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The Effect of the Euro Changeover on Prices: Evidence from Lithuania[*]

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ABSTRACT

At the aggregate level, I find that the euro changeover did not lead to a significant change in the overall inflation rate between 2015 and 2019 in Lithuania. When the measures are diversified, however, some inflationary effects emerge in sub-categories. I therefore analyze this heterogeneity at the disaggregated level using a large sample of prices that constitutes the CPI from 2010 to 2018. I show that significant price changes have been confined to the low-weighted components of the HICP. This explains why a spike in the overall price level did not occur at the time of the changeover.

Keywords: Euro changeover, synthetic difference-in-differences, regression discontinuity in time, price changes.

JEL Classification: E31, F33, L11.

1 Introduction

Lithuania officially became the 19th member of the euro area on 1 January 2015. The conversion of the litas to the euro has raised questions about the evolution of prices and about the behavior of price setters. However, to what extent has the "changeover" to the euro caused inflation?

According to a consumer survey, a majority of Lithuanians seemed convinced that price pressure would be strong. Indeed, the Flash Eurobarometer 402 of September 2014, "Introduction of the euro in Lithuania", reveals that 84% of respondents thought that the "changeover" to the euro would "increase prices". These views are reflected in the inflation perception index compiled by the European Commission, which, as we shall see, rose sharply in 2015. In contrast, such an acceleration did not materialize in the CPI and HICP measures. The year-on-year (y-o-y) monthly HICP inflation rate was even mostly negative in that year. The discrepancy between the actual and perceived inflation rates is therefore rather puzzling, since in a classical neoclassical model a redenomination of money should be neutral. Moreover, in all the other countries that faced a euro "changeover", the impact on headline inflation was on average rather small (Tables A1 and A2). It is thus reasonable to assume that this was also the case in Lithuania.

On the other hand, this does not exclude that at the disaggregated level, some prices of goods and services have changed significantly. Indeed, research associated with the introduction of the euro indicates that some sectors should theoretically have been more affected than others. This is mainly due to the heterogeneity of cost frictions (real and information) and the variety of pricing practices (Hobijn et al. (2006), Aucremanne et al. (2007), Dziuda and Mastrobuoni (2009), Meriküll and Rõõm (2015)). The aim of this research is therefore to measure the heterogeneous effects of the "changeover" in Lithuania.

At this time, only aggregate-level evaluations have been made. Eurostat (2015) estimated that the "changeover" in Lithuania should have had a one-off impact on general prices in a range of 0.04-0.11 percentage points (p.p.). Šiaudinis et al. (2020) gauged that the new currency increased the annual headline inflation in a range of 0.53 to 0.59 p.p. on average between 2015 and 2019. I perform synthetic difference-in-differences (Arkhangelsky et al. (2019)) on panels of official HICP inflation rates of euro area countries and find that the "changeover" did not have a significant impact on the "all-items" HICP inflation measure between 2015 and 2019. Moreover, I find an average annual treatment effect on inflation in services of about 1.5 p.p. over the same period. Among other results, this shows that the impact of the "changeover" was heterogeneous across the different price categories.

In this respect, I analyze price changes at the disaggregated level using a database containing most of the prices underlying the CPI in Lithuania between 2010 and 2018. I calculate exclusive unconditional moments that are indicative of the behavior of price setters. At the time of the "changeover" (January 2015), the average frequency of unweighted price increases for all-items rose by about 5 p.p. Meanwhile, the average size of unweighted price increases were slightly below their usual values by about 1 p.p. This explains why the overall unweighted inflation rate in this database is limited to about 0.4% for this month.

Finally, I assess the effet of the "changeover" in January 2015 using regression discontinuity (in time) designs (Hausman and Rapson (2018)). Running the estimates at the ECOICOP4 level, I find that about 30% of the price categories have statistically significant price level discontinuities. On average, these are negative (-0.7%), with the positive ones mostly in the low HICP weight categories. This result suggests that the combination of external shocks and public policies largely prevented prices from rising at that time.

In this paper, I first present the background of the euro introduction in Lithuania and discuss the perception of the price surge. In the second part, I estimate the "euro effect" at the aggregate level. In the third part, I analyze price changes at the disaggregated level. Finally, I conclude with some remarks.

2 Background and Literature

2.1 Background of the "changeover"

The euro became the sole legal tender in Lithuania on 16 January 2015 (after 15 days of dual currency circulation and a "big-bang" scenario). As the 19^{th}

country to join the euro area, Lithuania has benefited from all the previous experiences of "changeover". In this respect, the political authorities and the central bank maneuvered to avoid any inflationary effect. In particular, resolution n604 of 26 June 2013 outlines a "National Changeover Plan".[1] The latter details operational modalities, a global communication strategy, rules on price rounding and the creation of a memorandum on good business practices.[2] On the other hand, the central bank was responsible for supplying the new currency to commercial banks and other entities in order to exchange litas for euros. The fixed conversion rate was set at 1 euro against 3.45280 litas. Following this introduction, a period of mandatory dual price display began in August 2014 and gradually dissipated after mid-2015.

The "changeover" took place in a complex macroeconomic context. In August 2014, Russia imposed an embargo on many European food products. This led to a sharp drop in prices in the sector and strains on GDP (Lietuvos Bankas (2015)). In addition, the market price of oil fell by more than 50% from June to December 2014 (Arezki and Blanchard (2014)). Figure 2 shows that these combined events contributed significantly to a monthly decline in all-items inflation of about -1.3% in January 2015.

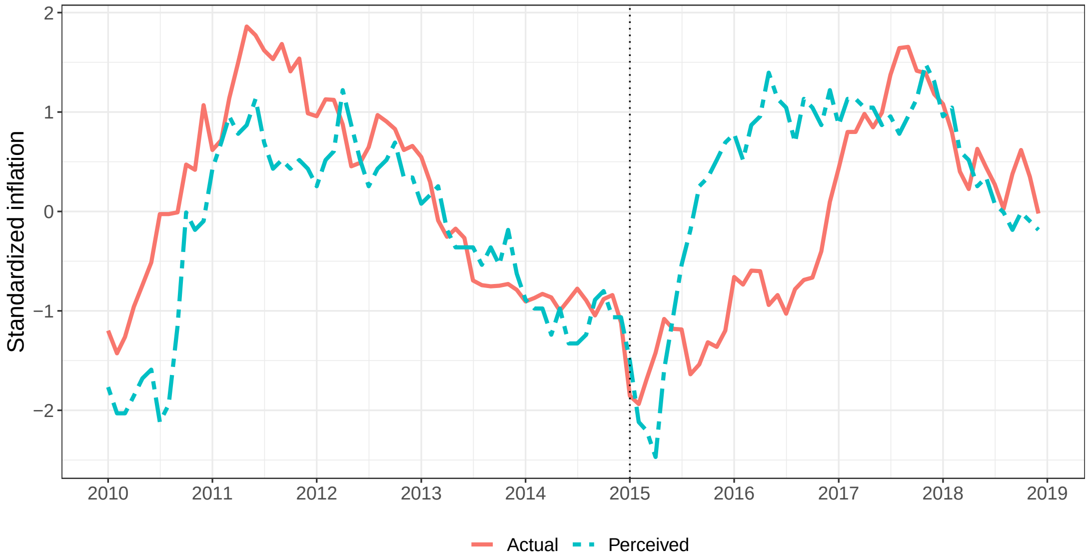
2.2 Perception of inflation

Beyond this deflationary episode, the European Commission Consumer Survey reveals that Lithuanians felt that prices were soaring after the first months of 2015. In Figure 1, this is reflected in the significant difference between the slopes of actual and perceived annual inflation. It is worth mentioning, however, that this phenomenon was not specific to Lithuania (Dziuda and Mastrobuoni (2009)). Several factors may explain this.

[1] More information is available in the legal act at the following link: https://e-seimas.lrs.lt/rs/legalact/TAD/0f7e7782be5911e3bda4be6f16c2da2b/. Note that the plan was amended in December 2013 and in June 2014.

[2] This operation started in August 2014. The subscribers of the memorandum received a logo in exchange for their good practices. Any violations (e.g. undue price increases and/or failure to comply with the rounding rule) could result in the entity being blacklisted on www.euro.lt or www.euras.lt. The list of entities that adhered to the memorandum can be found on www.euras.lt (which is currently not functioning properly). According to what remains of this website, the total number of members of the memorandum was 4004 and the number of outlets was 11885. The list of violators (not only the one in the memorandum, but also the one reported by consumers) includes 315 entities at the time of writing.

Figure 1: Actual and perceived monthly all-items HICP inflation



Notes: The "actual" inflation series is taken from Eurostat. "Perceived" inflation is extracted from the European Commission Consumer Survey. The latter is calculated via the balance of answers to the question: "How do you think that consumer prices have developed over the last 12 months?". Participants choose among prices have: risen a lot (AA); risen moderately (A); risen slightly; hardly changed (B); and fallen (BB). The balance of statistics are given by $Bal = AA + A/2 - B/2 - BB$. This indicator takes values from -100 to 100. The two measures of inflation are therefore standardized for comparison purposes. As such, the comparison is limited to changes in the slopes of the two series.

First, one may suppose that Lithuanians extrapolated a general price increase if they noticed some significant but specific changes. In this vein, Del Giovane and Sabbatini (2006) highlight that consumers tend to associate general inflation with the products that they are used to consuming. In turn, such misperceptions may generate self-fulfilling inflation expectations and create distortions in prices and wages (Stix (2009)). In addition, Eife and Maier (2007) document that preconceived beliefs about price increases led to a decline in German restaurant revenues during the 2002 "changeover". For Brachinger (2006), this phenomenon can be explained by the "prospect theory of inflation" according to which consumers feel more affected by price increases than price decreases because of loss aversion (see also Vogel et al. (2009)). Thus, it may only take a couple of sharp increases to generate this perception of soaring prices. On the other hand, the "changeover" has led to an increase in the need for information processing. Ehrmann (2011) finds that the easier the conversion rule, the higher the perception of inflation. From another perspective, Lamla and Lein (2014) assessed that the press and television intensified the perception of escalating prices in Germany.[3]

Second, perception may also have been linked to "real" (or actual) price changes. Indeed, Hobijn et al. (2006) note that conversion prompted restaurants to modify their prices due to menu costs. Their model predicts two price effects. The first is called "distributional churning", which means that many more restaurants adjust prices than usual. The second is referred to as the "horizon effect", which is characterized by a mismatch in the trajectories of new prices and expected marginal costs. This should translate into lower prices. Alternatively, Aucremanne and Cornille (2001) argue that conversion can lead to rounding towards attractive prices in the future. For example, prices ending in 0.99 are unlikely to remain as is after conversion. They therefore illustrate how the cents in the new prices may be adjusted upward to restore appeal. Finally, Dziuda and Mastrobuoni (2009) suggest that the decline in price transparency has led to price increases in the most competitive sectors. They hypothesize that new competitive prices are difficult to observe after the "changeover", putting upward pressure on prices. The authors predict, and confirm their prediction, that this tension should be inversely proportional to the product price in a sample of European prices.

Overall, these studies illustrate that some sectors must be more exposed to inflationary pressures than others. Therefore, I argue that the headline inflation rate is unlikely to fully reflect the "euro effect". In fact, Figure 2 shows that not all prices fell around the "changeover" in Lithuania.

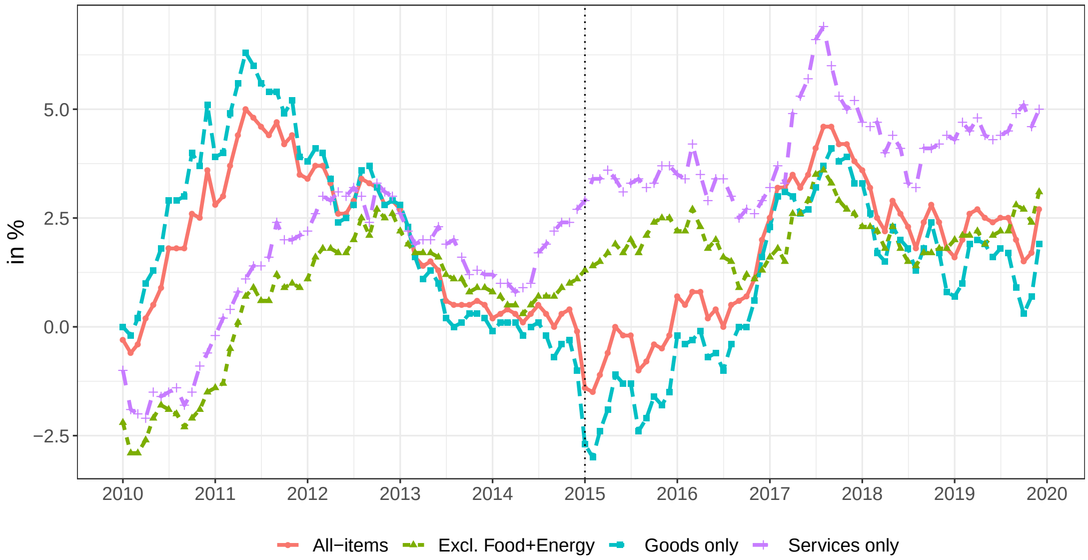
3 Macro prices analysis

3.1 Discussion

I begin by assessing the effect of the introduction of the euro at the aggregate level. Here, the term "aggregate" corresponds to the highest levels of the ECOICOP classification (see Figure B2 for more details on the complete classification). I separate my analysis according to these different strata and price measures, to avoid the following "aggregation" problems.

[3] In this respect, it is interesting to note that 54% of Lithuanian respondents in the Flash Eurobarometer 402 of September 2014 felt that it would be very useful to receive information about the "changeover" on television.

Figure 2: Year-over-year monthly HICP inflation rates



Notes: Data are extracted from Eurostat HICP inflation rates for Lithuania. The term "Excl. Food+Energy" refers to the HICP category "Overall index excluding energy, food, alcohol and tobacco".

First, the weighting mechanism used to calculate the headline inflation (all-items) can mitigate what I call "local" effects. These can occur if a category of goods or services is having a low weight in the overall price index. Let me take the example of the "communication" division, i.e., at the 2-digits level of the classification (ECOICOP1-08). Its weight in the HICP is modest, about 3% on average between 2010 and 2018, reflecting the minimal importance of this category in usual consumer expenditures (see Table A3 for the detailed weights at ECOICOP1 level.) As such, this division does not greatly influence the headline price index. Thus, if a large price increase in this category occurred at the "changeover", it may have gone unnoticed.

Second, it is difficult to obtain a reliable counterfactual at such an aggregate level (George et al. (2005), Abadie et al. (2010)). The ideal one would correspond to a control country where not only the evolution of prices but also the structure of the economy mimics that of Lithuania. My idea is therefore to design an "optimal" comparison group of countries in the spirit of Dziuda and Mastrobuoni (2009). More precisely, I rely on a SDID approach à la Arkhangelsky et al. (2019). This embodies the assumption of parallel trends by matching the pre-treatment trends of the control group with those of the treated unit(s).

I select all euro area countries to form the synthetic control group. By making this choice, I avoid the contamination effects of the treatment that could be caused by another "changeover" after 2015. Furthermore, it ensures that no change in the exchange rate regime is captured in the sample.

