18 July 2023

Summary of the key findings of the Price-setting Microdata Analysis (PRISMA) Research Network

1. Introduction

The ESCB General Council established the PRISMA Research Network in December 2018 with the task to collect and analyse micro price data from different sources, and report on its findings after 3 years. The research outcome of the ESCB PRISMA Network is documented in seven Occasional papers (OPs), with contributions by ECB and NCBs staff. Specifically, OP 319 documents key price setting facts in the euro area using a large dataset of micro prices underlying the HICP until 2019, while OP 321 draws implications of these facts for inflation dynamics and monetary policy transmission; OP 322 discusses normative consequences of micro heterogeneity for the level of the inflation objective. The remaining papers leverage the different micro dataset available to PRISMA to investigate a broad range of topics of relevance for central banks, including: properties of e-commerce and online prices in some specific sectors and countries in Europe (OP 320); a follow-up on analytical questions on inflation measurement after the strategy review (OP 323); the effects of the pandemic on price setting in 2020/2021 in some European countries (OP 324); household inflation heterogeneity (OP 325). This summary provides highlights from this body of work.

2. Micro price setting facts and implications for inflation dynamics and monetary policy

Inflation is the sum of heterogeneous individual price setting decisions, whose analysis requires micro data. Price adjustment is "lumpy": prices change infrequently, and both price increases and decreases can be large. Infrequent price adjustment is critical for the monetary transmission, as it shapes the speed at which aggregate shocks impact inflation. But in addition to this nominal rigidity, the size of the adjustment, i.e. by how much 'reset' prices adjust, also impacts inflation dynamics. A first aspect is whether price setting is state-dependent, i.e. the prices that change are those in need to adjust the most, since otherwise they would be very misaligned from their target value. In this case price changes can be very large also in response to small aggregate shocks, amplifying the reaction of aggregate inflation even with a relatively low repricing rate. Moreover, non-linearities in the size of aggregate shocks are also possible. A second aspect concerns 'real rigidities', i.e. the responsiveness of target prices to costs. If firms pass-through underlying changes in costs into price changes only partially, 'real rigidities' will slow down inflation dynamics and amplify the effects of infrequent repricing. Obviously, both how often and how much prices change can be gauged only with micro data. Likewise, micro data are necessary to investigate how

individual firms pass-through their costs into prices. The ESCB Inflation Persistence Network (IPN) pioneered studies of micro prices already in the early 2000s.[1]

PRISMA has updated and extended the IPN work in several dimensions. The micro data collected by PRISMA comprise 135 million price quotes underlying the HICP in 11 countries from 2010 to 2019, encompassing 166 categories of the euro area HICP (60% of products), a much larger share than the IPN 50 categories. PRISMA also reports and uses new price setting statistics (e.g. the full distribution of the size of price changes, crucial to understand firms' behaviour), and documents their evolution over time. Finally, PRISMA examines how the frequency and size of price changes shape the monetary transmission and inflation dynamics, including in response to demand and supply shocks.[2]

2.1 Price setting facts in the euro area in the low inflation period

The following five facts on price setting emerge in the 2010-19 period in the euro area.

i. **The frequency of price changes is low but heterogeneous across 'core' sectors.** On average 12% of consumer prices (ex-energy) change each month, falling to 8.5% when sales prices are excluded (close to the 10% US frequency). The typical non-sale retail price changes only every 12 months, entailing a slow transmission of nominal impulses.[3] The ex-sales repricing rate is lowest in services (6%, 17-month duration), highest in processed food (10%, 10-month duration).

ii. **Price changes are heterogeneous, with both small and large hikes and cuts.** Typical (non-zero) price changes ('reset' prices) are much larger than inflation (even excluding sales): the median increase and decrease stand at around 9% and 12%, respectively. However, price hikes and cuts are very heterogeneous: 14% are smaller than ±2% in absolute value, while around 20% are larger than ±14%. Firm-specific cost and demand shocks are thus more relevant than aggregate shocks for when and how much firms reset their prices.[4]

iii. **Price setting is mildly state-dependent, mainly driven by firm-specific shocks.** Micro data allow to directly measure which prices are more likely to change depending on their misalignment (though these scanner micro data are limited to supermarkets). The probability of price adjustment rises with the size of misalignment, mainly reflecting idiosyncratic shocks, but not very sharply.[5] This direct evidence of a moderate degree of state dependence can still influence the monetary transmission, especially by eliciting nonlinearities in response to

[1] See the IPN webpage: https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_ipn.en.html#:~:text=The%20IPN%20is%20a%20research,and%20in%20its%20member%20countries.

[2] Relative to the IPN, PRISMA work has also studied the role of sales prices in inflation dynamics, given their short-run volatility seemingly unrelated to aggregate factors. However, PRISMA has enjoyed a more limited access to PPI micro data than the IPN.

[3] A simple back of the envelope calculation would imply that a 1% increase in nominal costs of all firms would lead to 0.65% inflation over the next 12 months.

[4] The PPI micro data available to PRISMA show that producer price changes are more frequent and smaller than consumer prices, in line with previous IPN findings (see OP 319).

