourg are clearly visible in the month-on-month changes. Prices display distinctive drops in January and July of each year, but most recover in the following month. Given that these seasonal sales are concentrated in clothing and footwear (ECOICOP03 in Table 1) and in furnishings, household equipment and maintenance of house (ECOICOP05), the prominence of this seasonal pattern in the aggregate data is striking.

According to the data published by STATEC, there is considerable heterogeneity in inflation rates across our twelve product categories (Table 1). Annual inflation averaged at least 2.6% for alcohol, tobacco and narcotics (ECOICOP02), restaurants and hotels (ECOICOP11), housing, water, electricity, etc. (ECOICOP04), and education (ECOICOP10) while it was negative (-1.2%) in communications (ECOICOP08). Apart from this exception, all product categories saw prices rise on average over the observation period.

Figure 2
The National Index of Consumer Prices (NICP) in Luxembourg, 2005-2017, year-on-year and month-on-month inflation rates (in %)



Sources: STATEC, own calculations

Table 1:

Inflation rate and share of months with negative price change, by product category, 2005-2017 (in %)

ECOICOP LEVEL 1	PRODUCT DESCRIPTION	Y-O-Y INFLATION		M-O-M INFLATION	
		AVERAGE	VARIATION	AVERAGE	VARIATION
01	Food & non-alcoholic beverages	2.3	7.7	0.2	26.3
02	Alcohol, tobacco & narcotics	2.9	0.0	0.2	30.8
03	Clothing & footwear	0.8	12.8	0.4	36.5
04	Housing, water, electricity, gas & other fuels	2.7	30.1	0.2	36.5
05	Furnishings, household equipment, maintenance of house	1.6	0.0	0.2	28.8
06	Health	1.5	24.4	0.1	35.3
07	Transport	1.5	25.0	0.1	39.7
08	Communications	-1.2	84.6	-0.1	52.6
09	Recreation & culture	1.6	1.3	0.1	46.8
10	Education	2.6	0.0	0.2	0.0
11	Restaurants & hotels	2.8	0.0	0.2	4.5
12	Miscellaneous goods and services	2.1	1.9	0.2	23.7
	All Products	1.9	4.5	0.2	36.5

Sources: STATEC, own calculations

Stylised Fact 2: *The frequency of price change in Luxembourg is close to the euro area average. In line with international evidence, it varies widely across product categories and product types.*

According to the individual price data for Luxembourg, on average in any given month 14.7% of prices will be subject to a change (Table 2). In a cross-country study of micro price data from eleven euro area member states, Gautier et al. (2022) find an average price change frequency of 12%. Their estimate for Luxembourg is only 14.1%, since their sample is limited to products that are observed at least in three of the four largest euro area countries. On this basis, prices in Luxembourg changed more often than in the euro area as a whole, in Germany (11.5%) and France (12.7%), and slightly less often than in Belgium (14.5%).

As found in many other micro price studies, the frequency of price adjustment in Luxembourg varies considerably across product types and categories. Frequencies range from 1.1% in communications (COICOP08) to more than 25% in clothing and footwear (COICOP03). This heterogeneity also appears at the aggregate product type level. More than half of energy prices change each month, while services prices change very infrequently (Table 2). These patterns mirror those in the euro area and confirm findings that the price change frequency is negatively correlated with the share of labour costs in a given sector, but positively correlated with the share of raw material inputs and energy (Gautier et al., 2022).

Table 2:

Price change frequency, 2005-2017 (in %)

PRICE CHANGE FREQUENCY	PRODUCT TYPES					ALL PRODUCTS
	ENERGY	NON-ENERGY INDUSTRIAL GOODS	PROCESSED FOOD	UNPROCESSED FOOD	SERVICES	
All Price Changes	61.5	15.0	14.3	27.0	6.0	14.7
Price Increases	34.1	9.1	9.1	15.1	4.7	9.1
Price Decreases	27.4	5.9	5.2	11.9	1.3	5.6
Share of price decreases	44.6	39.7	36.3	44.1	21.5	37.9

Note: Figures in the table are averages weighted by consumer expenditure shares in 2017.