3.2 Method

The data extend from 2010 to 2019, so as not to capture the effects of the Great Recession on one end or the COVID-19 crisis on the other. The panel is balanced with I countries and T time periods. The variables of interest is a set of different measures of the Eurostat's HICP y-o-y monthly inflation rate.[4] I define π_{it} as the outcome variables of country i in a month t. The dummy variable $E_{it} \in \{0, 1\}$ stands for the exposure to the "changeover" (i.e. the treatment). Lithuania N_{lt} is subject to the treatment for periods $t > T_{pre}$. The other countries N_{eu} are not exposed $\forall t = 1, \ldots, T$. The SDID estimator $\hat{\tau}$ can be defined as a weighted two-way fixed-effects regression with covariates:

$$(\hat{\tau}, \hat{\alpha}, \hat{\gamma}, \hat{\lambda}, \hat{\beta}) = \underset{\tau,\alpha,\gamma,\lambda,\beta}{\arg\min} \left\{ \sum_{i=1}^{N} \sum_{t=1}^{T} \left(\pi_{it} - \alpha - \gamma_i - \lambda_t - X_{it}\beta - E_{it}\tau \right)^2 \hat{\omega}_i \hat{\varphi}_t \right\}. \tag{1}$$

where γ_i are country fixed effects, λ_t calendar-monthly fixed effects and α an intercept. The set of covariates X_{it} is described below. The causal effect of treatment exposure is given by τ. The country-specific weights $\hat{\omega}_i$ allow for an optimal match between the pre-treatment trends between Lithuania and the control group. Formally, I solve the following optimization problem:

$$\begin{gathered}
(\hat{\omega}_0, \hat{\omega}) = \underset{\omega_0 \in \mathbb{R}, \omega_i \in \Omega}{\arg\min} f_\omega(\omega_0, \omega), \\
f_\omega(\omega_0, \omega) = \textstyle\sum_{t=1}^{T_{pre}} \left(\omega_0 + \sum_{i=1}^{N_{eu}} \omega_i \pi_{it} - \frac{1}{N_{lt}} \sum_{i=N_{eu}+1}^{N} \pi_{it} \right)^2 + \zeta^2 T_{pre} \left\| \omega \right\|_2^2, \\
\Omega = \left\{ \omega \in \mathbb{R}_+^N : \textstyle\sum_{i=1}^{N_{eu}} \omega_i = 1, \; \omega_i = \frac{1}{N_{lt}} \, \forall i = N_{eu}+1, \ldots, N \right\}.
\end{gathered} \tag{2}$$

[4]The use of annual inflation rates allows trends to be captured and therefore improves the matching procedure.

where ξ is a L_2 regularization parameter.[5] Similarly, I look for time weights $\hat{\varphi}_t$ that balance the pre-treatment periods with the post-treatment ones. The problem is:

$$
\begin{gathered}
(\hat{\varphi}_0, \hat{\varphi}) = \underset{\varphi_0 \in \mathbb{R}, \varphi_i \in \Phi}{\arg\min} \, f_{\varphi}(\varphi_0, \varphi), \\
f_{\varphi}(\varphi_0, \varphi) = \textstyle\sum_{t=1}^{N_{eu}} \left(\varphi_0 + \sum_{i=1}^{T_{pre}} \varphi_t \pi_{it} - \frac{1}{T_{post}} \sum_{i=T_{pre}+1}^{T} \pi_{it} \right)^2, \\
\Phi = \left\{ \varphi \in \mathbb{R}_+^T : \textstyle\sum_{i=1}^{T_{pre}} \varphi_t = 1, \, \varphi_t = \frac{1}{T_{post}} \, \forall t = T_{pre}+1, \ldots, T \right\}.
\end{gathered} \tag{3}
$$

To improve the accuracy of the treatment estimates in (1), I account for various covariates X_{it}. They are composed of the y-o-y percentage change in industrial production, the unemployment rate (as a percent of the active population), the natural logarithm of final consumption of oil and petroleum products (in thousands of tonnes at annual frequency) and exports of goods and services (as a percent of GDP at quarterly frequency).[6] The latter two are intended to capture the effects of the export restrictions to Russia and the crash in oil prices of 2014 and 2015. All covariates are lagged by one period. Furthermore, in estimating the treatment effects of the "changeover" in other countries Hüfner and Koske (2008), and Rõõm and Urke (2014) note that it is difficult to determine an exact period at which these are supposed to appear. The reference treatment period for Lithuania is naturally January 2015, i.e. the exact date of the currency conversion. However, due to anticipatory behavior, prices may have changed before this date. For this reason, I consider an alternative scenario in which the treatment begins 6 months before January 2015, i.e., in July 2014. Thus, I argue that if the treatment effect is larger in July 2014 than in January 2015, the difference in coefficients will reflect the magnitude of anticipated price changes.

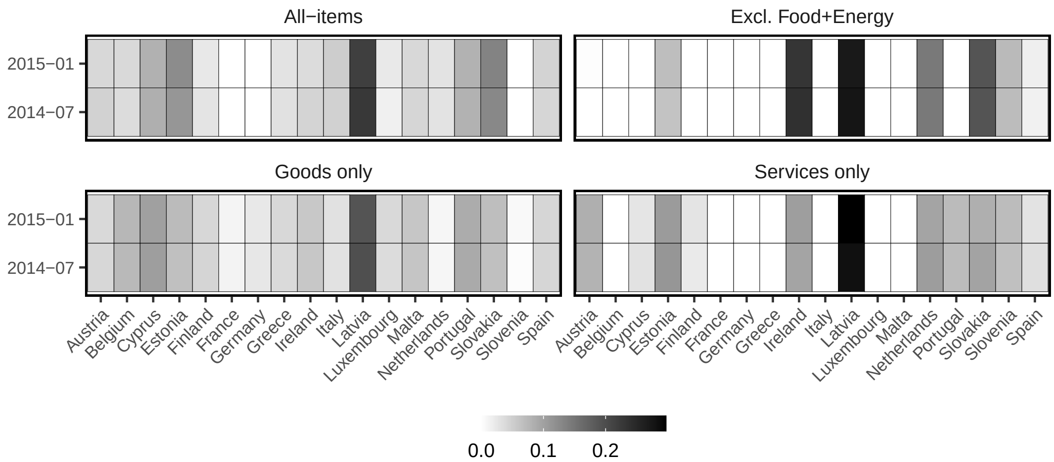
[5] I follow Arkhangelsky et al. (2019) to set the ridge penalty, that is $\xi = (N_{lt} T_{post})^{1/4} \hat{\sigma}$, $\hat{\sigma}^2 = \frac{1}{N_{eu}(T_{pre}-1)} \sum_{i=1}^{N_{eu}} \sum_{t=1}^{T_{pre}-1} (\Delta_{it} - \bar{\Delta})^2$ and $\Delta_{it} = \pi_{it+1} - \pi_{it}$, $\bar{\Delta} = \frac{1}{N_{eu}(T_{pre}-1)} \sum_{i=1}^{N_{eu}} \sum_{t=1}^{T_{pre}-1} \Delta_{it}$.

[6] Specifically, the production in industry is the y-o-y percentage change in the volume index of production in mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply. The series with a quarterly and annual frequency are transformed into monthly by assuming that there is no change during the missing months. All data are available on the Eurostat database.

3.3 Estimates

Figure 3 presents the estimated country weights $\hat{\omega}_i$ for the inflation rates at the highest aggregation level.[7] The matching procedure reveals that inflation trends in Latvia are essential to capture those in Lithuania. This is reassuring, as this neighboring country is a natural choice for comparison. Furthermore, the periphery countries of the euro area have higher weights on average than the core countries. Again, this is probably what an expert judgment would primarily consider. The inflation-trend matching procedure thus seems to serve its purpose well.

Figure 3: SDIDs country weights $\hat{\omega}_i$, year-over-year monthly inflation rates



Notes: The figure shows the country-specific weights $\hat{\omega}_i$ used to construct the synthetic counterfactuals. The weights provide optimal matches between the pre-treatment trends of the Lithuanian inflation rates and those of the control group. The titles of each sub-figure indicate which measure of inflation is being considered. The term "Excl. Food+Energy" refers to the HICP category "Overall index excluding energy, food, alcohol and tobacco". More details about the control group and the procedure are given in subsection 3.2.

I shall now turn to the SDIDs estimates. Table 1 summarizes the outcomes for the aggregate inflation measures. Standard errors are produced by placebo evaluations.[8] In the reference treatment period (January 2015, first column), the "changeover" in Lithuania had a zero effect on the headline inflation index (~ 0 p.p.). This finding does not necessarily imply that no prices in Lithuania changed significantly as a result of treatment exposure. In this respect, the

[7] Due to space constraints, I do not show the SDID weights of the inflation measures at the ECOICOP1 level (results in Table 2). I can provide them upon request.

[8] Following Arkhangelsky et al. (2019), the placebos are carried out by iteratively replacing the treated country with any country in the control group. For more details, the reader is referred to Algorithm 4 of the authors' Arxiv 2020 working paper.

estimates of the effects on the decomposition of the headline index provide some interesting insights. The yearly average effect on goods price growth is negative but non-significant (-0.31 p.p.). This is probably due to the fact that goods (food products) were particularly affected by the restrictions on exports to Russia; as evidence of this, the decline in inflation persisted well beyond 2015 in this price category (see Figure 2).

Table 1: SDIDs: year-over-year monthly inflation

	Treatment periods	
	2015-01	2014-07
All-items HICP	~ 0 (0.70)	-0.11 (0.57)
Goods only	-0.31 (1.00)	-0.33 (0.66)
Services only	1.48^{*} (0.81)	2.12^{***} (0.77)
Excl. Energy+Food+Alcohol+Tobacco	1.18^{**} (0.56)	1.14^{**} (0.53)

Notes: Coefficients are expressed in percentage points. "Goods only" refers to the HICP category entitled "Goods (Overall index excluding services)", "Services only" refers to the HICP category entitled "Services (Overall index excluding goods)". "Excl. Energy+Food+Alcohol+Tobacco" refers to the HICP category entitled "Overall index excluding energy, food, alcohol and tobacco". The total number of observations for each SDID is 2280. The standard errors are computed by 1000 placebo evaluations (see algorithm 4 in Arkhangelsky et al. (2019)). ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively. More details about the SDID procedure are given in subsection 3.2.

This downward trend may have contributed to masking the inflationary effects of the "changeover". To shed further light on this, I perform an SDID on a series of inflation rates excluding food, alcohol and tobacco. In addition, this measure of inflation does not take into account energy prices; these also experienced large price declines in 2015. In total, this amounts to removing from the overall price index about 40% of usual household consumption expenditure according to the HICP/CPI weights of 2020 (see Table A3). When this is done, the average effect in the benchmark treatment becomes significant and positive (1.18 p.p., line 4 in Table 1). How should this be understood?

This measure of inflation is more reflective of service prices, which typically account for only about 30% of the price reference index. Those have a positive and significant average treatment effect (1.48 p.p.). Three main factors may explain this phenomenon. First, at the time of the "changeover", this could reflect "distributional churning" effects. Indeed, services are a sector where the frequency of price changes is low on average in Lithuania (see Figure 6 below). As a result, the change in currency may have resulted in much larger than usual price adjustments to meet menu costs (Hobijn et al. (2006)). Second, as most services are generally not tradable (hairdressers, restaurants, etc.), price setters do not face external competition. This offers more room to change prices. Finally, Lithuania flourished after 2015, especially in 2017, when GDP growth reached about 4.3%. This inflation may therefore have been partly a reflection of the real economy, especially real wage growth.

Overall, changing the treatment exposure to 6 months before January 2015 only marginally affects the estimates (second column in Table 1). One exception concerns service prices for which the average treatment effect is larger, reaching about 2.12 p.p. It may therefore reflect anticipatory behavior of up to roughly 0.6 p.p.

The results provided until now indicate that "local" effects have occurred. I therefore extend the analysis to a lower aggregation stratum, namely ECOICOP1 (division level). Table 2 presents the SDID estimates. In the baseline treatment (first column), two divisions display strong statistical significance. The impacts are an average of 3.65 p.p. on the inflation in restaurants and hotels (C11) and 3.56 p.p. for miscellaneous goods and services. Notable services in this division include hairdressing, FISIM, and insurance. The divisions of housing, water, electricity, gas and other fuels (C4, -3.71 p.p.), furniture, household equipment and maintenance (C5 1.76 p.p.) and communications (C8, 5.24 p.p.) also exhibit treatment effects, but of less significance. However, if the treatment period is delayed by 6 months, the significance disappears and the coefficients shrink (second column). For C4 and C8, this difference is mainly explained by a lower matching precision than for the others (see panel A, Figure B1). In other words, the degree of confidence for these effects is very limited.

I thus test the robustness of these estimates. To do so, I reassign the treatment dates quite far from the time when the "changeover" occurred. Time placebo estimates of July 2012 and January 2013 are presented in Table A4.[9]

[9]Time placebos are presented only for those inflation measures which have significant average treatment effects in the benchmark treatment. The rest are available on request.

Table 2: SDIDs: year-over-year monthly inflation, ECOICOP1 level

	Treatment periods	
	2015-01	2014-07
Food and non-alcoholic beverages (C1)	-1.52 (1.24)	-1.34 (1.27)
Alcoholic beverages, tobacco and narcotics (C2)	2.76 (2.85)	2.06 (2.02)
Clothing and footwear (C3)	0.96 (1.92)	0.59 (1.02)
Housing, water, electricity, gas and other fuels (C4)	-3.71^{*} (2.00)	-1.98 (1.93)
Furnishings, household equipment and routine household maintenance (C5)	1.76^{*} (1.06)	0.32 (0.70)
Health (C6)	0.43 (1.35)	0.84 (0.61)
Transport (C7)	1.92 (1.92)	-2.77^{**} (1.26)
Communication (C8)	5.24^{*} (2.87)	3.92 (2.66)
Recreation and culture (C9)	0.90 (1.26)	-0.45 (1.33)
Education (C10)	-0.24 (4.61)	-0.32 (2.18)
Restaurants and hotels (C11)	3.65^{**} (1.47)	3.07^{*} (1.64)
Miscellaneous goods and services (C12)	3.56^{***} (0.96)	2.66^{***} (0.60)

Notes: Coefficients are expressed in percentage points. The total number of observations for each SDID is 2280. The standard errors are computed by 1000 placebo evaluations (see algorithm 4 in Arkhangelsky et al. (2019)). ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively. More details about the SDID procedure are given in subsection 3.2.

When treatment periods are shifted over time, the coefficients lose their magnitude and significance.[10] This increases the confidence in the estimated effects in the reference treatment. Finally, I perform an additional test. I revert to the baseline treatment dates of July 2014 and January 2015, but exclude Estonia

[10] A notable exception is the communication division (C8). The matching procedure is not of good quality for this division (adjusted RMSE of 2.70 p.p. in July 2012 and 2.79 in January 2013). For this division, the results of the benchmark treatment (January 2015) must therefore be taken with a grain of salt.

and Latvia from the control group. Both countries joined the euro area between 2010 and 2019 (in 2011 and 2014 respectively), making my results potentially vulnerable to bias. Tables A5 and A6 show the outcomes. The coefficients and their significance are quite similar to those of the benchmark. Thus, the inclusion of these two countries does not cause large downward biases on the coefficients, as one might expect. I therefore argue that they should be included, as otherwise the matching procedure is of lower quality (see panel B, Figure B1). Overall, this analysis of aggregate data indicates that some sectors in Lithuania have experienced a significant "euro effect". These are generally the same sectors as in the other euro area countries (Sturm et al. (2009)).

4 Micro prices analysis

4.1 Data

I now delve deeper and examine price behaviors at disaggregated ECOICOP levels. For this purpose, I benefit from a unique data set containing a wide range of prices underlying the CPI in Lithuania. The data is provided by the Lithuanian Statistical Office (Lietuvos Statistikos Departamentas) and spans from January 2010 to December 2018. The price observations are monthly and cover (after cleaning, see below) about 64% (75 of 117) of the ECOICOP level 3 (4-digit) categories and 57% (173 of 303) of the ECOICOP level 4 (5-digit) categories (see Table A7). This represents about 73% of consumer expenditures, based on average HICP weights at the ECOICOP4 level between 2010 and 2018. The data enables identification of items down to the elementary aggregate (EA) level, i.e., between the "elementary product group" (EPG) and "target sample" levels.[11] Thus, for example, I observe an EPG called "rice" which includes two "targeted samples" and numerous items. The first target consists of 1 kg packages and the second of 400 g packages. Within these targets, "rice" items are differentiated by a 12-digit identifier (the first 5 of which are the ECOICOP4 indicators), a number referring to a specific outlet where it is sold, the type of outlet, and a geographical location. Of the six locations, five are the largest cities in Lithuania: Vilnius, Kaunas, Klaipėda, Šiauliai and

[11] For more details on ECOICOP classification, see Figure B2.