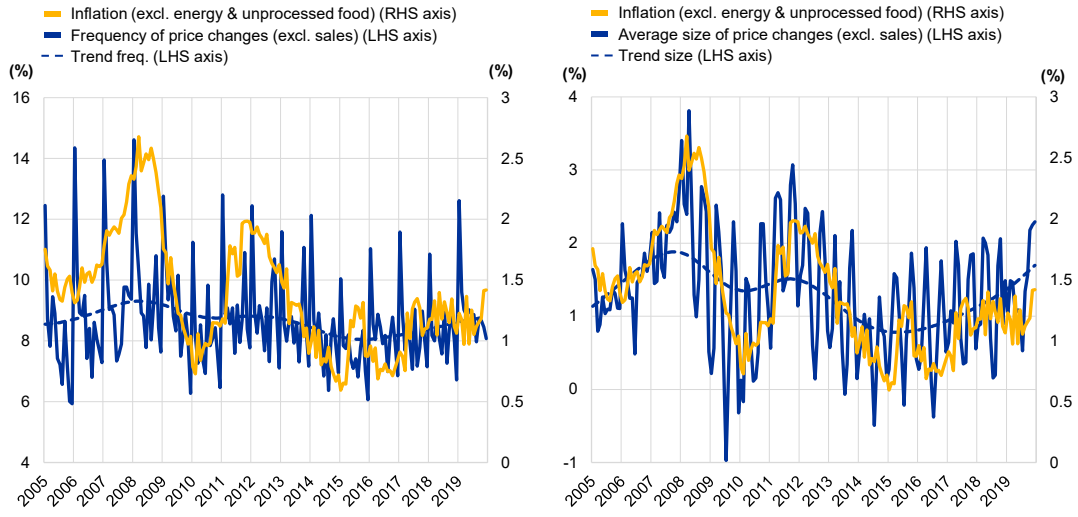
[5] Misalignment is measured as distance from 'reset' prices of exactly the same product in neighbouring stores (see OP 319).

variations in trend inflation or large cost shocks. In the current volatile environment, more frequent and larger price changes are likely to occur than suggested by historical regularities.

iv. **The repricing rate showed no trend in 2005-19 but was mildly volatile in the short run.** Despite several possible structural influences, the repricing rate shows little sign of a downward or upward trend during the low inflation period.[6] However, it does vary over time (1st column of Chart 1). First, it is seasonal, as price increases are more frequent in January.[7] Second, it is somewhat cyclical, as it was around 1pp higher in 2008-09 and 1pp lower in 2014-17.

v. **Cyclical inflation variation was due to fluctuations in the average size of price changes.** The small cyclical variation in frequency did not contribute much to fluctuations in aggregate inflation, which instead mainly reflected shifts in the average size of price changes (2nd columns of Chart 1). Consistent with idiosyncratic shocks as the main driver of price changes during the low inflation period, aggregate disturbances affected inflation by shifting the relative number of firms increasing or decreasing their prices, rather than the size of price increases and decreases, or the repricing rate. This 'linear' behaviour of aggregate inflation could change however when aggregate shocks are larger than in the historical experience, because of the above non-linearities in firm-level decisions. For instance, US evidence confirms that in the 1978-82 'Great Inflation' period the repricing rate rose to over 15%.[8]

Chart 1: Inflation vs Frequency and Average Size of Price Changes (Reset prices)



Notes: Calculations by Banque de France staff based on PRISMA CPI micro data.

2.2 Implications for inflation dynamics and monetary policy transmission

PRISMA has analysed the macroeconomic implications of the micro evidence on price setting by estimating the effects of structural demand and supply shocks, and by using simulations from

[6] When comparing the same limited sample of products analysed by the IPN in the period 1996-2001, the repricing rate was at 7.8%, lower than 10.2%.in the 2007-2011 period.

[7] The repricing rate is 4 percentage points higher in January; this can matter for monetary transmission if synchronization of price changes makes them react more to aggregate disturbances.

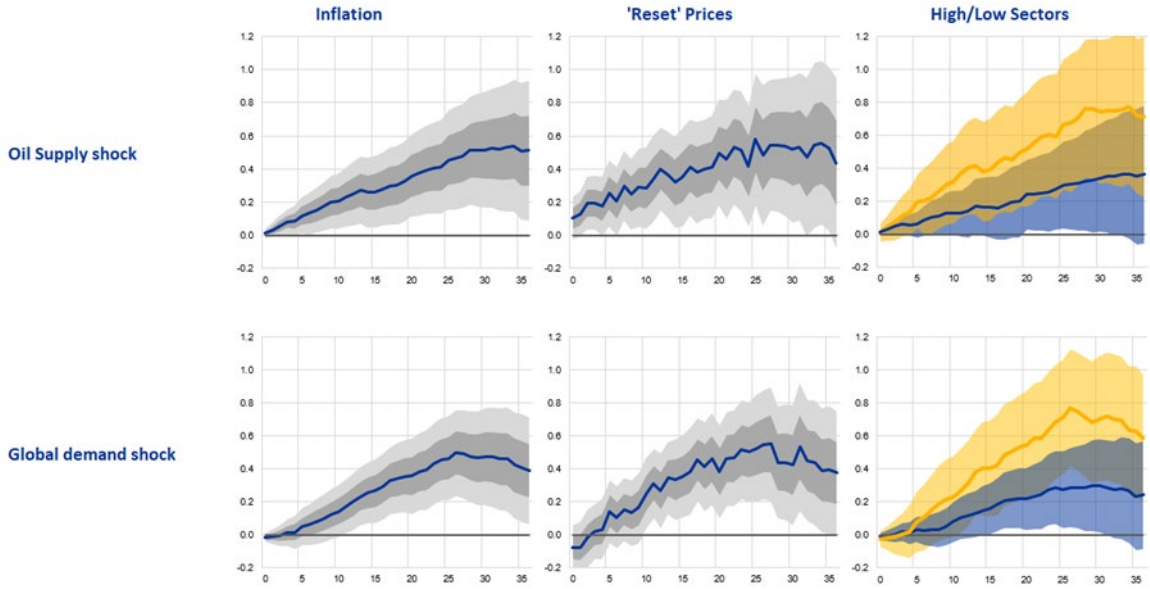
[8] See Nakamura, E., J. Steinsson, P. Sun and D. Villar, "The Elusive Costs of Inflation: Price Dispersion during the U.S. Great Inflation", Quarterly Journal of Economics, November 2018, Pages 1933–1980.