Sources: STATEC, own calculations

Stylised Fact 3: *In general, price increases are more common than price decreases.*

Price increases are more common than price decreases in all product categories except communications (ECOICOP08). Of the remaining eleven categories, only food and non-alcoholic beverages (ECOICOP01), clothing and footwear (ECOICOP03), and recreation and culture (ECOICOP09) have similar shares of increases and decreases, while price decreases are almost entirely absent in restaurants and hotels (ECOICOP11) and education (ECOICOP10).

Price decreases were most common for energy and unprocessed food (Table 2). At the opposite extreme, price decreases were least common for services, where there were around four price increases for every price decrease. In weighted terms, 38% of all price changes are price decreases. Even accounting for positive inflation overall, these findings suggest some nominal downward price rigidity, especially in non-energy industrial goods, processed food, and services. Given the high degree of downward real wage rigidity in Luxembourg (Lünnemann and Wintr, 2010), one could infer that obstacles to cutting wages might translate into fewer price cuts in product types with a high labour share, such as services.

Table 3 reports the average size of price changes by product type. Energy, the product type with the highest frequency of price changes, displays the smallest average price adjustment. At the level of the twelve product categories, the average price decrease is generally larger than the average price increase (except for communications (ECOICOP08) and for housing, water, electricity, etc. (ECOICOP04)). This is also true for four out of the five product types presented in Table 3.

Price changes in Luxembourg are relatively small by international comparison. Based on a common sample of products, Gautier et al. (2022) report that in Luxembourg the median price increase was 7.4% and the median price decrease was 10.4%. These figures are below the overall medians reported in this analysis. They are also below the euro area median price increase (9.9%) and decrease (13.0%). For Germany, the median estimates are 10.5% (increase) and 14.0% (decrease). For France, they are 8.3% and 12.7%, respectively.

Table 3:

Average size of price changes, 2005-2017 (in %)

PRICE CHANGE MAGNITUDES	PRODUCT TYPES					ALL PRODUCTS
	ENERGY	NON-ENERGY INDUSTRIAL GOODS	PROCESSED FOOD	UNPROCESSED FOOD	SERVICES	
All Price Changes	3.7	9.7	9.1	13.7	12.0	10.5
Price Increases	4.0	9.0	8.4	12.7	11.2	9.8
Price Decreases	3.4	11.5	11.9	15.6	11.6	11.3

Note: Weighted averages in percent.

Sources: STATEC, own calculations

Stylised Fact 4: *Compared to 1999-2004, price changes in Luxembourg were less common in 2005-2017. There were also more price decreases.*

To provide a comparison with the 1999-2004 results reported by Lünnemann and Mathä (2005), we limit the product categories available in the 2005-2017 sample to match those in the previous study and aggregate statistics using 2000 expenditure weights. Differences across product types became more pronounced over time: the frequency of price changes increased for energy (i.e. the product type with the most flexible prices) but it declined for services (i.e. the product type with the most infrequent price changes). Overall, the price change frequency decreased by 1.2 percentage points to 15.4%. One possible explanation for less frequent price changes in non-energy industrial goods is the reduction in the share of temporary sales from 6.0% to 2.7%. Although sales became less frequent in non-energy industrial goods and unprocessed food, they became more common for processed food. Of course, the apparent increase in temporary price changes may not be related to seasonal sales but could indicate general changes in the price-setting behaviour of firms.

Table 4 also provides evidence that price decreases have become more frequent since 1999-2004. Their share in all price changes increased by 6 percentage points for energy and 5 percentage points for processed food. Among product categories, alcohol, tobacco and narcotics (ECOICOP02), and health items (ECOICOP06) registered the largest increases in the share of price decreases (12 and 9 percentage points, respectively). Despite these marked changes, the overall share of price decreases rose only slightly from 36.5% in 1999-2004 to 39.1% in 2005-2017.