Panevėžys.[12] An example of a "rice" item could be: a 1 kg package sold in a supermarket in Šiauliai between May 2010 and March 2012. Overall, the number of items in the sample (after cleansing) is 103,747. In addition, the database contains "flags" which can indicate a reason for a price change. There are 24 different flags for reporting sales (promotions), product replacements, quality changes, seasonality, etc. Table A8 shows their labels and occurrences.

I treat noise in the database by the following steps. First, I remove duplicates. Second, I consider a price change to be zero when it results from a change of less than one euro cent in January 2015. This is because the conversion to euro primarily involved rounding prices to the nearest cent. If this were not taken into account, statistics such as the frequency of price changes would be close to 100% at that time. Third, I remove observations if they are flagged as "seasonal". Fourth, I eliminate all observations of an item if any of its occurrences do not lie between the 1st and the 99th percentile of the distribution of absolute price growth (excluding zero price growth).[13] Fifth, there are EPGs in which the number of items is rather low. I favor representativeness by keeping data if more than 25 of them were observed within a month. Sixth, the coverage of ECOICOP4 categories varies significantly from month to month. To avoid distorting the aggregate statistics, I exclude data for a category if it is not observed for at least 100 months, i.e. more than eight years out of a total of nine years.

The coverage of the data at ECOICOP1 level after cleaning is highlighted in Figure 4. The two categories housing (including, water, electricity, gas and other fuels) (04) and transport (07) are both under-representative of the official statistics (panel A). In particular, I do not observe the prices of electricity (04510), heat energy (04550), diesel (07221) and petrol (07222), which account for about 11% of the average HICP weights between 2010 and 2018.[14] This

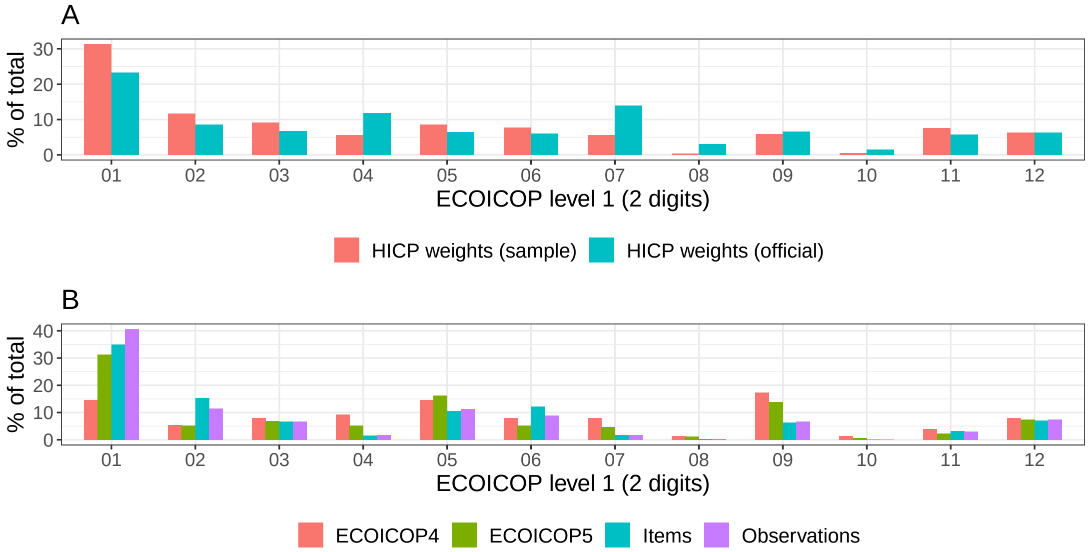
[12] The last one is called "another territory".

[13] In doing so, I lose about 13% of the total number of points. I could keep more if I only removed the specific points and not the whole set of observations. However, it is very common to find persistent prices for products with an outlier monthly growth. For example, it may be that if a price increases by 300%, it stays the same for several periods. It is difficult to understand what the reasonable price is for this item (before or after this growth?) as it may well be a product replacement or a measurement error. If this precaution is not taken into account, I have found that the statistics are much more volatile and less representative of the official inflation series.

[14] Specifically, I observe some of these prices in the raw data. Electricity (04510) has no ob-

absence, as we shall see, will be important in understanding the "euro effect". The two panels therefore reveal that the following aggregate statistics will be slightly biased by an over-representation of the food and non-alcoholic beverages category (01).

Figure 4: Micro dataset average coverage between 2010 and 2018



Notes: The average coverage is in terms of HICP weights between 2010 and 2018. The first two bars indicate the difference between the official HICP coverage and the observed sample. In both panels, the sum of all bars of the same color is 100%.

There is another issue that requires attention. Sales (discounts) and product substitutions may greatly influence micro price statistics (Klenow and Kryvtsov (2008), Nakamura and Steinsson (2008)). To understand their importance in my sample, I produce a "regular" series of price changes. To do so, I make use of the flags provided by the statistical institute. I assign a value of zero to any price change that is signaled by a flag other than "the price has actually changed" (RP).[15] This flag also marks price changes that have no economic significance for my analysis. Indeed, a fraction of them appear if a price has reverted to its former value after a promotion or replacement (what can be called a V-shaped scenario of price changes). Many cases similar to the

servations, heat energy (04550) 2360, diesel (07221) 18 073 and petrol (07222) 23 403. However, these categories contain many duplicates and outliers. After the fourth cleaning step, only 531, 415 and 724 data points remain for heat energy, diesel and petrol respectively. Naturally, these points disappear in the last steps.

[15]Note that I replace price changes with zeroes rather than dropping the observations; otherwise statistics would be non-comparable across price series ("regular" and "benchmark").

following example are observable: Suppose a price is 10 in the first month. The second month, the item is on discount at a price of 9 (hence flagged as a discount, "AKC"). In the third month, the price returns to 10. In month 3, the price change from month 2 to 3 may be flagged as "the price has actually changed" ("RP") by the statistical office. This is not what I consider a "pure" price change because the increase in month 3 is the result of a discount in month 2. Therefore, I set the price change to 0 in month 3. Note that observations of flags prior to August 2013 are rare (e.g., flags for sales are missing), so the "regular" series will largely coincide with the standard ones prior to that date.

4.2 Definitions

Price behaviors will be first highlighted through unconditional statistics. I approximate the monthly inflation rates at the ECOICOP4 level as follows:[16]

$$\begin{aligned} \tilde{\pi}_{jt} &= \frac{1}{N_{jt}} \sum_{n}^{N_{jt}} (p_{njt} - p_{njt-1}) \\ &= \left(\frac{1}{N_{jt}} \sum_{n}^{N_{jt}} I_{njt} \right) \times \left(\frac{\frac{1}{N_{jt}} \sum_{n}^{N_{jt}} (p_{njt} - p_{njt-1})}{\frac{1}{N_{jt}} \sum_{n}^{N_{jt}} I_{njt}} \right) \triangleq f_{jt} \times \Delta p_{jt}. \end{aligned} \tag{4}$$

for n items and j ECOICOP4 categories in a month t. p_{njt} is the natural logarithm of a unit price; i.e., obtained by dividing a euro price by its unit measure (e.g. 1(kg)).[17] By doing so, I prevent changes in unit measurements from being captured as price changes. I_{njt} are price change indicators; i.e. $I_{njt} = 1$ if $p_{njt} \neq p_{njt-1}$, and 0 otherwise. In this decomposition, Δp_{jt} is the average size of price changes and f_{jt} the average frequency of price changes. Isolating the frequency of price changes is interesting because it sheds light on the degree of price rigidity. It will also reveal whether many individuals changed their prices more than usual during the "changeover". The overall frequency can be

[16] I assume uniformly weighted averages because HICP/CPI weights are not publicly observable below the ECOICOP4 level.

[17] Before January 2015, the unit price changes are calculated from prices in euros using the official conversion rate of 3.45280 litas for 1 euro.

further decomposed as:

$$f_{jt} = \frac{1}{N_{jt}} \sum_{n}^{N_{jt}} I_{njt} = \frac{1}{N_{jt}} \sum_{n}^{N_{jt}} I^{+}_{njt} + \frac{1}{N_{jt}} \sum_{n}^{N_{jt}} I^{-}_{njt} \triangleq f^{+}_{jt} + f^{-}_{jt}. \tag{5}$$

where I^{+}_{njt} are price increase indicators; i.e. $I^{+}_{njt} = 1$ if $p_{njt} > p_{njt-1}$, and 0 otherwise. I^{-}_{njt} are price decrease indicators; i.e. $I^{-}_{njt} = 1$ if $p_{njt} < p_{njt-1}$, and 0 otherwise. A similar decomposition can also be applied to the average size of price changes:

$$\begin{aligned} \Delta p_{jt} &= \frac{\frac{1}{N_{jt}} \sum_{n}^{N_{jt}} (p_{njt} - p_{njt-1})}{\frac{1}{N_{jt}} \sum_{n}^{N_{jt}} I_{njt}} \\ &\triangleq \frac{f^{+}_{jt}}{f_{jt}} \times \underbrace{\frac{\frac{1}{N_{jt}} \sum_{n}^{N^{+}_{jt}} (p_{njt} - p_{njt-1})^{+}}{f^{+}_{jt}}}_{\Delta p^{+}_{jt}} - \frac{f^{-}_{jt}}{f_{jt}} \times \underbrace{\frac{\frac{1}{N_{jt}} \sum_{n}^{N^{-}_{jt}} (|p_{njt} - p_{njt-1}|)^{-}}{f^{-}_{jt}}}_{\Delta p^{-}_{jt}} \end{aligned} \tag{6}$$

where Δp^{+}_{it} and Δp^{-}_{it} split the size of non-zero changes in rising and falling prices, respectively. N^{+}_{jt} denotes the number of price increases and N^{-}_{jt} of price decreases. According to these decompositions, the j inflation rates are now:

$$\tilde{\pi}_{jt} = f^{+}_{jt} \times \Delta p^{+}_{jt} - f^{-}_{jt} \times \Delta p^{-}_{jt}. \tag{7}$$

Then, the aggregate weighted monthly inflation rate is calculated as follows:

$$\pi_t = \sum_{j}^{J} \omega_{jt} \tilde{\pi}_{jt} \tag{8}$$

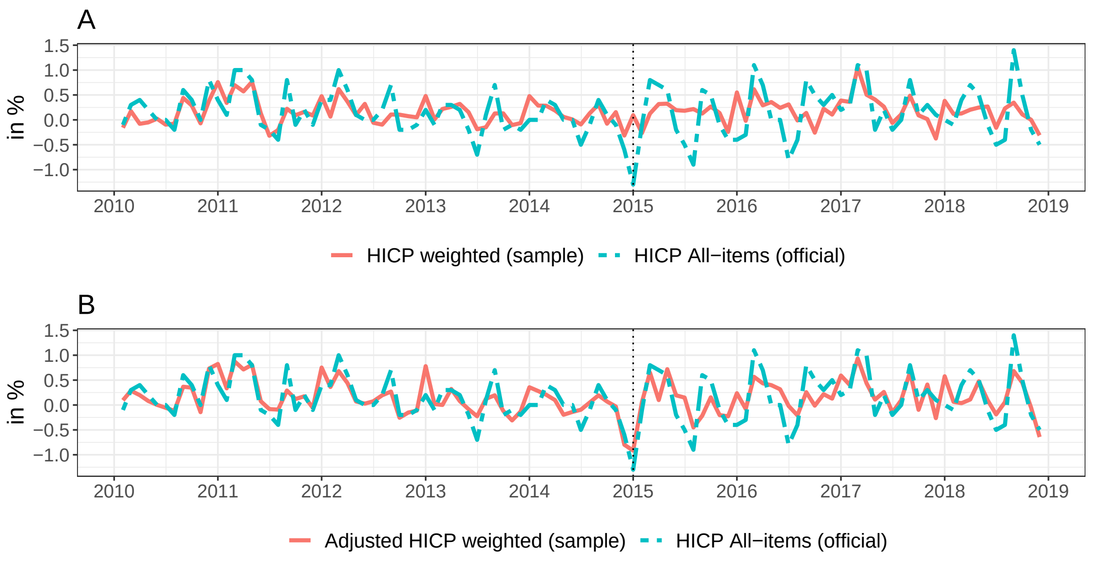
where ω_{jt} are the HICP weights between 2010 and 2018 at the ECOICOP4 level.[18]

[18] It should be recalled that the database covers around 73% of HICP consumer expenditures on average between 2010 and 2018. Therefore, in each case, the weights are normalized. Cases where the aggregate statistics or inflation are not weighted are given by a standard average calculation.

4.3 Unconditional moments

To begin, Figure 5 examines what the microprice database represents in terms of official inflation. Panel A highlights the unweighted monthly inflation of the sample for which HICP coverage averages about 73% at the ECOICOP4 level over the period. The latter evolves within the range of values of the official series but has a distinctly lower volatility (the correlation between the two series is 53%). At the time of the "changeover", the inflation of the sample is 0.09% while the official inflation is -1.3%. How is this difference to be understood, given that the sample is fairly representative? There are two main explanations. First, important ECOICOP4 price categories are missing

Figure 5: Monthly HICP inflation rates: sample and official



Notes: "Adjusted HICP weighted (sample)" means that I add to the observations the official monthly rate of change of electricity (04510), heat energy (04550), diesel (07221) and petrol (07222). In panel A the benchmark coverage of the HICP ECOICOP4 weights is about 73%, while in panel B it is roughly 84%. The differences with the official rates are therefore due to computation methods and to missing observations. The official series is obtained from Eurostat.

from the sample and these categories are the ones that largely explain the drop in official inflation in January 2015. Among these are regulated electricity prices (04510), which were revised downward by an average of -6.3% on that date.[19] Moreover, the prices of diesel (07221) and petrol (07222) decreased by -10.2% and -11.6%, respectively. Finally, the prices of heat energy (04550)

[19] During the data sample, electricity was a monopoly where the price is regulated by the National Energy Regulatory Council (NERC).

fell by -0.1%.[20] Adjusting for their absence restores a negative inflation rate of -0.92% (panel B) in January 2015 and a correlation of 75% with the official series. This therefore suggests that the evolution of electricity prices and the global oil glut in 2014 largely masked potential "euro effect" over the period. These findings are mirrored in the y-o-y monthly HICP inflation rates in Figure B3. In the sample series, annual inflation decelerates but is positive in January 2015 (1.13%, correlating to 82% with official inflation). The adjustments for energy and oil increase the correlation to 95%, obtaining an annual inflation of -1% against the official -1.4%.

Second, Table 3 reveals that HICP weights also play an important role in stifling inflationary effects during the "changeover". Indeed, I find that, on average, categories with lower HICP weights experienced the largest price increases at that time. This last point is reflected in the difference between the unweighted and weighted sample inflation series, which is about -0.34 p.p. in January 2015. The difference even reaches -1.18 p.p. when the series are adjusted.