models calibrated to match price setting in micro data. First, estimation of the response of micro prices to structural shocks can help to identify which margins of price adjustment matter for the inflationary consequences of aggregate shocks in the data. Second, the micro price evidence can be used to derive implications for the monetary policy transmission mechanism through the lens of state-of-the-art price-setting models, which feature state dependence in the decision to revise prices.

Consistent with infrequent price changes, inflation has responded slowly to aggregate shocks during the low inflation period. In line with Chart 1, the repricing rate did not significantly respond to inflationary (oil) supply and demand shocks, nor monetary policy shocks.[9] Inflation dynamics (1st column of Chart 2), was driven by adjustment in the average size of price changes ('reset' prices, 2nd column of Chart 2), at the typically slow repricing rate prevailing in the period.[10]

Faster responses in sectors with high vs low repricing rates confirm that nominal rigidities matter for inflation dynamics. For oil supply shocks, the response of food prices was faster and larger than in services, in line with differences in their repricing rates (3rd column of Chart 2, high frequency in yellow).

Chart 2: Inflation Effects of Shocks to Oil Supply and Global Demand



Notes: Calculations by Eurosystem staff. Light grey areas: 2 standard deviation confidence intervals; dark grey areas: 1 standard deviation confidence interval. In high/low sector column, the yellow (blue) line is the inflation response of high (low) frequency sectors; the shaded area is the 2 standard deviation confidence intervals. Percentage points on y-axis, months after the shocks on x-axis.

The slow short-run inflation response to aggregate shocks was due not only to nominal rigidities, but also a subdued reaction of reset prices, in line with a significant role of real rigidities. Reset prices (based on non-zero micro price changes) did not react much in the aftermath of the above shocks, contributing to the slow inflation response due to infrequent repricing. Reset prices took up to two years to fully react to either shock (2nd column of Chart 2). Adjustment in reset prices reflects channels linking firm-

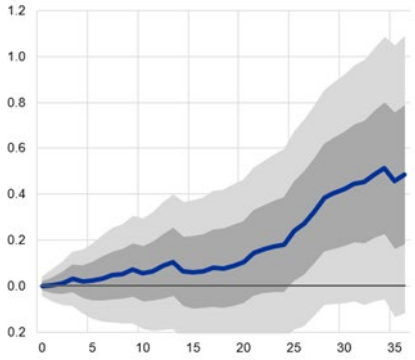
[9] To deliver the same inflation response, the oil shock is set to decrease the global supply of oil (by 1%) and increase its price, while the global demand shock is set to increase the demand for oil also increasing its price. See OP 321 for details about the results in this section.

[10] Aggregate inflation in this exercise is constructed at country-COICOP5-sector level, using the frequency and size of price changes computed from microdata. Specifically, inflation from time t-1 to time t for a given COICOP5 sector in a given country is obtained multiplying the corresponding frequency of price changes times the corresponding average size of (non-zero) price changes.

level marginal costs and their target prices, such as the desired level of markups, and second-round effects connecting marginal costs and macroeconomic conditions, such as how (un)employment influences wages. The response of reset prices provides direct evidence of how these 'real rigidities' affected shock propagation in addition to nominal rigidities.[11]

Prices dynamics are more persistent in response to inflationary than disinflationary oil supply shocks. Chart 3 shows the difference in the (absolute value of) price responses to an inflationary and disinflationary oil supply shock. This difference is positive and increasing, becoming statistically significant after 24 months. The asymmetry to inflationary oil supply shocks is due to more persistent responses of reset prices, suggesting that the latter's underlying drivers can be a source of asymmetries and non-linearities in addition to state dependence.

Chart 3: Difference in Absolute Price Effects of Inflationary and Disinflationary Oil Supply Shocks



Notes: Calculations by ECB staff. Light grey areas: 2 standard deviation confidence intervals; dark grey areas: 1 standard deviation confidence interval. Percentage points on y-axis; months after the shock on x-axis.

Nominal and real rigidities contributed to a relatively flat Phillips curve in the low inflation period, in line with previous estimates for the euro area. Empirical estimates based on the global demand shock confirm previous findings of a relatively inelastic but stable link between core inflation and unemployment in the euro area during the low inflation period.

According to models calibrated to match the micro price evidence, shifts in trend inflation above 5-6% would materially raise the slope of the euro area Phillips curve. Shifts in trend inflation between zero and 5-6% would have small effects on the Phillips curve. However, non-linearities in price setting implied by the degree of state dependence prevailing in the low inflation period entail that in model simulations increases in trend inflation (and thus in firms' long-run inflation expectations) above 5-6% would materially raise the repricing rate and the slope of model-based Phillips curves.

