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Price setting during the coronavirus (COVID-19) pandemic

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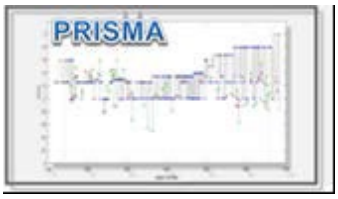

No 324

Price-setting Microdata Analysis Network (PRISMA)

This Occasional Paper contains research conducted within the Price-setting Microdata Analysis Network (PRISMA). PRISMA (2018-22) consisted of economists from the European Central Bank (ECB) and the national central banks (NCBs) of the European System of Central Banks (ESCB). PRISMA was coordinated by a team chaired by Luca Dedola (ECB) and consisting of Chiara Osbat (ECB), Peter Karadi (ECB) and Georg Strasser (ECB). Fernando Alvarez (University of Chicago), Yuriy Gorodnichenko (University of California Berkeley), Raphael Schoenle (Federal Reserve Bank of Cleveland and Brandeis University) and Michael Weber (University of Chicago) acted as external consultants (for further information, see Price-setting Microdata Analysis Network (PRISMA)).

This work is part of a set of papers within the ECB's Occasional Paper Series, resulting from the report of the ECB's PRISMA network, which is summarised here.

Set of Occasional Papers related to the ECB's PRISMA network

No 319, "Price adjustment in the euro area in the low-inflation period: evidence from consumer and producer micro price data"

No 320, "E-commerce and price setting: evidence from Europe"

No 321, "Some implications of micro price-setting evidence for inflation dynamics and monetary transmission"

No 322, "Micro price heterogeneity and optimal inflation"

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Contents

Abstract

The coronavirus (COVID-19) pandemic caused a deep recession globally, as well as in the euro area, accompanied by a steep decline in inflation rates in 2020. This paper reviews some of the main challenges created by the pandemic for inflation measurement and provides micro price data analysis of how price setting has reacted to the strong COVID-19 shock. For this purpose, we use three different, but complementary, microdata sources for specific countries and sectors: micro price data underlying the official consumer price indices in Germany, Italy, Latvia and Slovakia; (scanner) data from German and Italian supermarkets; and online (web-scraped) prices for Poland. A common finding of the micro price studies in this paper is that state dependence significantly contributed to the price-setting response to the COVID-19 shock. Nevertheless, the extent and degree of responses varies widely by sector and even country, also depending on the severity of the pandemic situation.

Keywords: price rigidity, inflation, consumer prices, heterogeneity, microdata, COVID-19.

JEL codes: D4, E31.

Executive summary

The coronavirus (COVID-19) pandemic caused a deep recession globally, as well as in the euro area, accompanied by a steep decline in inflation rates in 2020. This paper analyses the main challenges created by the pandemic for inflation measurement and provides micro price data analysis of how price setting has reacted to the strong pandemic shock. The discussion mainly focuses on developments in 2020, when the impact of COVID-19 was hitting hardest and containment measures in Europe were most severe.

First, this paper reviews the inflation measurement challenges associated with the pandemic and the resulting containment measures, which hampered standard price collection and led to sudden changes in consumer expenditures. These unprecedented compositional changes in household expenditures were not reflected in the weighting structure of the euro area Harmonised Index of Consumer Prices (HICP) in 2020, which is conventionally based on past expenditure information. Furthermore, the temporary shut-down of entire economic sectors, such as restaurants and hairdressing services, as well as bricks-and-mortar shops, created issues for price collection.

Second, this paper provides new micro price data analysis of how price setting has reacted to the huge and unforeseen COVID-19 shock, reflecting combined demand and supply shocks. Analysing how price setting has changed in response to this unprecedented macroeconomic event may help to shed light on the nature of price rigidity. Under state-dependent pricing, strong shocks may give rise to non-linearities in the monetary transmission mechanism, by affecting the repricing rate and the Phillips curve. The volatile pandemic environment may thus provide evidence on the strength of non-linearities in the euro area.

Our analysis is based on three different but complementary microdata sources, which reflect heterogeneity across countries and sectors: micro price data underlying the official consumer price indices (CPIs) in Germany, Italy, Latvia and Slovakia; (scanner) data from German and Italian supermarkets and online (web-scraped) prices for food, hygiene products and electronics in Poland. These datasets also reflect the heterogeneous impact of the pandemic, which brought about a sharp increase in demand for supermarket goods and for goods sold online more generally, while reducing the availability of hygiene and electronic products.