Table 3: Sample monthly HICP inflation rates: January 2015

	Unweighted	Unweighted (adjusted)	Weighted	Weighted (adjusted)
	(1)	(2)	(3)	(4)
Monthly inflation, %	0.43	0.26	0.09	-0.92
Δ with (1), p.p.	–	-0.17	-0.34	-1.35
Δ with (2), p.p.	0.17	–	-0.17	-1.18

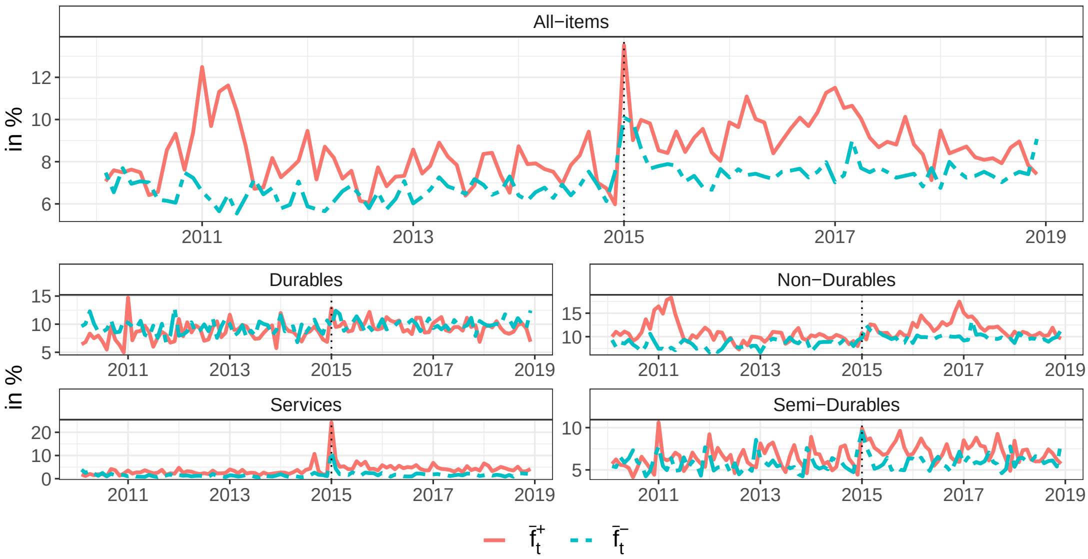
Notes: The series are weighted using the HICP weights at ECOICOP4 level. "(adjusted)" means that I add to the observations the official monthly rate of change of electricity (04510), heat energy (04550), diesel (07221) and petrol (07222). Δ refers to a difference.

Beyond that, the question remains as to how the price setter behaved at the time. Were the price changes due to more individuals readjusting their prices than usual, or were the size of the price changes larger than typical, or both? To answer this, I now present the decomposition of the inflation series into its frequency and size components – following the expressions (4) and (7). Figure 6 shows the monthly aggregate unweighted average frequencies of price increases and decreases. These statistics reveal that in January 2015,

[20] These four categories alone represent about 11% of the average HICP weights between 2010 and 2018 and greatly reflect the impacts of the late 2014 oil crisis.

the fraction of individuals who changed prices was higher than usual. For all-items statistics, the average frequency of price increases is about 13.5%, while the typical is about 8.5%. Meanwhile the average frequency of price decreases is about 10% whereas it usually averages around 7%. Compared to December 2014, the average frequency of price increases changed by 7.5 p.p. and that of price decreases by 2.5 p.p. Clearly, all sub-categories contributed to the increased frequency of upward and downward price adjustments. In particular, many service prices were revised higher. Indeed, the average frequency of their upward price changes increased from about 2.1% to 24.3% between December 2014 and January 2015 compared to a typical average of 3.8%. In addition, both series for all-items display a slight break in trend since 2015; this break is apparent in each of the sub-categories.

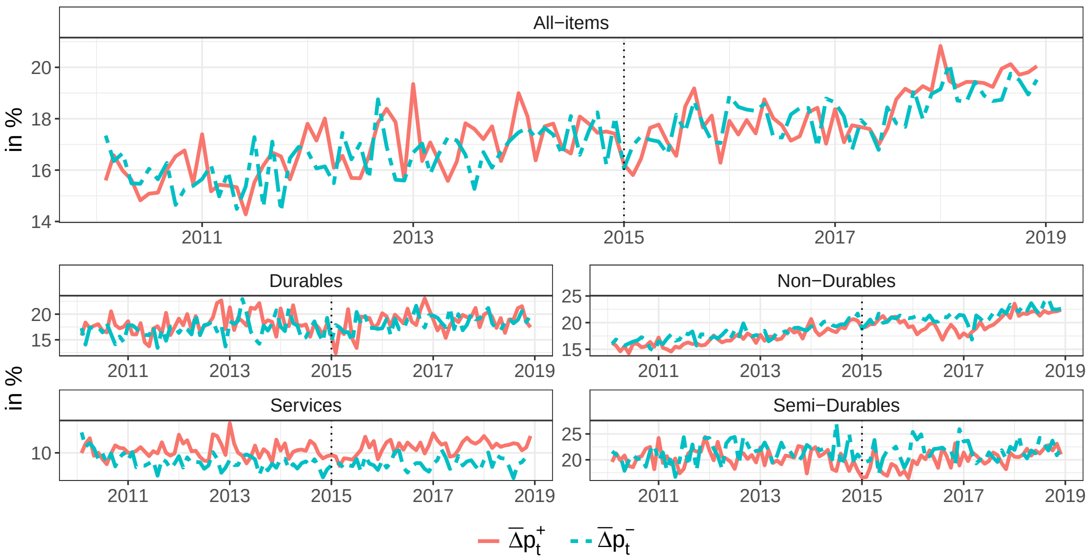
Figure 6: Unweighted average frequency of price increases and decreases



Notes: The average frequency of price increases (red solid lines) is calculated in two steps: 1) $f_{jt}^{+} = \frac{1}{N_{jt}} \sum_{n}^{N_{jt}} I_{njt}^{+}$ for n items and j ECOICOP4 categories. I_{njt}^{+} are price increase indicators; i.e. $I_{njt}^{+} = 1$ if $p_{njt} > p_{njt-1}$, and 0 otherwise. 2) $\bar{f}_t^{+} = \frac{1}{J} \sum_{j}^{J} f_{jt}^{+}$. The average frequency of price decreases (blue dashed lines) is computed in two steps: 1) $f_{jt}^{-} = \frac{1}{N_{jt}} \sum_{n}^{N_{jt}} I_{njt}^{-}$ where I_{njt}^{-} are price decrease indicators; i.e. $I_{njt}^{-} = 1$ if $p_{njt} < p_{njt-1}$, and 0 otherwise. 2) $\bar{f}_t^{-} = \frac{1}{J} \sum_{j}^{J} f_{jt}^{-}$.

How did such a large increase in the frequency of price changes in January 2015 not turn into an overall price spike? The answer is that fluctuations in the average size of price changes were not large. Indeed, Figure 7 illustrates that the average size of price increases for all-items is about 16.2% and the average size of price decreases is roughly 16.1% on that date. Both are around their respective period averages of 17.3% and 17.2%, respectively. The average size of price increases decreased by 1.2 p.p. between December 2014 and January 2015; the average size of price decreases decreased by 2 p.p. This feature is also reflected in the sub-components of inflation. An exception is prices for services, where the average size of upward and downward price changes increased by about 0.3 and 1.2 p.p., respectively, over the same period. It should be noted, however, that these changes retained a fairly typical average size for price increases and decreases in services. Furthermore, there are clear upward trends in both all-items series. Notably, however, this phenomenon has been evident since 2010, making it difficult to attribute it to the introduction of the euro. These trends were mainly driven by the evolution of prices of "non-durables", which represent about 59.1% of HICP weights on average between 2010 and 2018.[21]

Figure 7: Unweighted average size of price increases and decreases



Notes: The average size of price increases (red solid lines) is calculated in two steps: 1) $\Delta p_{jt}^+ = \frac{1}{N_{jt}} \sum_n^{N_{jt}^+} (p_{njt} - p_{njt-1})^+ \,/\, f_{jt}^+$ for n items and j ECOICOP4 categories. f_{jt}^+ is computed in (5). 2) $\bar{\Delta}p_t^+ = \frac{1}{J} \sum_j^J \Delta p_{jt}^+$. The average size of price decreases (blue dashed lines) is computed in two steps: 1) $\Delta p_{jt}^- = \frac{1}{N_{jt}} \sum_n^{N_{jt}^-} (|p_{njt} - p_{njt-1}|)^- \,/\, f_{jt}^-$. 2) $\bar{\Delta}p_t^- = \frac{1}{J} \sum_j^J \Delta p_{jt}^-$.

I now illustrate how the behavior of price setters has been reflected in the decomposition of the benchmark-weighted inflation series. Recall that

[21] "Services" account for about 20%, "durables" 6.4% and "semi-durables" 14.5% of HICP weights on average over the same period.

the latter presents a monthly inflation rate on all-items of 0.09% in January 2015, while the unweighted rate is 0.43%. Figure B4 display the frequency statistics. The weighted average frequency of price increases peaks at about 13.5% for January 2015, which is similar to the unweighted series. In parallel, the average weighted frequency of price decreases is about 1.4 p.p. higher than the unweighted frequency (11.4% vs. 10%). Both weighted all-items frequency series experience significant jumps between December 2014 and January 2015 (about 6.5 p.p. for price increases and 3 p.p. for price decreases).

Figure B5 reports the weighted size statistics. The weighted average of price increases is about 15.3% for January 2015, while it is 16.2% in the unweighted case. The weighted average of price decreases is about equal in both cases, at around 16.1%. Both ensemble size-weighted statistics drop at the time of the "changeover" by about -2.7 p.p. for price increases and -2.2 p.p. for price decreases, respectively. Overall, these January 2015 weighted frequency and size averages imply that the first term of the expression (7) is lower than that of the unweighted statistics but the second term is higher; thus, overall inflation is necessarily lower for the weighted prices. In other words, the categories with a higher weight in the HICP experienced a greater number of price decreases than the others on average. In addition, the most consumed products experienced smaller price increases than the others on average.

I mentioned earlier that pricing behavior can appear different if sales (promotions) and replacements are excluded. I thus provide similar statistics on the "regular" series. Figures B6 and B7 show the outcomes. Naturally, the "regular" inflation series is permanently higher than the reference series. This is because the downward price changes are significantly smaller on average and therefore the average price change is higher. Next I look at the change in inflation between December 2014 and January 2015. It is about 0.78 p.p. in the unweighted benchmark series and about 0.92 p.p. in the unweighted "regular" series. This indicates that sales and replacements apparently played a small role at the "changeover", about 0.14 p.p. In January 2015, the change in the average frequency of price increases is 1 p.p. higher in the "regular" series than in the benchmark one. The difference in variation is of the same order of magnitude for the average frequency of price decreases. By contrast, the average size of price increases varies by 2 p.p. in the "regular" series, whereas it falls by -1.2 p.p. in the benchmark one. Meanwhile, the average size of price decreases varies by 1.7 p.p. in the "regular" series while it is -2 p.p. in the benchmark one. All components of the inflation thus varied positively in the "regular" series; price changes were more frequent and larger in both directions (positive and negative). Since the two offset each other in the inflation (see the two terms in equation (7)), this explains why the change in "regular" series inflation between December 2014 and January 2015 is close to that of the reference one.

Finally, Table A9 shows the ECOICOP4 categories for which the average frequency and size of price changes in January 2015 ($\bar{f}_{J15}, \bar{\Delta} p_{J15}$) are both higher than the respective averages for all categories over the period ($\bar{f}, \bar{\Delta} p$). The sum of their HICP weights is about 13.3% with 17 of these 32 categories being services. The category with the highest weight (2.116%) is "Spirits and liqueurs" (2111) and the category with the highest inflation rate (4.27%) is "Other recording media" (9149). The average unweighted inflation for those categories is about 1.88%. The average frequency of increases in these prices is about 26.5% and the average frequency of the size of price increases is about 13.9%. The former is highly unusual compared to the average frequency across all-items over the period (8.5%), while the latter is within the range of the typical size of price increases (17.3%). This again confirms that the inflationary pressures of the "changeover" were the result of a larger number of price changes but for which the average size remained standard.

4.4 Regression discontinuity in time

The unconditional moments indicate that the significant price increases in January 2015 were on average mainly concentrated in categories with low HICP weights. At the aggregate level, these were masked by price declines in other price categories driven by, *inter alia*, global external shocks. I now intend to isolate the impact of the "changeover" from these confounding factors by implementing regression discontinuity (in time) designs (RDiTs, Hausman and Rapson (2018)). I start by estimating the price level discontinuities for each ECOICOP4 category. In each case, the model has the following form:

$$p_{it} = \alpha + \beta D_{it} + \theta_1 T_{it} + \theta_2 (D_{it} \cdot T_{it}) + \mathbf{X}_{t-1} \phi + \gamma O_t + \lambda_i + f_{it} + \varepsilon_{it} \tag{9}$$

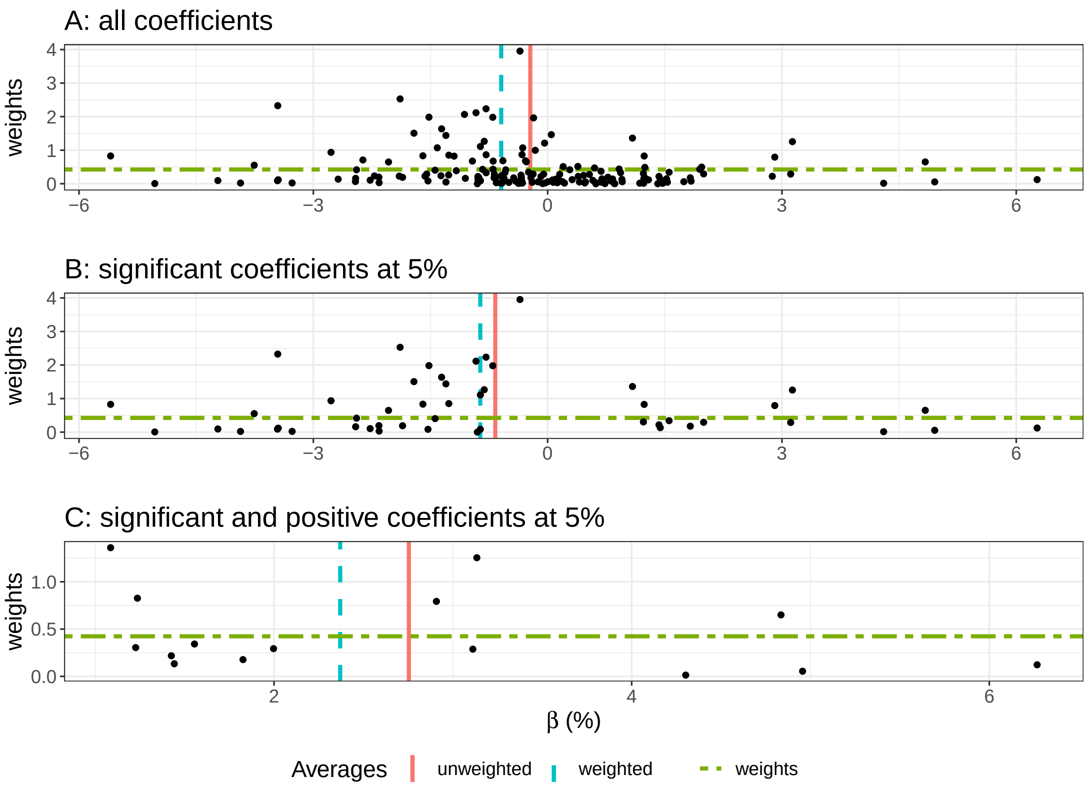
where i indexes the different items and p_{it} are the natural logarithms of the monthly unit prices. Item-fixed effects are denoted by λ_i and f_{it} are dummies for sales and replacement flags. The matrix $\mathbf{X}_{t-1}$ contains first lagged control variables of the Lithuanian economy; these are the y-o-y percentage change in industrial production, the unemployment rate (as percent of the active population), the exports of goods and services (as percent of GDP at quarterly frequency) and the monthly percentage change in the price of European Brent crude oil.[22] The variables O_t is a series of monthly global oil supply shocks (Baumeister and Hamilton (2019)). The model specification is linear and the time trends T_{it} are centered on January 2015 (τ). The dummy variables $D_{it} \equiv \mathbb{1}\{T_{it} \geq \tau\}$ have a value of one when time exceeds the threshold τ. β is the coefficient of interest representing the discontinuity of the average price level. I perform local-linear regressions to avoid the estimates being biased by too many macroeconomic fluctuations. Accordingly, the time window before and after the threshold is set to 9 months.