Similarly, large shocks to nominal costs have non-linear effects on inflation dynamics in the calibrated models. Consistent with the fluctuations in the repricing rate observed in the data, e.g. in 2008-09, non-linearities in price setting imply that in the model-based simulations nominal shocks affect the repricing rate, the more so the larger their size. But these cost shocks have to be larger than 15% for non-linearities to significantly accelerate simulated inflation dynamics in their aftermath.[12] Given the relatively

[11] A few studies within the PRISMA network have investigated specific channels through which real rigidities may affect price adjustment (see OP 321). It is worthwhile to stress that the level at which reset prices converge after oil supply shocks reflects also the latter's broader impact, e.g. on disposable incomes.

[12] Recall from Section 2.1 above that only around 10% of all price increases are above 15%.

stable environment in the period for which micro data have been available, there is little direct evidence on the empirical values of the shock thresholds, which remain an open question.

Since 2022, due to the supply chain disruptions caused by the coronavirus (COVID-19) pandemic and the major shocks caused by the Ukraine war, inflation has risen sharply in all euro area countries. This period of more volatile and higher inflation allows to investigate further the presence of non-linearities in repricing rates and to understand better the transmission of such large shocks to inflation.

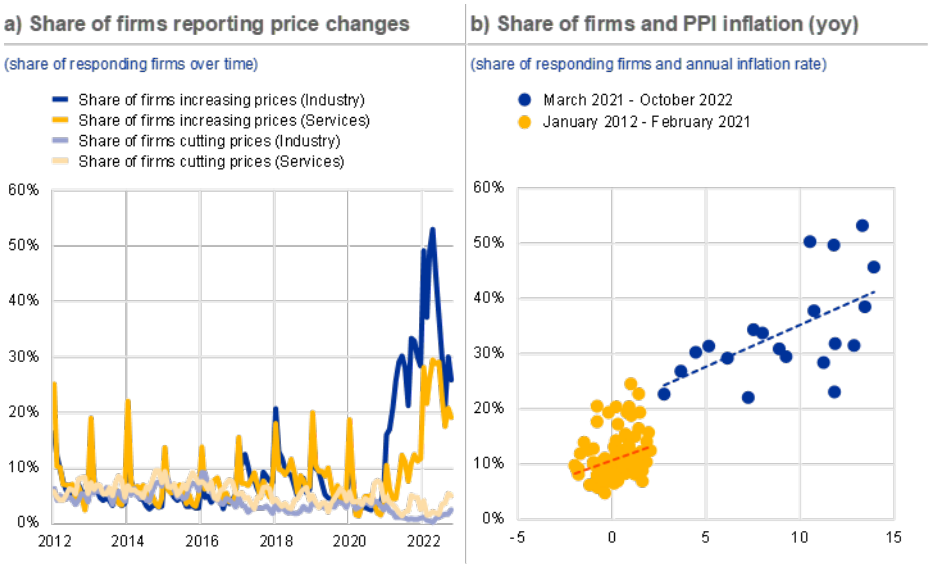
However, more recent micro price data underlying HICPs and producer price indices (PPI) in the euro area countries have not been available to PRISMA. Various alternative data sources and previous findings from the academic literature documenting pricing patterns in a period of high and more volatile inflation allow to investigate how features of price adjustments change with higher inflation.[13] A few papers have documented the features of price adjustment in the mid-1970s and 1980s, when inflation was high and more volatile. Overall, when trend inflation is higher than 5%, the correlation between frequency and inflation becomes stronger in the data.[14]

Firm-level business surveys could provide timely information on the frequency of price adjustment in 2022. For example, every month, Banque de France collects qualitative information from business leaders about their price decisions. This survey is conducted among several thousands of firms of all sizes, in the manufacturing sector and also in business-to-business services. Chart 4 below shows the evolution of the frequency of firms reporting price increases and decreases in the period 2012-22. In the low-inflation period, the overall frequency of firms reporting price changes was broadly constant, while the frequencies of price increases and price decreases moved in opposite directions, consistent with the findings in OP 319 for both CPI and PPI microdata. Since inflation was higher and more volatile in late 2021 and early 2022, the share of firms reporting price changes has been steadily rising across all sectors, including services. The peak frequency of firms changing prices in April 2022 was close to 50% in the manufacturing sector and 30% in business services, ranging between 10% and 15% in the period 2012-21 (compared with an average monthly frequency of price changes in the French PPI of around 27%). This increase in the frequency of price changes by firms is mainly driven by a sharp rise in price increase frequency. Overall, in the manufacturing sector, the frequency of price changes moves more closely in line with inflation when PPI inflation is higher than 4% to 5%.

[13] For the period 2020-21, OP 324 also provide detailed evidence on how large economic shocks induced by the COVID-19 period have affected pricing patterns in several euro area countries.

[14] In addition to Nakamura et al. (2018) for the US, there is evidence that also in Norway the frequency of price adjustment correlates much more strongly with inflation when the inflation rate is high and more volatile than when inflation is low and relatively stable (Wulfsberg, F. (2016), "Inflation and Price Adjustment, Evidence from Norwegian Consumer Price Data 1975–2004", American Economic Journal: Macroeconomics, Vol. 8, pp. 175-194). Results from other countries during periods of hyperinflation corroborate these findings (see Alvarez, F., Beraja, M., Gonzalez-Rozada, M. and Neumeyer, A. (2018), "From Hyperinflation to Stable Prices: Argentina's Evidence on Menu Cost Models", Quarterly Journal of Economics, Vol. 134, No 1, pp. 451-505 Gagnon, E. (2009), "Price Setting under Low and High Inflation: Evidence from Mexico", Quarterly Journal of Economics, Vol. 124, pp. 1221-1263).