Table 4:

Comparison of key statistics between 1999-2004 and 2005-2017 (changes in % or in percentage points)

MEASURE	CATEGORY	PRODUCT TYPES										ALL PRODUCTS	Δ
		ENERGY	Δ	NON-ENERGY INDUSTRIAL GOODS	Δ	PROCESSED FOOD	Δ	UNPROCESSED FOOD	Δ	SERVICES	Δ		
Frequency of price changes	1999-2004	51.9		16.2		12.3		26.4		7.0		16.6	
	2005-2017	61.1	+ 9.2	14.5	- 1.7	13.4	+ 1.1	29.0	+ 2.6	5.4	- 1.6	15.4	- 1.2
Share of temporary sales	1999-2004	0.0		6.0		0.0		1.0		0.0		3.0	
	2005-2017	0.1	+ 0.1	2.7	- 3.3	0.4	+ 0.4	0.6	- 0.4	0.0	± 0	1.1	- 1.9
Share of price decreases	1999-2004	38.1		40.7		30.3		44.1		17.0		36.5	
	2005-2017	44.4	+ 6.3	40.8	+ 0.1	35.4	+ 5.1	44.6	+ 0.5	19.4	+ 2.4	39.1	+ 2.6

Note: While we exclude all types of product and shop replacements in our calculations, Lünnemann and Mathä (2005) only exclude shop replacements. This has little effect on reported statistics. In this table, data is aggregated using the 2000 consumer expenditure weights and a one-month sales filter to identify temporary sales.

Sources: STATEC, Lünnemann and Mathä (2005), own calculations

Stylised Fact 5: *There is little evidence for economy-wide synchronisation of price adjustments.*

If price-setters synchronise price adjustments, this will have important implications for macroeconomic models. Time-dependent pricing models assume that prices are stable for fixed periods, which might lead to perfectly synchronised price-setting or to its opposite, perfect staggering, if the share of prices that 'mature' each month is distributed uniformly across the year. However, empirical evidence indicates that many price changes tend to cluster at specific points during the year. In state-dependent pricing models, price adjustment may be highly synchronised when price-setters are subject to the same (aggregate) economic shocks. For instance, in a state-dependent price setting, a spike in oil prices could simultaneously create a gap between the current and the desired price level for many price-setters, prompting them to raise prices around the same time. In this context, perfect synchronisation would require all prices to change in a given month (or no prices to change). In contrast, perfect staggering would arise if the share of sellers who adjust prices remains stable across different months.

In practice, it is difficult to measure the degree of synchronisation and to report it as a single number. The literature often relies on the estimated frequency of price changes, comparing the standard deviation of price change frequency over time to the largest possible standard deviation for the given dataset. For instance, if the share of firms that adjust prices in a given month is constant over time, the standard deviation will be zero (perfect staggering). In contrast, if either all or no price-setters change prices, the standard deviation over time will be maximised (perfect synchronisation) (Fisher and Konieczny, 2000). Therefore, the synchronisation ratio tends toward one with increasing price synchronisation. Since the number of observations in our dataset varies over time, we follow Wintr (2006) and replace relative frequency with the absolute number of observed price changes per period. The resulting index ranges between zero and one and can be interpreted as the share of firms that are perfectly synchronised in a dichotomous world consisting of only two types of price-setters: either perfectly staggered or perfectly synchronised.

In Luxembourg, there is little evidence supporting either perfect synchronisation or perfect staggering. Table 5 presents synchronisation ratios, also when considering price increases and price decreases separately. Synchronisation is highest for energy prices, while it is lowest for processed and unprocessed food. Overall, price decreases are less synchronised, suggesting there may be upward strategic complementarities between price-setters and that sellers may be more likely to interpret price decreases by their competitors as temporary. Across all products, there is only mixed evidence that price changes are synchronised, so both time- and state-dependent pricing models could be consistent with the data. While price synchronisation among energy products seems plausible, price adjustments in the broader economy seem to reflect region-, sector- and firm-specific shocks. Finally, it is important to note that synchronisation estimates are sensitive to the aggregation level: synchronisation is fairly high at the disaggregated level (54%) while it is fairly low at the aggregate level (22%). These findings support the existence of strategic complementarities within industries, suggesting that price-setters attempt to reduce relative price movements between competitors but show muted reactions to price developments outside their respective industries (Fisher and Konieczny, 2000).

Table 5:

Synchronisation ratios, 2005-2017

SYNCHRONISATION RATIOS	PRODUCT TYPES					ALL PRODUCTS
	ENERGY	NON-ENERGY INDUSTRIAL GOODS	PROCESSED FOOD	UNPROCESSED FOOD	SERVICES	
All Price Changes	94.5	44.4	29.1	31.9	47.8	46.9
Price Increases	92.7	43.9	29.8	29.9	47.3	46.3
Price Decreases	94.0	42.3	26.1	27.2	42.2	43.1

Sources: STATEC, own calculations

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