Figure 8 shows the RDiTs estimates. Panel (A) displays all the β coefficients of the ECOICOP4-level regressions. Most of these are concentrated around 0 and have a lower weight than the average HICP weight in 2015. The price discontinuities were overall slightly negative with an unweighted average of -0.22% and a weighted average of -0.59%. Panel (B) reports the coefficients significant at the 5% level only (Tables A10 and A11 add further details). These represent about 31% of the total number of ECOICOP4 (53 out of 168) and account for 37% of the 2015 HICP weights.[23] Two distinct masses of price discontinuities are now concentrated to the left and right of 0. Interestingly, the negative ones have significantly higher weights in the HICP than the positives. In aggregate, the unweighted average price discontinuities are -0.67% while the weighted ones are -0.86%. These results further corroborate the fact that the significant increases in the price level in January 2015 were mainly in categories with a lower than average HICP weight, thus having little influence in the aggregate. Panel (C) depicts only the positive price discontinuities

[22] European Brent crude oil data is obtained from the FRED database. The series and frequency transformation are similar to those used in the SDID estimates.

[23] Note that I exclude 5 ECOICOP4 categories in all RDiTs; namely 4522, 4530, 4549, 7224 and 7243. These are directly related to energy and oil prices. As I have shown above, changes in these prices are independent of the "changeover" to the euro, and they strongly bias the aggregate estimates downwards.

Figure 8: RDiTs January 2015 by ECOICOP4: 9 months window



Notes: The black dots represent the average treatment effect β in the equation (9) for each regression at the ECOICOP4 level. The time window is 9 months, the trend is linear and the threshold τ is fixed at January 2015. The vertical lines represent the averages of these coefficients, either unweighted (red solid lines) or weighted by the HICP 2015 weights (blue dotted lines). The green dashed lines show the average HICP weight in 2015. The pvalues that determine the significance of the coefficients are computed with robust standard errors. More details on the significant coefficients at 5% (panel (B)) can be found in Tables A10 and A11.

that are significant at the 5% level. They represent 10% of the total number of ECOICOP4 and about 6.2% of the 2015 HICP weights. In aggregate, the average increase in these discontinuities is 2.75% with unweighted coefficients and 2.37% with weighted coefficients. As a robustness check, Figure B8 in the appendix illustrates the estimates with a time window around January 2015 of 6 months. The results are on the whole quite similar. However, fewer price discontinuities are significant at the 5% level and the aggregate averages are lower.[24]

After all, one question remains: is it that unusual to observe such price

[24] I acknowledge that all the RDiT estimates are very sensitive to the external shocks that I mention in the paper (oil and export bans), even though the control variables should capture some of their effects. In my view, this explains why a significant number of price discontinuities have negative coefficients.

Table 4: RDiTs January: unweighted prices, 9 months window

τ	2013-01	2014-01	2015-01	2016-01	2017-01
β	0.225	0.682*	-0.246	0.509***	0.863***
	(0.222)	(0.381)	(0.197)	(0.149)	(0.326)
θ_1	0.118**	-0.120	0.0171	0.155***	0.0553
	(0.0509)	(0.0994)	(0.0474)	(0.0567)	(0.0602)
θ_2	-0.228	0.160**	0.149	0.0969	0.261*
	(0.146)	(0.0745)	(0.122)	(0.0731)	(0.137)
$IndProd_{t-1}$	0.00509	0.0101	-0.000783	-0.0147	-0.0173
	(0.00315)	(0.00869)	(0.00707)	(0.0114)	(0.0167)
Unp_{t-1}	-0.849**	-0.188	-0.183	0.261	0.298
	(0.425)	(0.254)	(0.204)	(0.391)	(0.267)
Exp_{t-1}	-0.0867*	-0.0839***	0.0174	0.00450	-0.00428
	(0.0455)	(0.0320)	(0.0371)	(0.0325)	(0.0633)
$Brent_{t-1}$	0.00505	0.0205	0.00202	0.0100**	-0.0212
	(0.00398)	(0.0156)	(0.00397)	(0.00493)	(0.0130)
$OilSupply_t$	0.0802	0.160**	-0.0192	-0.0343	0.149
	(0.0600)	(0.0643)	(0.0258)	(0.0213)	(0.0914)
$SalesRep_t$	-8.458***	-10.42***	-12.67***	-12.55***	-12.82***
	(0.451)	(0.487)	(0.588)	(0.584)	(0.502)
α	-16.66*	-29.17***	-37.83***	-42.21***	-37.37***
	(9.052)	(4.106)	(3.703)	(3.196)	(3.455)
Obs.	881,810	878,862	858,531	842,399	860,059

Notes: $IndProd_{t-1}$ stands for the industrial production, Unp_{t-1} for the unemployment rate, Exp_{t-1} for the exports, $Brent_{t-1}$ for the Brent crude oil prices, $OilSupply_t$ for the global oil supply shocks and $SalesRep_t$ for the flags of sales and replacements. More details on the model are shown in equation (9). Standard errors in parentheses are adjusted for the 168 clusters at ECOICOP4 level. ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively.

discontinuities in January in Lithuania? Figures 5 to 7 are revealing; increases in monthly inflation are often located in that particular month. To gain further insight, I estimate other January RDiTs, but this time pooling all the data.[25] Table 4 shows the estimates when the treatment threshold (τ) is set to January for each year from 2013 to 2017, and the time window is 9 months in each case. The first row (β) shows the average discontinuity of unweighted prices for each of the January months considered. Leaving aside January 2015, all

[25]There is no change compared to the benchmark specification except that I assume different fixed effects. To be precise, the model is the following: $p_{it} = \alpha + \beta D_{it} + \theta_1 T_{it} + \theta_2 (D_{it} \cdot T_{it}) + \mathbf{X}_{t-1}\phi + \gamma O_t + \lambda_j + f_{it} + \varepsilon_{it}$; where λ_j are ECOICOP4-items fixed effects.

coefficients are positive and significant (except for 2013). In parallel, the average effect in January 2015 is negative (-0.246%) but not significant. In other words, the usual average January effect did not materialize in January 2015. This may be due to several reasons. First, competitive pressure may have reduced price setters' room to maneuver. Second, public policy actions against abusive practices may also have curbed the usual price adjustment practices. Thus, price changes may have been anticipated and delayed in a granular way. Third, joint crises due to external shocks (oil and exports) may have largely reduced the probability of upward price changes.

5 Conclusion

As the surveys reveal, the introduction of the euro was perceived as an inflationary event in Lithuania. In this research, I use innovative modeling techniques (SDID and RDiT) and two databases to investigate whether this in fact happened. Overall, I find no significant increase in average prices or in the headline HICP inflation rate at the time of the "changeover" and in the 5 years that followed. However, I reveal that some of the sub-components of the reference index, such as prices of services, experienced significant increases from 2015 to 2019. This indicates that the aggregation stifled some heterogeneous response of price categories to the "changeover".

I therefore dig deeper and analyze a micro-level database containing most of the prices underlying the CPI in Lithuania between 2010 and 2018. I calculate exclusive unconditional moments that are indicative of the behavior of price setters. At the time of the "changeover" (January 2015), I find that the average frequency of unweighted price increases and decreases increased sharply from their usual levels. In addition, I reveal that the average size of price increases and decreases remained within their standard values. This explains why there was no spike in the aggregate prices at that time.

Furthermore, I estimate the impact of the "changeover" in January 2015 using RDiTs. At the ECOICOP4 level, I find that positive price discontinuities are mostly found on categories with low HICP weights and represent about 6% of the HICP 2015 weights. Finally, an estimate on all prices does not reveal any discontinuity with the average aggregate price in January 2015.

To sum up the findings of this paper, the "changeover" to the euro did not generate more overall inflation than usual, although heterogeneous responses occurred. Thus, it seems that public policies were successful. Finally, I would argue that the euro has allowed the country to converge further, so that upward price trends in certain categories, such as services, primarily reflect improvements in the real economy.

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Appendix

Table A1: Estimates of euro changeover effect, scholars and central banks

Countries	Effects, p.p.	Categories	Sources
Euro area	0.34	all-items HICP	Hüfner and Koske (2008)
Euro area	[0.05-0.23]	all-items HICP	Sturm et al. (2009)
Slovakia	0.33	all-items HICP	Hüfner and Koske (2008)
Netherlands	[0.2-0.4]	all-items HICP	Folkertsma et al. (2002)
Germany	0.3	all-items HICP	Deutsche Bundesbank (2014)
Belgium	0.18	all-items HICP	Banque Nationale de Belgique (2002)
Portugal	0.23	all-items HICP	Santos et al. (2002)
France	0.20	all-items HICP	Attal-Toubert et al. (2002)
Spain	[0.2-0.4]	all-items HICP	Banco de España (2002)
Estonia	[0-0.5]	all-items HICP	Rõõm and Urke (2014)

Table A2: Estimates of euro changeover effect, Eurostat

Countries	Effects, p.p.	Categories	Sources
Euro area	0.20	all-items HICP	Eurostat (2003)
Euro area	0.04	Health	Eurostat (2003)
Euro area	0.03	Rents	Eurostat (2003)
Euro area	0.10	Restaurants, cafés and the likes	Eurostat (2003)
Euro area	0.01	Gardens, plants and flowers	Eurostat (2003)
Euro area	0.01	Hairdressing salons	Eurostat (2003)
Slovenia	0.24	all-items HICP	Eurostat (2007)
Slovakia	0.3	all-items HICP	Eurostat (2009)
Estonia	[0.2-0.3]	all-items HICP	Eurostat (2011)
Latvia	[0.12-0.21]	all-items HICP	Eurostat (2014)

Table A3: HICP and CPI weights, average from 2010 to 2018, ECOICOP1 level

ECOICOP1	Label	HICP	CPI
01	Food and non-alcoholic beverages	23.33	24.66
02	Alcoholic beverages, tobacco and narcotics	8.52	8.22
03	Clothing and footwear	6.70	7.13
04	Housing, water, electricity, gas and other fuels	11.79	12.87
05	Furnishings, household equipment and routine household maintenance	6.37	5.61
06	Health	6.06	6.54
07	Transport	13.96	12.92
08	Communication	3.11	3.53
09	Recreation and culture	6.64	6.46
10	Education	1.46	1.74
11	Restaurants and hotels	5.73	4.78
12	Miscellaneous goods and services	6.34	5.54
	Total	100	100
	Consumer goods (2020)	-	69.62
	Consumer services (2020)	-	30.38

Notes: The data are extracted from the *Official Statistics Portal* for Lithuania https://osp.stat.gov.lt/statistiniu-rodikliu-analize#/. CPI weights for consumer goods and services are only available since 2020.

Table A4: SDIDs: year-over-year monthly inflation, time placebos

	Treatment periods	
	2012-07	2013-01
Services only	-0.99 (1.10)	-1.18 (1.18)
Excl. Energy+Food+Alcohol+Tobacco	-0.38 (0.83)	-0.66 (0.90)
Housing, water, electricity, gas and other fuels (C4)	-3.60 (2.45)	-0.17 (3.20)
Furnishings, household equipment and routine household maintenance (C5)	-0.52 (1.00)	-0.37 (1.10)
Transport (C7)	-1.76 (2.84)	-0.47 (2.02)
Communication (C8)	-5.22^{***} (1.78)	-6.57^{**} (2.80)
Restaurants and hotels (C11)	-1.31 (1.23)	-0.63 (1.83)
Miscellaneous goods and services (C12)	0.25 (0.75)	-1.70 (1.52)

Notes: Coefficients are expressed in percentage points. The total number of observations for each SDID is 2280 The standard errors are computed by 1000 placebo evaluations (see algorithm 4 in Arkhangelsky et al. (2019)). ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively. More details about the SDID procedure are given in subsection 3.2

Table A5: SDIDs: year-over-year monthly inflation, excl. Latvia and Estonia

	Treatment periods	
	2015-01	2015-01
All-items HICP	-0.25 (0.98)	-0.16 (0.77)
Goods only	-0.33 (0.98)	-0.23 (0.69)
Services only	1.24 (0.74)	2.18^{***} (0.78)
Excl. Energy+Food+Alcohol+Tobacco	1.12^{**} (0.55)	0.87 (0.54)

Notes: Coefficients are expressed in percentage points. "Goods only" refers to the HICP category entitled "Goods (Overall index excluding services)", "Services only" refers to the HICP category entitled "Services (Overall index excluding goods)". "Excl. Food+Energy" refers to the HICP category entitled "Overall index excluding energy, food, alcohol and tobacco". The total number of observations for each SDID is 2040. The standard errors are computed by 1000 placebo evaluations (see algorithm 4 in Arkhangelsky et al. (2019)). ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively. More details about the SDID procedure are given in subsection 3.2.