Chart 4: Share of firms changing their prices in French business survey and PPI inflation



Notes: Calculations by ECB staff. Light grey areas: 2 standard deviation confidence intervals; dark grey areas: 1 standard deviation confidence interval. Percentage points on y-axis; months after the shock on x-axis.

2.3 Micro price heterogeneity and the optimal inflation target

A well-known normative implication of nominal rigidities according to benchmark models is that the optimal level of inflation in the long run should be close to zero. Zero long-run inflation is optimal as it minimizes relative price distortions and welfare costs due to infrequent price adjustment in benchmark macro models. However, these models neglect other factors than nominal rigidities underlying price dispersion, such as the presence of product lifecycles and their effect on relative product prices.

Micro data from France, Germany and Italy for 2015-2019 show that declining trends in relative prices over product lifetime, as well as infrequent price changes, are a key feature of euro area consumer prices. When accounting for product lifecycles, the optimal inflation rate minimizing relative price distortions with nominal price rigidities should be significantly higher than zero. A positive inflation rate results in a decline in relative prices when newly entering products charge a higher (but afterwards constant) price than the average existing products, whose nominal prices do not adjust over time. This way, relative prices fall because entering product prices keep rising over time: there is positive inflation. A positive average rate of inflation thus helps implementing an efficient decline in relative prices over the product lifetime, without requiring undesirable adjustments in the sticky prices of individual goods.

Accounting for product-level relative price trends, estimates of the optimal inflation rate that minimizes relative price distortions range between 1.1% and 1.7% for a weighted average across France, Germany and Italy. The optimal inflation rate equals the weighted average of the (negative) of the different rates of relative price declines estimated across sectors, mainly driven by non-energy industrial goods.

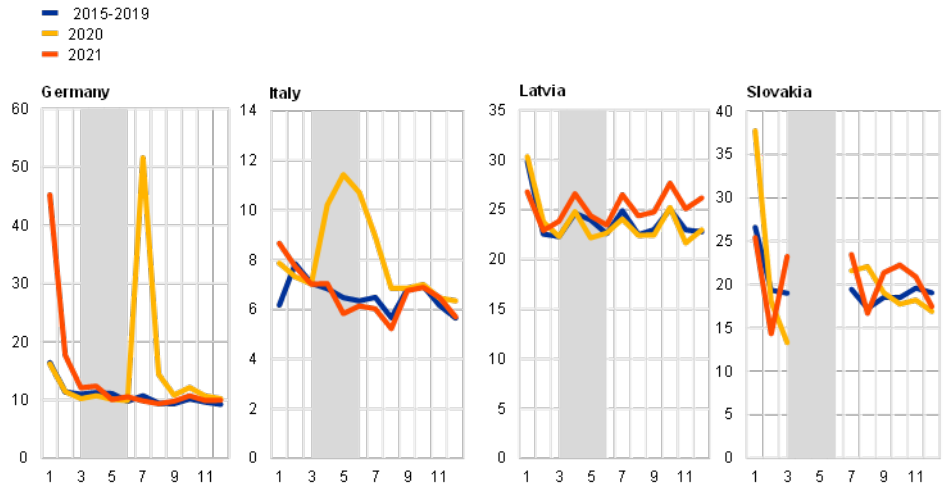
These results abstract from other important factors that may influence the optimal inflation objective, such as the presence of an effective lower bound on the nominal interest rate. The ECB

strategy review discussed several of these factors in addition to the ELB constraint, including e.g. the presence of downward rigidities in nominal wages.[15] However, it remains non-trivial to quantify the exact contribution of these additional factors over and beyond the contribution from lifecycle trends in relative product prices in making the optimal inflation rate higher than previously thought.

3. Price setting during the Covid-19 pandemic: Evidence from some sectors and countries

Price setting in the pandemic year 2020 was analysed using several micro data sources for specific countries and sectors. Against the background of the economic impact of the COVID pandemic and the associated containment measures, OP 324 focuses on the price-setting effects of the large and unforeseen COVID shock in 2020 (due to data availability, which indeed also posed severe challenges for inflation measurement, also analysed in OP 324). The analysis is based on three different but complementary micro data sources: micro price data underlying the official CPI in Germany, Italy, Latvia and Slovakia; (scanner) data from German and Italian supermarkets, online (web scraped) prices for Poland. The pandemic impacted countries and sectors differently, e.g. bringing about a sharp increase in the demand for supermarket goods and more generally for goods sold online, while decreasing availability of hygiene and electronic products.[16] Moreover, policy responses differed across countries too. Germany implemented a temporary VAT cut, modulated differently across sectors and goods. Therefore, the price setting effects of the pandemic should be expected to be highly heterogeneous and especially prominent in some sectors or countries. As discussed above, under state-dependent pricing, large shocks can affect the repricing rate and give rise to non-linearities in the monetary policy transmission mechanism and the Philips curve. The volatile pandemic environment can thus provide evidence on the strength of non-linearities in the euro area.

Chart 5: Monthly Frequency of Price Changes in 2020 and 2021 (vs 2015-2019)



Notes: Calculations by NCBs staff based on national CPI micro data. Months on x-axis; percentage points on y-axis. Grey shaded area marks the first wave of the COVID pandemic in Europe from March to June 2020. No observations for Slovakia for April-June

[15] See OP 322 and the ECB Strategy Review Work stream on the price stability objective: https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op269~3f2619ac7a.en.pdf?217b41c0e8888c1e237932190d594ff9.

[16] This is most clearly shown by web scraped data for Poland indicating that the outbreak of the COVID-19 pandemic contributed to a strong decline in the availability in food, hygiene and electronic products; the frequency of price changes only slightly increased for the last two product categories.

2020. The basket of products is country-specific and constant across all years and months. The statistics are weighted using euro area HICP weights (2017-20 average).

National CPI micro data show that the price setting effects of the pandemic in 2020 were largest in Italy, while in Germany it was the VAT change that most impacted price setting in summer 2020. [17] In Italy, where the first wave of the pandemic was more severe, the repricing rate increased by more than 8 pp during April to July 2020, more than twice its period average in previous years (Chart 4). Inflation fell reflecting the higher frequency of price decreases and the smaller size of price increases. In Germany the initial months of the pandemic did not affect price setting. In July 2020 with the introduction of the VAT cut the repricing rate spiked to more than 50%, driven by an equivalent rise in the frequency of price decreases.[18] Price cuts remained marginally more frequent for the rest of the year, while the average size of price changes became persistently negative, due to a much larger incidence of small price cuts.

While 2020 movements in the Italian repricing rate are broadly comparable to other euro area episodes in the last 15 years, price flexibility increased remarkably in reaction to the German VAT changes. Compared on the same time scale, the change in the repricing rate observed in Italy in 2020 is at least as large as the change observed during the Global Financial Crisis in the euro area during 2008-2009. In contrast, the reaction by German price setters was so strong as to get close to mimicking full price flexibility, since the pass-through of the VAT cut was fast and large at over 60% (see Box 1 in OP 324). This evidence suggests that nonlinearities resulting in faster inflation dynamics may become more relevant not only in a more volatile environment with larger shocks, as would be predicted by state dependence in price setting, but also in the aftermath of especially salient shocks, like the German VAT change. In line with this conjecture, preliminary evidence based on online prices of German supermarkets shows that the repricing rate in the second quarter of 2022 has risen sharply relative to the same period in 2021.

4. New facts on e-commerce and online prices in Europe

A key aspect of the pervasive impact of digitalisation has been the rise of online retailing, yet comprehensive data are still lacking to thoroughly analyse the consequences of this phenomenon on inflation dynamics in Europe. While the Covid-19 pandemic accelerated the already existing trends everywhere, especially in the retail sector, the diffusion of e-commerce has been very heterogenous across countries and sectors in Europe. PRISMA work spotlights important parts of e-commerce in Europe, providing indicative evidence for a rapidly evolving market, rather than definitive conclusions. It draws from diverse and complementary data sources allowing to directly compare online and offline prices mostly of (non-energy) goods: i) CPI microdata for Germany, which include price quotes from internet trade (represented on the basis of 2015 weights); ii) web scraped data for Poland matched with the Polish CPI microdata; iii) household-level scanner data for online and offline supermarket (FMCG) purchases in France, Spain and the UK.[19]

[17] Evidence based on supermarkets, which faced a positive demand shock during the first wave of the pandemic, indicates that state dependence mainly characterized the behaviour of sales prices, which usually are not affected by aggregate conditions.

[18] The cut was introduced with effect from 1 July to 31 December 2020 – with a drop in the regular VAT rate from 19% to 16% and in the reduced VAT rate from 7% to 5%.

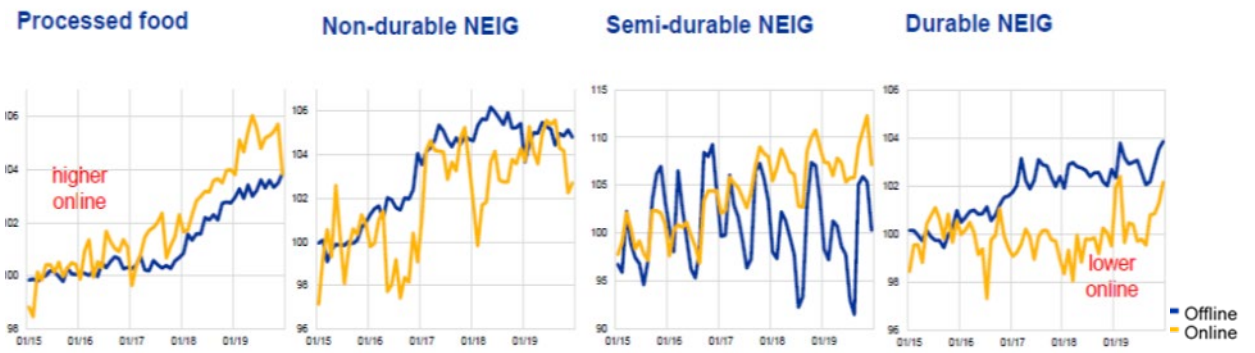
[19] FMCG is the acronym of “Fast-moving consumer goods”, which include e.g. groceries, household maintenance and hygiene products, and pet food.

This diverse and complementary set of microdata allowed to analyse the level of online prices, their dynamics and price setting. OP 320 compares online and offline retailing by examining the differences in price levels and price dispersion, inflation differentials, and micro price changes, as a key question is whether online prices are more flexible than offline prices.

Whether online prices are higher or lower than their offline counterparts tends to depend on the distribution model, the sector and the country. While previous research has found many instances of differences between online and offline price levels in either direction, a reason why online prices can be higher is home delivery. This is confirmed by a case study of UK vs France FMCG online and offline prices. In the former market home-delivered online purchases are more expensive, while in the latter self-picked-up online purchases have lower prices than purchases in brick-and-mortar stores.