Table A6: SDIDs: year-over-year monthly inflation, ECOICOP1 level, excl. Latvia and Estonia

	Treatment periods	
	2015-01	2014-07
Food and non-alcoholic beverages (C1)	-0.92 (1.40)	-0.48 (1.52)
Alcoholic beverages, tobacco and narcotics (C2)	0.14 (2.70)	-0.08 (1.77)
Clothing and footwear (C3)	1.22 (1.45)	~ 0 (1.13)
Housing, water, electricity, gas and other fuels (C4)	-2.70 (2.34)	-1.55 (2.25)
Furnishings, household equipment and routine household maintenance (C5)	1.06 (0.85)	1.62*** (0.61)
Health (C6)	1.37 (1.53)	1.63*** (0.56)
Transport (C7)	2.20 (1.83)	−2.52** (1.25)
Communication (C8)	4.87 (4.18)	4.06 (2.73)
Recreation and culture (C9)	0.74 (0.96)	-0.60 (1.05)
Education (C10)	0.14 (6.25)	-0.15 (4.40)
Restaurants and hotels (C11)	4.04*** (1.04)	2.03* (1.07)
Miscellaneous goods and services (C12)	3.40*** (1.25)	2.82*** (0.78)

Notes: Coefficients are expressed in percentage points. The total number of observations for each SDID is 2040. The standard errors are computed by 1000 placebo evaluations (see algorithm 4 in Arkhangelsky et al. (2019)). ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively. More details about the SDID procedure are given in subsection 3.2

Table A7: ECOICOP4 level observed in the micro price database

	Label	ECOICOP4	Weights	Class.
1	Rice	1111	0.13	ND
2	Flours and other cereals	1112	0.29	ND
3	Bread	1113	1.7	ND
4	Other bakery products	1114	1.05	ND
5	Pizza and quiche	1115	0.24	ND
6	Pasta products and couscous	1116	0.16	ND
7	Breakfast cereals	1117	0.15	ND
8	Other cereal products	1118	0.15	ND
9	Beef and veal	1121	0.21	ND
10	Pork	1122	1.42	ND
11	Poultry	1124	0.8	ND
12	Edible offal	1126	0.07	ND
13	Dried, salted or smoked meat	1127	2.23	ND
14	Other meat preparations	1128	0.91	ND
15	Fresh or chilled fish	1131	0.17	ND
16	Frozen fish	1132	0.34	ND
17	Frozen seafood	1134	0.02	ND
18	Dried, smoked or salted fish and seafood	1135	0.55	ND
19	Other preserved or processed fish and seafood-based preparations	1136	0.3	ND
20	Fresh whole milk	1141	0.01	ND
21	Fresh low fat milk	1142	0.57	ND
22	Preserved milk	1143	0.03	ND
23	Yoghurt	1144	0.38	ND
24	Cheese and curd	1145	1.55	ND
25	Other milk products	1146	0.81	ND
26	Eggs	1147	0.43	ND
27	Butter	1151	0.44	ND
28	Margarine and other vegetable fats	1152	0.11	ND
29	Olive oil	1153	0.05	ND
30	Other edible oils	1154	0.4	ND
31	Other edible animal fats	1155	0	ND

32	Fresh or chilled fruit	1161	1.04	ND
33	Dried fruit and nuts	1163	0.25	ND
34	Preserved fruit and fruit-based products	1164	0.01	ND
35	Fresh or chilled vegetables other than potatoes and other tubers	1171	0.96	ND
36	Frozen vegetables other than potatoes and other tubers	1172	0.02	ND
37	Dried vegetables, other preserved or processed vegetables	1173	0.31	ND
38	Crisps	1175	0.1	ND
39	Sugar	1181	0.33	ND
40	Jams, marmalades and honey	1182	0.09	ND
41	Chocolate	1183	0.21	ND
42	Confectionery products	1184	0.74	ND
43	Edible ices and ice cream	1185	0.25	ND
44	Sauces, condiments	1191	0.49	ND
45	Salt, spices and culinary herbs	1192	0.1	ND
46	Baby food	1193	0.1	ND
47	Ready-made meals	1194	0.17	ND
48	Other food products n.e.c.	1199	0.19	ND
49	Coffee	1211	0.83	ND
50	Tea	1212	0.22	ND
51	Cocoa and powdered chocolate	1213	0.02	ND
52	Mineral or spring waters	1221	0.24	ND
53	Soft drinks	1222	0.25	ND
54	Fruit and vegetable juices	1223	0.29	ND
55	Spirits and liqueurs	2111	2.14	ND
56	Alcoholic soft drinks	2112	0.07	ND
57	Wine from grapes	2121	1.04	ND
58	Wine from other fruits	2122	0.12	ND
59	Fortified wines	2123	0.11	ND
60	Lager beer	2131	1.51	ND
61	Cigarettes	2201	3.48	ND
62	Cigars	2202	0	ND
63	Other tobacco products	2203	0.01	ND
64	Clothing materials	3110	0.02	SD
65	Garments for men	3121	1.52	SD

66	Garments for women	3122	2.4	SD
67	Garments for infants (0 to 2 years) and children (3 to 13 years)	3123	0.49	SD
68	Other articles of clothing	3131	0.23	SD
69	Clothing accessories	3132	0.04	SD
70	Cleaning of clothing	3141	0.01	S
71	Repair and hire of clothing	3142	0.01	S
72	Footwear for men	3211	0.68	SD
73	Footwear for women	3212	1.05	SD
74	Footwear for infants and children	3213	0.22	SD
75	Repair and hire of footwear	3220	0.03	S
76	Materials for the maintenance and repair of the dwelling	4310	1.35	ND
77	Services of plumbers	4321	0.09	S
78	Services of painters	4324	0.18	S
79	Other services for maintenance and repair of the dwelling	4329	0.17	S
80	Water supply	4410	0.5	ND
81	Maintenance charges in multi-occupied buildings	4441	0.42	S
82	Liquefied hydrocarbons (butane, propane, etc.)	4522	0.4	ND
83	Liquid fuels	4530	0.02	ND
84	Other solid fuels	4549	1	ND
85	Household furniture	5111	1.61	D
86	Lighting equipment	5113	0.08	D
87	Other furniture and furnishings	5119	0.21	D
88	Carpets and rugs	5121	0.05	D
89	Other floor coverings	5122	0.1	D
90	Furnishing fabrics and curtains	5201	0.05	SD
91	Bed linen	5202	0.19	SD
92	Table linen and bathroom linen	5203	0.07	SD
93	Other household textiles	5209	0.03	SD
94	Refrigerators, freezers and fridge-freezers	5311	0.32	D
95	Clothes washing machines, clothes drying machines and dish washing machines	5312	0.23	D
96	Cookers	5313	0.19	D
97	Heaters, air conditioners	5314	0.1	D
98	Cleaning equipment	5315	0.06	D
99	Food processing appliances	5321	0.18	SD

100	Coffee machines, tea makers and similar appliances	5322	0.09	SD
101	Irons	5323	0.03	SD
102	Toasters and grills	5324	0.02	SD
103	Repair of household appliances	5330	0.03	S
104	Glassware, crystal-ware, ceramic ware and chinaware	5401	0.16	SD
105	Cutlery, flatware and silverware	5402	0.02	SD
106	Non-electric kitchen utensils and articles	5403	0.34	SD
107	Motorised major tools and equipment	5511	0.37	D
108	Non-motorised small tools	5521	0.12	SD
109	Miscellaneous small tool accessories	5522	0.2	SD
110	Cleaning and maintenance products	5611	0.89	ND
111	Other non-durable small household articles	5612	0.44	ND
112	Cleaning services	5622	0.03	S
113	Pharmaceutical products	6110	3.49	ND
114	Pregnancy tests and mechanical contraceptive devices	6121	0.01	ND
115	Other medical products n.e.c.	6129	0.05	ND
116	Corrective eye-glasses and contact lenses	6131	0.16	ND
117	Other therapeutic appliances and equipment	6139	0.14	D
118	Specialist practice	6212	0.39	S
119	Dental services	6220	0.82	S
120	Services of medical analysis laboratories and X-ray centres	6231	0.21	S
121	Other paramedical services	6239	0.32	S
122	Bicycles	7130	0.1	D
123	Spare parts for personal transport equipment	7212	0.66	SD
124	Lubricants	7224	0.07	ND
125	Maintenance and repair of personal transport equipment	7230	1.43	S
126	Hire of garages, parking spaces and personal transport equipment	7241	0.04	S
127	Driving lessons, tests, licences and road worthiness tests	7243	0.18	S
128	Passenger transport by bus and coach	7321	1.28	S
129	Passenger transport by taxi and hired car with driver	7322	0.35	S
130	Fixed telephone equipment	8201	0.01	D
131	Mobile telephone equipment	8202	0.25	D
132	Equipment for the reception, recording and reproduction of sound	9111	0.04	D
133	Equipment for the reception, recording and reproduction of sound and vision	9112	0.45	D

134	Other equipment for the reception, recording and reproduction of sound and picture	9119	0.09	D
135	Cameras	9121	0.08	D
136	Calculators and other information processing equipment	9134	0	D
137	Pre-recorded recording media	9141	0.03	SD
138	Unrecorded recording media	9142	0.01	SD
139	Other recording media	9149	0.08	SD
140	Games and hobbies	9311	0.05	SD
141	Toys and celebration articles	9312	0.32	SD
142	Equipment for sport	9321	0.12	SD
143	Garden products	9331	0.14	ND
144	Plants and flowers	9332	0.54	ND
145	Products for pets	9342	0.34	ND
146	Veterinary and other services for pets	9350	0.05	S
147	Recreational and sporting services — Participation	9412	0.78	S
148	Cinemas, theatres, concerts	9421	0.36	S
149	Museums, libraries, zoological gardens	9422	0.08	S
150	Photographic services	9425	0.05	S
151	Fiction books	9511	0.24	SD
152	Educational text books	9512	0.05	SD
153	Other non-fiction books	9513	0.1	SD
154	Paper products	9541	0.09	ND
155	Other stationery and drawing materials	9549	0.17	ND
156	Education not definable by level	10500	0.35	S
157	Restaurants, cafés and dancing establishments	11111	3.25	S
158	Fast food and take away food services	11112	0.29	S
159	Canteens	11120	1.09	S
160	Hotels, motels, inns and similar accommodation services	11201	0.87	S
161	Hairdressing for men and children	12111	0.1	S
162	Hairdressing for women	12112	0.43	S
163	Personal grooming treatments	12113	0.3	S
164	Electric appliances for personal care	12121	0.02	SD
165	Non-electrical appliances	12131	0.06	ND
166	Articles for personal hygiene and wellness, esoteric products and beauty products	12132	2.05	ND
167	Jewellery	12311	0.2	D

168	Clocks and watches	12312	0.04	D
169	Repair of jewellery, clocks and watches	12313	0.02	S
170	Travel goods	12321	0.36	SD
171	Other personal effects n.e.c.	12329	0.4	SD
172	Funeral services	12703	0.46	S
173	Other fees and services	12704	0.19	S
	Total	-	73.16	-

Notes: The column "Weights" refers to the average ECOICOP4 HICP weights between 2010 and 2018. The column "Class" indicates the classification into "S" = Services, "D" = Durables, "ND" = Non-durables, "SD" = Semi-durables.

Table A8: Flags explaining monthly price changes: labels and occurrences

Flag	Description	Total obs.	Share (%)
1	Product price start recording	264	0.03
AKC	Offer	149 291	14.17
HK	A product of the same quality at the same price appeared	27 808	2.64
YP	Special supply or demand	460	0.04
ISP	Collection sale	808	0.08
KIE	Quantity discount	59	0.01
KK	New price component	11	~ 0
KP	Quality change (between [-70%: -30%] and [+ 30%: + 70%])	38	~ 0
KTK	Another replacement product	129 635	12.31
KTN	Another discount	1 195	0.11
KTP	Other reason	67 400	6.40
MEN	Monthly discount	13 414	1.27
MOK	Tax rates have changed	311	0.03
NEZ	Minor change in quality [-29%: +29%]	2 276	0.22
NIM	A new trading, service or business unit	1	~ 0
NK	New collection	2 137	0.20
PK	New product component	21	~ 0
PSS	Weekend discount	5545	0.05
RGL	Change in regular price	315	0.03
RK	The price was incorrect	589	0.06
RP	The price has actually changed	629 951	59.80
SAV	Weekly discount	26 271	2.49
SEZ	Seasonal discount	200	0.02
SVE	Holiday discount	386	0.04
	Total	1 053 386	100

Notes: These flags are attached to about 20% of the total observations (5 206 684 after cleansing, see section 4 for more details).

Table A9: Decomposition of inflation at the ECOICOP4 level: high frequency and size categories in January 2015

E4	Label	f	f^+	f^-	Δp	Δp^+	Δp^-	π	ω
1134	Frozen seafood	24.24	19.7	4.55	14.24	22.24	-20.42	3.45	0.013
1183	Chocolate	28.42	16.84	11.58	2.63	16.87	-18.08	0.75	0.194
1223	Fruit and vegetable juices	31.74	17.22	14.52	2.91	27.45	-26.18	0.92	0.19
2111	Spirits and liqueurs	26.01	14.84	11.18	3.57	23.07	-22.32	0.93	2.116
2121	Wine from grapes	25.26	13.77	11.49	2.19	28.95	-29.89	0.55	1.439
3141	Cleaning of clothing	30.77	24.36	6.41	5.18	7.74	-4.55	1.59	0.005
3142	Repair and hire of clothing	66.43	44.06	22.38	2.46	6.47	-5.43	1.63	0.016
3220	Repair and hire of footwear	55.05	37.61	17.43	2.54	6.28	-5.54	1.4	0.022
4324	Services of painters	58.14	44.19	13.95	3.41	5.28	-2.5	1.98	0.293
4329	Other services for maintenance and repair of the dwelling	57.14	42.86	14.29	6.26	9.07	-2.17	3.58	0.288
5121	Carpets and rugs	25.93	12.96	12.96	2.73	13.98	-8.51	0.71	0.06
5312	Clothes washing machines, clothes drying machines and dish washing machines	29.55	15.91	13.64	2.68	12.39	-8.65	0.79	0.247
5313	Cookers	26.47	17.16	9.31	4.12	10.92	-8.39	1.09	0.18
5330	Repair of household appliances	60.61	48.48	12.12	6.13	7.95	-1.17	3.71	0.035
6131	Corrective eye-glasses and contact lenses	31.82	18.18	13.64	5.13	13.39	-5.89	1.63	0.177
6139	Other therapeutic appliances and equipment	30.3	19.7	10.61	7.48	21.24	-18.06	2.27	0.161
6220	Dental services	32.36	21.09	11.27	4.18	9.82	-6.37	1.35	0.654
7230	Maintenance and repair of personal transport equipment	28.22	19.8	8.42	3.69	7.58	-5.47	1.04	1.361
7241	Hire of garages, parking spaces and personal transport equipment	54.55	36.36	18.18	5.35	9.81	-3.58	2.92	0.045
7322	Passenger transport by taxi and hired car with driver	55.32	29.79	25.53	7.36	17.32	-4.25	4.07	0.141
9112	Equipment for the reception, recording and reproduction of sound and vision	30.48	19.05	11.43	2.82	13.39	-14.81	0.86	0.685
9121	Cameras	56.1	31.71	24.39	4.37	28.5	-27	2.45	0.082
9149	Other recording media	32.39	19.89	12.5	13.19	32.45	-17.44	4.27	0.123
9332	Plants and flowers	26.32	15.79	10.53	5.16	15.63	-10.54	1.36	0.65
9350	Veterinary and other services for pets	38.3	27.66	10.64	3.02	4.83	-1.69	1.16	0.055
11112	Fast food and take away food services	33.96	24.53	9.43	2.1	5.64	-7.1	0.71	0.304
12111	Hairdressing for men and children	57.14	38.96	18.18	4.49	8.96	-5.08	2.57	0.116
12112	Hairdressing for women	56.34	42.25	14.08	3.02	5.53	-4.5	1.7	0.515
12113	Personal grooming treatments	49.57	35.47	14.1	3.7	8.05	-7.24	1.83	0.371
12132	Articles for personal hygiene and wellness, esoteric products and beauty products	27.64	16.58	11.06	4.89	24.75	-24.9	1.35	1.98
12313	Repair of jewellery, clocks and watches	47.22	38.89	8.33	7.57	10.76	-7.36	3.57	0.013
12703	Funeral services	30.77	23.08	7.69	6.04	8.59	-1.61	1.86	0.793
	Total	-	-	-	-	-	-	-	13.32

Notes: All columns with figures are expressed as a percentage. The ECOICOP4 (E4) categories selected in this table have an average frequency (f) and size (Δp) in January 2015 that is greater than the average frequency and size of all categories on that date. For each ECOICOP4: f is the average frequency of price changes, f^+ is the average frequency of price increases and f^- is the average frequency of price decreases. Δp is the average size of price changes, Δp^+ is the average size of price increases and Δp^- is the average size of price decreases. π is the inflation calculated as $f \times \Delta p$. ω is the weight in the HICP in 2015. All these statistics are computed following the expressions (4), (5) and (6). Of 32, 6 of these categories are "durables", 8 are "non-durables", 17 are "services" and 1 is a "semi-durable".