In contrast with US evidence, in European countries online and offline price dispersion of FMCG is similar, running against the view that e-commerce might increase price discrimination. By simplifying price comparisons, the rise of e-commerce may reduce information frictions and foster price transparency, but it may also offer new opportunities to segment markets e.g. with personalized pricing. The latter view has found support in US evidence of higher dispersion of online prices than offline prices, including for FMCG. However, this is not the case for France, Spain, and the UK, where price dispersion for the same goods sold by the same retailer is quite small and comparable online and offline.

Chart 6: Online and Offline Price Indices from German CPI (2015-2019)



Notes: Bundesbank staff calculations based on German CPI micro data. “Online” denotes the outlet type “internet trade”, “offline” all remaining brick-and-mortar outlet types. Statistics are derived at the level of 270 online/offline products (COICOP 10-digit level) which are consistently available from 2015M1 onwards. The average price by product is aggregated to a given product category and channel using the corresponding 2015 expenditure and outlet-type weights.

Online and offline inflation can differ in terms of volatility and dynamics, but no common pattern emerges across the sectors and countries PRISMA has examined. On the one hand, German CPI data show that in most goods sectors in the period 2015-2019 online inflation is more volatile than inflation of offline prices, while their correlation is typically low, except for processed food (Chart 5).[20] Moreover, online inflation in this period has been lower for durable NEIG, and higher for processed food and semidurable NEIG. On the other hand, when comparing inflation in the prices of similar or even the same goods, online and offline differentials are much smaller, as in the case of supermarkets in France and the UK (thus consistent with German evidence).

[20]The correlation coefficient between online and offline annual rates is 0.59 for processed food, 0.19 for non-durables, -0.07 for semi-durables and -0.02 for durables.

Online prices can be picked as to mimic official inflation improving its nowcast in real time. The NBP has been successfully tracking official inflation in real time, carefully matching the goods and methodologies followed by the Polish statistical institute. PRISMA has seen to the launch of the Daily Price Data (DPD) project, involving large-scale web-scraping of online prices at the ECB. The DPD, available also to NCB staff, will be useful for forecasting inflation and further closing knowledge gaps concerning the e-commerce impact on inflation (see Box 4 in OP 320).

Online prices of most goods change more frequently than in brick-and-mortar stores, while the respective sizes of both price cuts and hikes are not consistently different. The repricing rate for non-energy goods, except for processed food, is higher online than offline in both Poland and Germany (standing at 16.7% and 11.1%, respectively). Interestingly, price changes in online food services in Poland are as frequent as in brick-and-mortar restaurants. However, the (absolute) size of online price increases and decreases has been lower in Germany, whereas in Poland the opposite tends to be the case. Overall, these findings are consistent with lower price setting frictions online, at least for goods. They confirm previous evidence supporting the conclusion that as online trade gains market share in more and more sectors, aggregate price flexibility might increase.

From a central bank perspective, the diffusion of e-commerce may thus result in increased inflation volatility but also higher price flexibility and a swifter nominal transmission of monetary policy impulses. This has two consequences. One the hand, higher inflation volatility due to online prices dynamics can complicate the goal of achieving price stability over shorter time horizons. On the other hand, an overall increase in price flexibility will make it less costly to achieve this goal in terms of consequences for economic activity at any point in time.

5. On substitution and quality bias in inflation measurement

The ECB in its strategy review pointed at directions for improvement of the HICP, including better quantification of potential biases.[21] Two such biases are the substitution bias and quality adjustment bias. Most analyses of substitution bias rest on the concept of cost of living, positing that preferences are stable, homogeneous, and homothetic.

Preference shifts and heterogeneity characterize consumer behaviour, influencing measurement of the cost of living and substitution bias. Climate change may make the impact of preference shifts particularly relevant as it causes the introduction of new varieties of “green” goods and services (km-zero food, sustainable tourism), and a shift from “brown” to “green” products. Furthermore, PRISMA data show that consumption baskets and thus inflation vary across income classes (e.g. higher-income households tend to buy more expensive goods), pointing to non-homotheticity of preferences.

When preferences are heterogeneous and/or non-homothetic it is important to monitor different experiences of inflation across classes of consumers/citizens. This is particularly important when very large relative price changes affect items that enter the consumption baskets of the rich and the poor, the young and the old, in very different proportions. In the presence of the large heterogeneity in household-

[21] The ECB Strategy Review concluded that the HICP remains the most appropriate gauge of price stability, and that a main improvement is the inclusion of owner-occupied to improve its representativeness.

level inflation discussed in the next section, timely information on dispersion in inflation rates and the underlying prices and consumer baskets would be very useful from a central bank perspective.

Another open area of analysis concerns the impact of quality adjustment on measured inflation. Evidence based on web-scraped prices shows that the various implicit quality adjustment methods can produce extremely different inflation trends when product churn is fast. In the euro area specifically, using different methods of quality adjustment can be an overlooked source of divergent inflation trends in subcategories, and, if pervasive, show up in overall measured inflation divergence across countries.[22]

6. Household inflation heterogeneity

Households differ widely in their consumption baskets and the prices they pay, which can lead to wide differences in the inflation they experience, also relative to the average HICP inflation. The average, 'representative' household hardly exists. If some households experience persistently high inflation, despite aggregate inflation in line with the central bank's policy target, this could lead to a divergence of inflation expectations and impair the credibility of monetary policy. Whether monetary policy itself has a direct effect on inflation heterogeneity is equally important for central banks. OP 325 of the report examines household level heterogeneity by leveraging consumer panel data at the highest level of granularity, comprising transaction prices and quantities of supermarket (FMCG) goods.[23]

Households in many European countries experience very different inflation rates, mostly idiosyncratic to the specific household in the (FMCG) consumer panel. Households hardly differ in the product categories they consume, but massively in the specific products and brands they pick, reflecting the high differentiation in the FMCG markets considered. This result may likely extend to other broad categories of goods and even services with many varieties (such as apparel, furnishings, health, restaurants, and recreation). **Inflation differentials may also originate from price differentiation by retailers** along household characteristics, including along national borders.[24]

During the past low inflation period, low-income households in the consumer panel faced on average slightly higher inflation. It is well-known that the consumption share of groceries is larger for lower-income households; moreover, the granular FMCG consumer panel shows that these households purchased goods with a slightly higher inflation rate than those purchased by higher-income households. Combined with the variation in cross-country inflation differentials, inflation differences between household groups in different countries can become very large.

Lower-income households however substitute away from products getting relatively more expensive, narrowing average inflation differences with higher income households when this is

[22] Practitioners may be tempted to extend the use of explicit hedonic adjustment methods to solve this problem, but these methods are also subject to problem of preference stability and heterogeneity – perhaps a reason why hedonic adjustment is often perceived by the public as untransparent and unrepresentative.

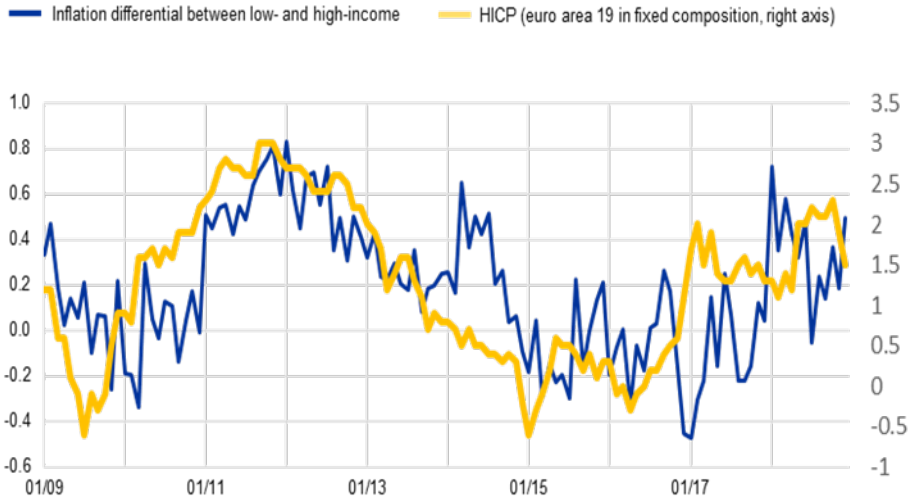
[23] Usually studies of household inflation heterogeneity rely on the household budget survey (HBS), a set of national surveys collated by Eurostat. HBS data cover all the consumption basket but come with three limitations. First, they cannot account for differences in the price paid by different households. Second, the quantity information is rather coarse, i.e. only broad product groups are available, rather than at individual product level. Third, the publicly available information is often stale and does not provide information about other household characteristics than income classes.

[24] OP 325 also documents a great deal of market segmentation along the quite homogeneous German-Austrian border.

considered. Inflation differences become smaller when the computation of price indices by income groups considers consumer substitution, departing from HICP methodology.[25]. Nevertheless, many households across all income groups do not seem to substitute away from products that are getting more expensive, reinforcing the case for examining inflation measures in light of actual consumer behaviour.

Household inflation differentials across income groups can be large at times, with low-income households experiencing lower inflation when aggregate inflation was also lower. The inflation differential between low- and high-income households was positive during the euro area crisis but negative between 2015 and 2017 (Chart 6). However, income differences and demographic characteristics such as age or size account only for a small fraction of the dispersion in individual household inflation, which is instead related to preferences and shopping behaviour. This raises the issue of reconciling aggregate measures of inflation with more detailed information on the dispersion at the household level.

Chart 7: Inflation Differential in Supermarket Goods between Low- and High-income Households



Notes: Calculations by ECB staff based on household consumer panel of purchases of supermarket goods. Weighted average across changing sample of nine EA countries (Austria, Belgium, France, Germany, Italy, Netherlands, Portugal, Slovakia, and Spain), starting with six countries in 2009, increasing to seven in 2011, to eight in 2013, and finally to nine in 2014; percentage points on vertical axis.

7. Conclusions

The PRISMA Research Network revamped the analysis of price micro data in the ESCB, revisiting and extending the results of its predecessor, the IPN. The PRISMA research outcome summarised here provides a comprehensive picture of the role of nominal rigidities in price setting in the euro area, documenting key facts using a large dataset of micro prices underlying the HICP until 2019. It also draws implications of these facts for inflation dynamics and monetary policy transmission, with an emphasis on the relevance of state-dependent price setting in volatile environments, including during the pandemic in 2020/2021. Finally, PRISMA has leveraged micro dataset newly available to the ESCB to shed new light on e-commerce and online prices in some specific sectors and countries in Europe and to investigate household inflation heterogeneity, drawing also some implications for inflation measurement.

[25] Technically, the differences are smaller when using a Paasche index of a Laspeyeres index, on which the HICP is based.