Table A10: RDiTs January 2015: ECOICOP4 categories significant at 5%, 9 months window

Label	ECOICOP4	β (%)	S.E.	Weights
Breakfast cereals	1117	1.442	0.698	0.133
Pork	1122	-0.812	0.206	1.265
Poultry	1124	-1.265	0.493	0.851
Fresh whole milk	1141	-0.899	0.422	~0
Fresh low fat milk	1142	-2.037	0.787	0.647
Preserved milk	1143	-2.157	0.636	0.031
Yoghurt	1144	1.555	0.522	0.342
Cheese and curd	1145	-1.357	0.293	1.637
Other milk products	1146	-1.597	0.262	0.833
Butter	1151	-2.447	0.596	0.416
Olive oil	1153	4.956	1.256	0.054
Fresh or chilled fruit	1161	-2.773	0.827	0.936
Fresh or chilled vegetables other than potatoes and other tubers	1171	3.134	1.527	1.254
Frozen vegetables other than potatoes and other tubers	1172	-3.271	1.259	0.022
Dried vegetables, other preserved or processed vegetables	1173	-1.441	0.384	0.403
Crisps	1175	-3.459	1.097	0.09
Jams, marmalades and honey	1182	-1.532	0.664	0.084
Chocolate	1183	-2.16	0.727	0.194
Baby food	1193	-0.862	0.395	0.085
Coffee	1211	-5.595	0.752	0.828
Fruit and vegetable juices	1223	-1.858	0.591	0.19
Spirits and liqueurs	2111	-0.917	0.195	2.116
Wine from grapes	2121	-1.302	0.34	1.439
Wine from other fruits	2122	-2.272	0.768	0.105
Fortified wines	2123	-2.458	0.536	0.16
Lager beer	2131	-1.52	0.273	1.984
Cigarettes	2201	-1.889	0.138	2.529
Garments for men	3121	-1.712	0.558	1.506
Garments for women	3122	-3.455	0.525	2.327
Services of plumbers	4321	-4.222	1.337	0.094
Services of painters	4324	1.997	0.869	0.293

Other services for maintenance and repair of the dwelling	4329	3.112	0.991	0.288
Heaters, air conditioners	5314	-3.449	1.554	0.119
Cleaning and maintenance products	5611	1.236	0.442	0.826
Pharmaceutical products	6110	-0.354	0.153	3.954
Corrective eye-glasses and contact lenses	6131	1.827	0.863	0.177
Maintenance and repair of personal transport equipment	7230	1.086	0.552	1.361
Passenger transport by bus and coach	7321	-0.861	0.221	1.109
Fixed telephone equipment	8201	-5.03	1.703	0.005
Other recording media	9149	6.267	1.252	0.123
Plants and flowers	9332	4.835	0.958	0.65
Museums, libraries, zoological gardens	9422	-3.932	1.821	0.021
Other stationery and drawing materials	9549	1.426	0.578	0.218
Restaurants, cafés and dancing establishments	11111	-0.788	0.206	2.235
Fast food and take away food services	11112	1.226	0.547	0.304
Articles for personal hygiene and wellness, esoteric products and beauty products	12132	-0.703	0.285	1.98
Repair of jewellery, clocks and watches	12313	4.302	1.343	0.013
Travel goods	12321	-3.757	1.068	0.552
Funeral services	12703	2.908	0.994	0.793
Total				37.576

Notes: The column "Weights" refers to the ECOICOP4 HICP weights of 2015. The column "S.E." robust standard errors. The model, data and assumptions are detailed in the subsection 4.4.

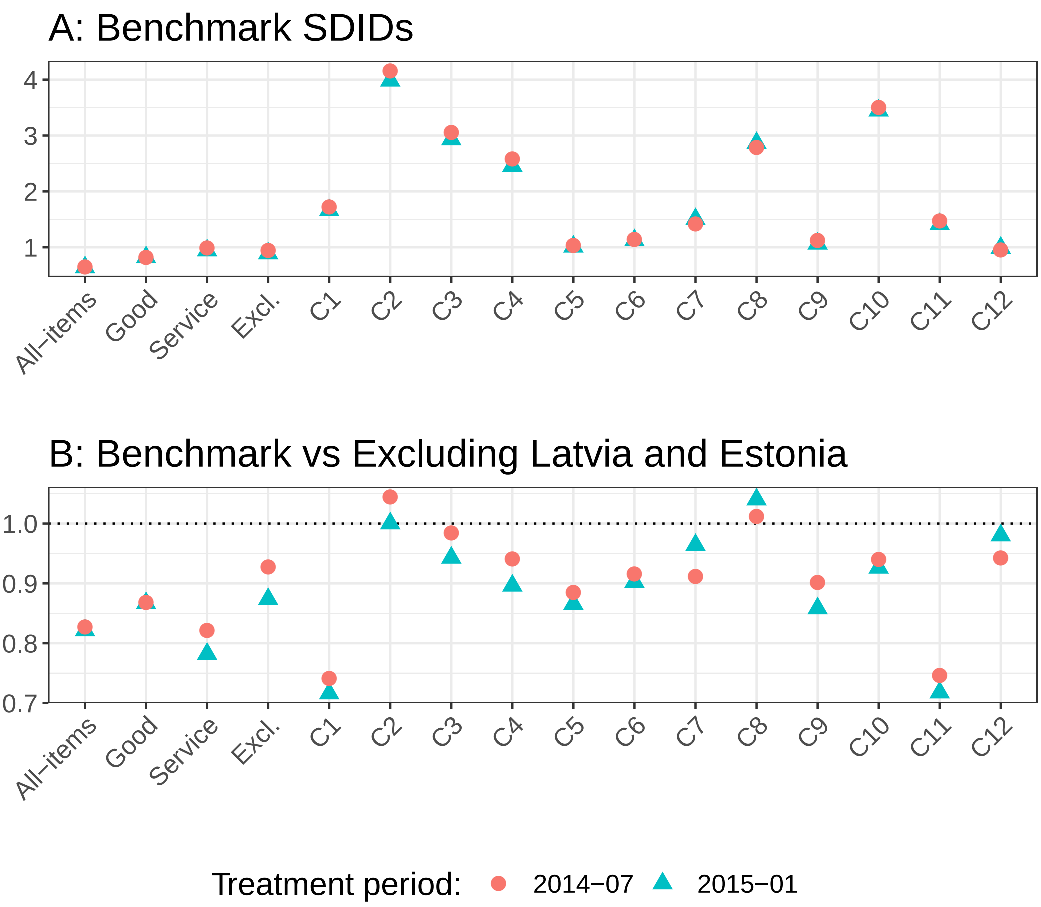
Table A11: RDiTs January 2015: ECOICOP4 categories significant at 5%, 6 months window

Label	ECOICOP4	β (%)	S.E.	Weights
Breakfast cereals	1117	3.282	0.873	0.133
Dried, smoked or salted fish and seafood	1135	-1.185	0.598	0.427
Preserved milk	1143	-1.624	0.745	0.031
Other milk products	1146	-1.204	0.329	0.833
Butter	1151	-1.557	0.772	0.416
Other edible animal fats	1155	1.639	0.745	0.002
Fresh or chilled fruit	1161	-7.435	1.051	0.936
Fresh or chilled vegetables other than potatoes and other tubers	1171	-13.775	1.703	1.254
Crisps	1175	-3	1.421	0.09
Confectionery products	1184	-1.889	0.613	0.674
Coffee	1211	-3.23	0.954	0.828
Soft drinks	1222	-1.924	0.585	0.181
Fruit and vegetable juices	1223	-1.938	0.781	0.19
Spirits and liqueurs	2111	-1.408	0.257	2.116
Wine from grapes	2121	-1.415	0.459	1.439
Lager beer	2131	-2.229	0.36	1.984
Cigarettes	2201	-0.473	0.18	2.529
Garments for men	3121	-2.622	0.706	1.506
Garments for women	3122	-3.729	0.655	2.327
Garments for infants (0 to 2 years) and children (3 to 13 years)	3123	-1.334	0.583	0.511
Footwear for men	3211	-3.279	1.141	0.675
Footwear for women	3212	-4.334	1.425	1.069
Footwear for infants and children	3213	-2.607	1.29	0.215
Other services for maintenance and repair of the dwelling	4329	3.309	1.204	0.288
Coffee machines, tea makers and similar appliances	5322	-4.582	2.012	0.136
Repair of household appliances	5330	3.198	1.382	0.035
Pharmaceutical products	6110	-0.626	0.193	3.954
Other paramedical services	6239	1.801	0.847	0.329
Other recording media	9149	4.304	1.559	0.123
Veterinary and other services for pets	9350	1.282	0.616	0.055
Recreational and sporting services — Participation	9412	-1.714	0.566	0.863

Travel goods	12321	-3.123	1.253	0.552
Total				26.701

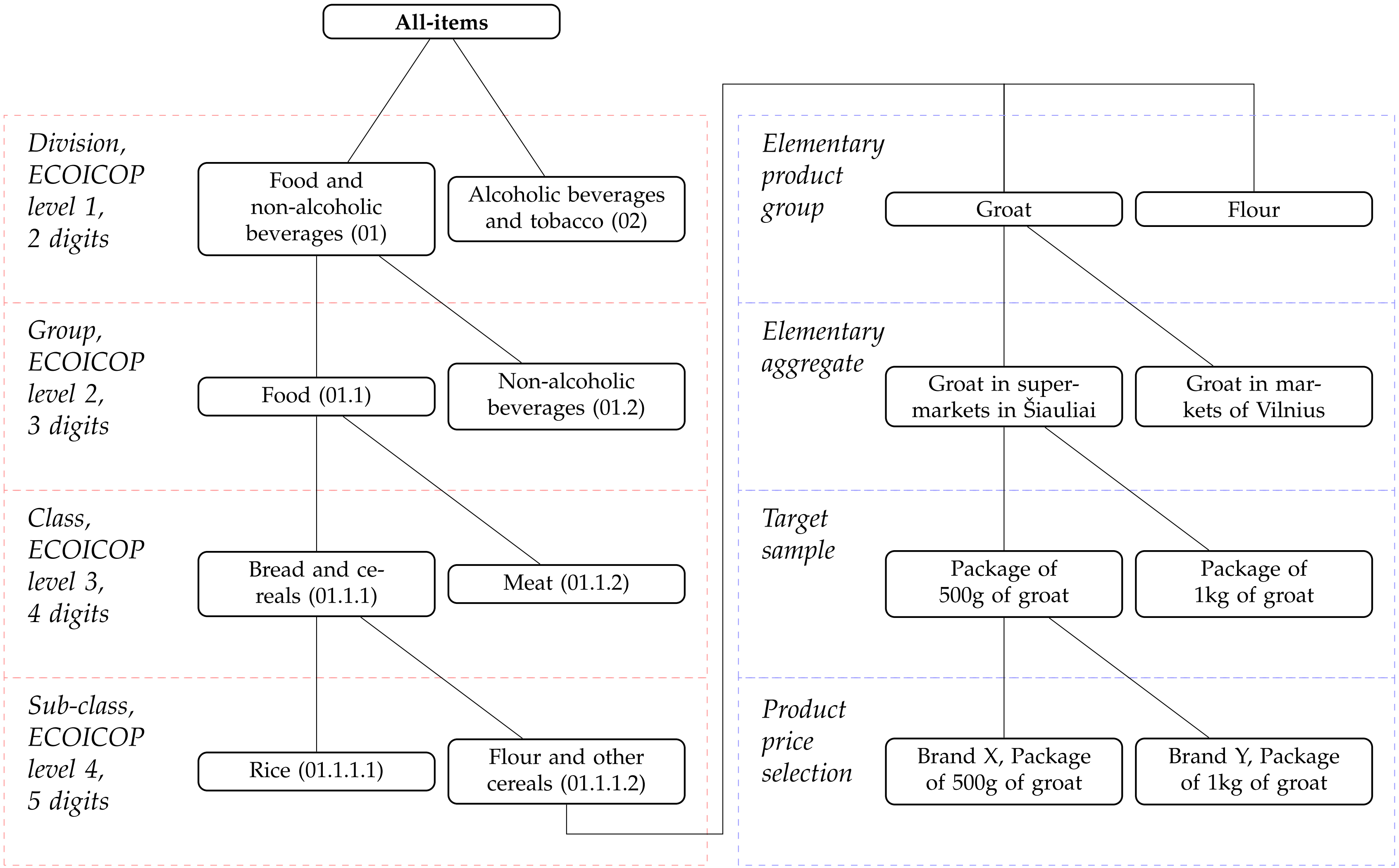
Notes: The column "Weights" refers to the ECOICOP4 HICP weights of 2015. The column "S.E." robust standard errors. The model, data and assumptions are detailed in the subsection 4.4.

Figure B1: Regularized RMSEs



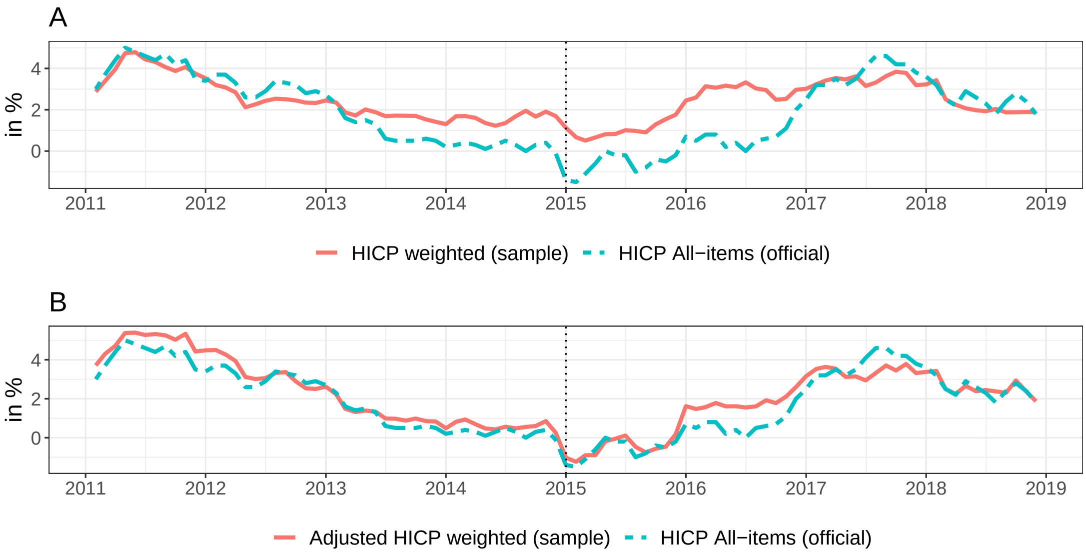
Notes: Panel A shows the pairwise sum of the regularized RMSE of the two Frank-Wolfe algorithms related to the benchmark SDIDs summarized in Tables 1 and 2. Panel B gives the ratio of the regularized RMSEs of the benchmark SDID to those excluding Latvia and Estonia from the pool (Tables A5 and A6). A value less than 1 implies that the RMSEs of the former are lower than those of the latter. "Good" refers to the HICP category entitled "Goods (Overall index excluding services)", "Service" refers to the HICP category entitled "Services (Overall index excluding goods)". "Excl." refers to the HICP category entitled "Overall index excluding energy, food, alcohol and tobacco". More details about the SDID procedure are given in subsection 3.2.

Figure B2: Classification of "groat" by ECOICOP, HICP methodology



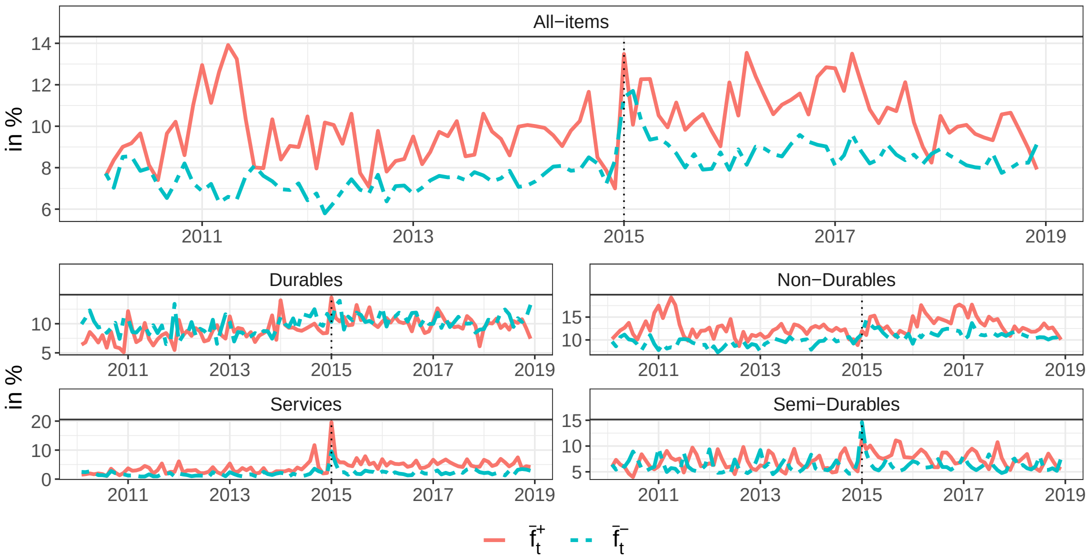
Notes: This tree represents the categorization of "groat" at all levels of the ECOICOP classification according to the HICP methodology. If a level is surrounded in red, the weighting and the price index are public. Beyond that, in blue, the classification is confidential and specific to each country. More information on the complete classification of HICP in ECOICOP categories can be found on the Eurostat nomenclature website: https://ec.europa.eu/eurostat/ramon

Figure B3: Year-over-year monthly HICP inflation rates: sample and official



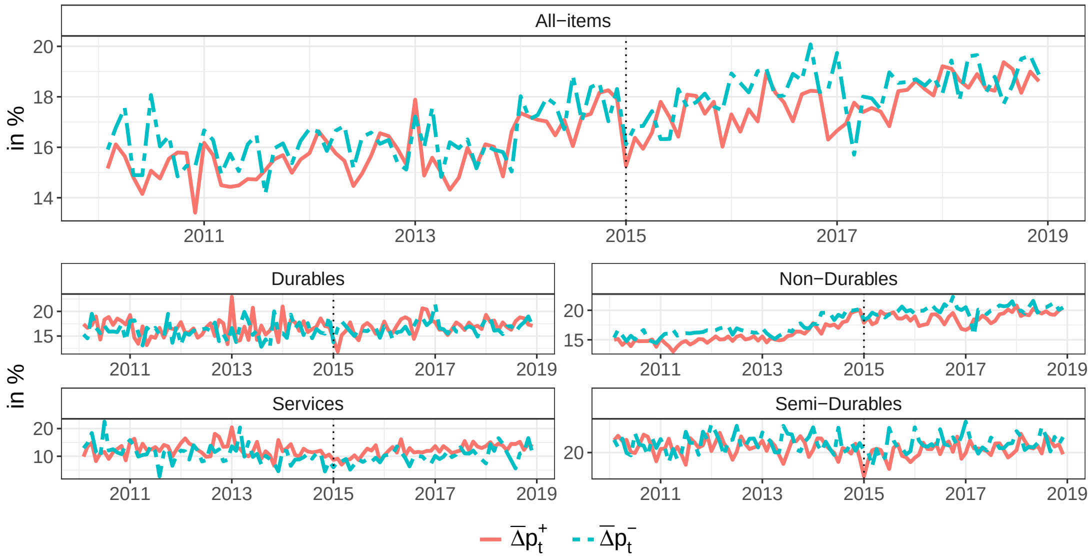
Notes: "Adjusted HICP weighted (sample)" means that I add to the observations the official y-o-y monthly rate of change of electricity (04510), heat energy (04550), diesel (07221) and petrol (07222). In panel A the benchmark coverage of the HICP ECOICOP4 weights is about 73%, while in panel B it is roughly 84%. The differences from the official rates are therefore due to computation methods and to missing observations. The official series is obtained from Eurostat.

Figure B4: Weighted average frequency of price increases and decreases



Notes: The average frequency of price increases (red solid lines) is calculated in two steps: 1) $f_{jt}^+ = \frac{1}{N_{jt}} \sum_n^{N_{jt}} I_{njt}^+$ for n items and j ECOICOP4 categories. I_{njt}^+ are price increase indicators; i.e. $I_{njt}^+ = 1$ if $p_{njt} > p_{njt-1}$, and 0 otherwise. 2) $\bar{f}_t^+ = \sum_j^J \omega_{jt} f_{jt}^+$. The average frequency of price decreases (blue dashed lines) is computed in two steps: 1) $f_{jt}^- = \frac{1}{N_{jt}} \sum_n^{N_{jt}} I_{njt}^-$ where I_{njt}^- are price decrease indicators; i.e. $I_{njt}^- = 1$ if $p_{njt} < p_{njt-1}$, and 0 otherwise. 2) $\bar{f}_t^- = \sum_j^J \omega_{jt} f_{jt}^-$.

Figure B5: Weighted average size of price increases and decreases

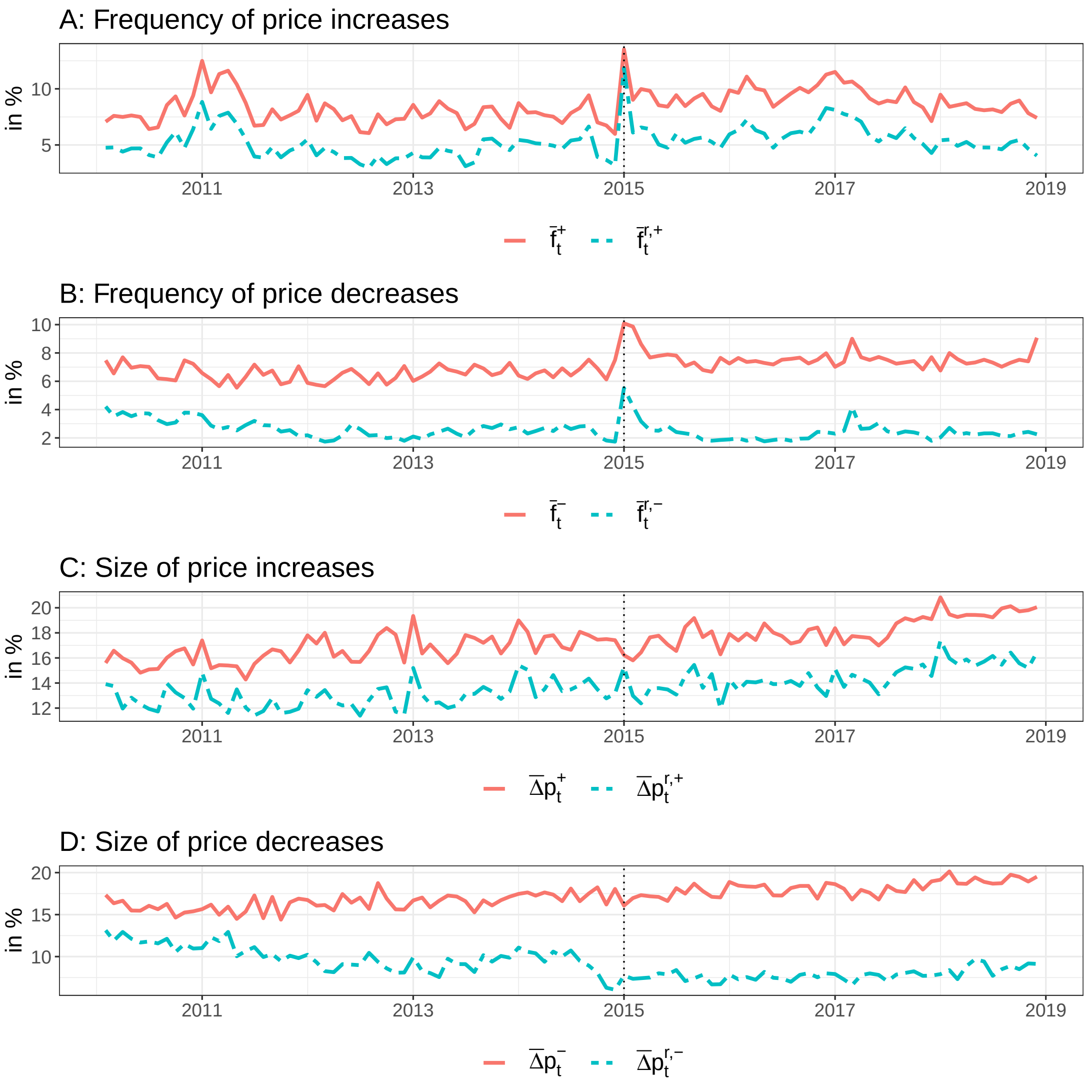


Notes: The average size of price increases (red solid lines) is calculated in two steps: 1) $\Delta p_{jt}^+ = \frac{1}{N_{jt}} \sum_n^{N_{jt}^+} (p_{njt} - p_{njt-1})^+ / f_{jt}^+$ for n items and j ECOICOP4 categories. f_{jt}^+ is computed in (5). 2) $\bar{\Delta} p_t^+ = \sum_j^J \omega_{jt} \Delta p_{jt}^+$. The average size of price decreases (blue dashed lines) is computed in two steps: 1) $\Delta p_{jt}^- = \frac{1}{N_{jt}} \sum_n^{N_{jt}^-} (|p_{njt} - p_{njt-1}|)^- / f_{jt}^-$. 2) $\bar{\Delta} p_t^- = \sum_j^J \omega_{jt} \Delta p_{jt}^-$.

Figure B6: Benchmark and "regular" all-items inflation (unweighted) series decomposed

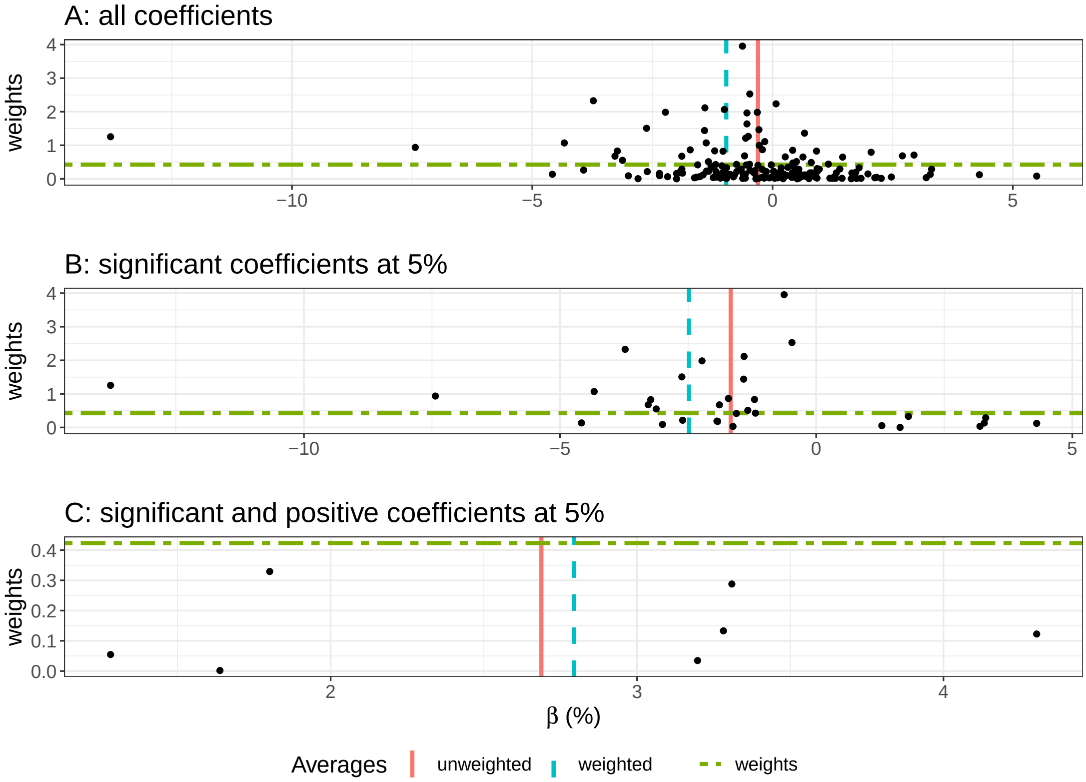
Notes: The "regular" series are calculated using the flags provided by the statistical institute (see more details in subsection 4.1). All statistics for benchmark series are represented by red solid lines and those for "regular" series by blue dashed lines (as well as the superscript "r" in the statistics). For each type of series, inflation is decomposed as follows: The average frequency of price changes is calculated in two steps: 1) $f_{jt} = \frac{1}{N_{jt}} \sum_n^{N_{jt}} I_{njt}$ for n items and j ECOICOP4 categories. I_{njt} are price changes indicators; i.e. $I_{njt} = 1$ if $p_{njt} \neq p_{njt-1}$, and 0 otherwise. 2) $\bar{f}_t = \frac{1}{J} \sum_j^J f_{jt}$. The average size of price changes is computed in two steps: 1) $\Delta p_{jt} = \left(\frac{1}{N_{jt}} \sum_n^{N_{jt}} (p_{njt} - p_{njt-1}) \right) / \left(\frac{1}{N_{jt}} \sum_n^{N_{jt}} I_{njt} \right)$. 2) $\bar{\Delta} p_t = \frac{1}{J} \sum_j^J \Delta p_{jt}$. Note that by definition $\bar{\pi}_t = \bar{f}_t \times \bar{\Delta} p_t$, however, the product of the aggregated average frequency and size may differ from the aggregated inflation due to the covariance term.

Figure B7: Benchmark and "regular" all-items inflation (unweighted) series decomposed, 2



Notes: The "regular" series are calculated using the flags provided by the statistical institute (see more details in the subsection 4.1). All statistics for benchmark series are represented by red solid lines and those for "regular" series by blue dashed lines (as well as the superscript "r" in the statistics). For each type of series, inflation is decomposed as follows: The aggregate frequency of price increases is calculated in two steps: 1) $f^+_{jt} = \frac{1}{N_{jt}} \sum_n^{N_{jt}} I^+_{njt}$ for n items and j ECOICOP4 categories. I^+_{njt} are price increase indicators; i.e. $I^+_{njt} = 1$ if $p_{njt} > p_{njt-1}$, and 0 otherwise. 2) $\bar{f}^+_t = \frac{1}{J} \sum_j^J f^+_{jt}$. The aggregate frequency of price decreases is computed in two steps: 1) $f^-_{jt} = \frac{1}{N_{jt}} \sum_n^{N_{jt}} I^-_{njt}$ where I^-_{njt} are price decrease indicators; i.e. $I^-_{njt} = 1$ if $p_{njt} < p_{njt-1}$, and 0 otherwise. 2) $\bar{f}^-_t = \frac{1}{J} \sum_j^J f^-_{jt}$. The aggregate size of price increases is calculated in two steps: 1) $\Delta p^+_{jt} = \frac{1}{N_{jt}} \sum_n^{N^+_{jt}} (p_{njt} - p_{njt-1})^+ \,/\, f^+_{jt}$ for n items and j ECOICOP4 categories. f^+_{jt} is computed in (5). 2) $\bar{\Delta} p^+_t = \frac{1}{J} \sum_j^J \Delta p^+_{jt}$. The aggregate size of price decreases is computed in two steps: 1) $\Delta p^-_{jt} = \frac{1}{N_{jt}} \sum_n^{N^-_{jt}} (|p_{njt} - p_{njt-1}|)^- \,/\, f^-_{jt}$. 2) $\bar{\Delta} p^-_t = \frac{1}{J} \sum_j^J \Delta p^-_{jt}$.

Figure B8: RDiT January 2015: 6 months window



Notes: The black dots represent the average treatment effect β in the equation (9) for each regression at the ECOICOP4 level. The time window is 6 months, the trend is linear and the threshold τ is fixed at January 2015. The vertical lines represent the averages of these coefficients, either unweighted (red solid lines) or weighted by the HICP 2015 weights (blue dotted lines). The green dashed lines show the average HICP weight in 2015. The pvalues that determine the significance of the coefficients are computed with robust standard errors.