This paper documents heterogeneous responses to the COVID-19 shock concerning countries, sectors and even products, also depending on the severity of the pandemic situation. National CPI microdata show that the price-setting effects of the pandemic in 2020 were largest in Italy, while in Germany, it was the change in value added tax (VAT) that most affected price setting in the summer of that year. Thus, in Italy, the change in the repricing rate in 2020 was at least as large as the change observed during the Global Financial Crisis in the euro area in 2008-09. At the product level, contact-intensive services, such as hairdressing and restaurants, showed more price increases, while clothing and footwear goods showed more price

decreases after the first lockdown, consistent with differences in demand effect and reopening costs. Likewise, web-scraped data for Poland reflect considerable heterogeneity in the price-setting response of products, with a lower frequency of price changes for food and electronics (laptops), whereas the frequency of price changes increased for hygiene products. Finally, evidence based on supermarkets, which experienced a positive demand shock during the first wave of the pandemic, signals a significant sales-inflation response in Italy and Germany during the first COVID-19 wave in 2020. This was again substantially stronger in Italy, which has structurally more flexible supermarket prices than Germany.

Moreover, a common finding of the micro price studies in this paper is that state dependence significantly contributed to the price-setting response to the COVID-19 shock. The evidence based on German and Italian supermarkets indicates that state dependence mainly characterised the behaviour of sales prices, which are usually not affected by aggregate conditions. The change in the repricing rate in Germany suggests that non-linearities 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 – particularly salient shocks, such as the change in German VAT. Future research could aim to apply the evidence presented on price setting during the pandemic to test theoretical models incorporating price-setting features.

1 Introduction

The coronavirus (COVID-19) pandemic caused a deep recession globally, as well as in the euro area, accompanied by a steep decline in inflation rates in 2020. The first wave of the pandemic hit European countries mainly between March and April 2020, with unprecedented speed and intensity, and was accompanied by containment measures in most countries. The resulting dramatic decline in economic activity was followed by a strong but uneven rebound in activity and rising inflation rates (see ECB, 2020, and ECB, 2021).

The economic impact of the COVID-19 pandemic, combining both supply and demand shocks, has been heterogeneous across sectors. Due to its nature, the COVID-19 shock can be described as a "messy combination of disaggregated sectoral supply and demand shocks" (Baqaee and Farhi, 2022). In the light of the high level of uncertainty surrounding the COVID-19 outbreak in the spring of 2020, a substantial change in consumer expenditures could be observed, with a significant rise in precautionary demand for certain goods and even the panic-buying of selected goods in bulk (such as food and hygiene products). In contrast, demand in other sectors of the economy, for example tourism and recreational services, temporarily collapsed. Simultaneously, the pandemic was a major shock to personal mobility. Numerous activities requiring face-to-face interactions froze, as services in multiple sectors of the economy were suspended. From the supply perspective, many firms experienced disruption to their operations due to the scarcity of production inputs.

Likewise, policy responses during the COVID-19 pandemic differed considerably across European countries, possibly increasing cross-country sectoral heterogeneity. As well as differences between countries in terms of demand and supply mechanisms, the timing and stringency of government containment measures and economic policy responses were clearly country-specific. For example, from July to December 2020, Germany implemented a temporary value added tax (VAT) cut, modulated differently across sectors and goods. Hence, the price-setting effects of the pandemic should be expected to be highly heterogeneous and particularly evident in some sectors or countries.

This paper analyses the main challenges created by the COVID-19 pandemic for inflation measurement and provides micro price data analysis of how price setting has reacted to the strong pandemic shock. The discussion focuses mainly on developments in 2020, when the impact of the COVID-19 shock was highest and containment measures in Europe were most severe.

First, this paper reviews the inflation measurement challenges associated with the pandemic and the resulting containment measures, which hampered standard price collection and led to sudden changes in consumer expenditures. These unprecedented compositional changes in household expenditures were not reflected in the weighting structure of the euro area Harmonised Index of Consumer Prices (HICP) in 2020, which is conventionally

based on past expenditure information. Furthermore, the temporary shut-down of entire economic sectors, such as restaurants and hairdressing services, as well as brick-and-mortar shops, created issues for price collection.

Second, this paper provides new micro price data analysis of how price setting has reacted to the huge and unforeseen COVID-19 shock, reflecting a combination of demand and supply shocks. Analysing how price setting has changed in response to this unprecedent macroeconomic event may help to shed light on the nature of price rigidity. Under state-dependent pricing, large shocks may give rise to non-linearities in the monetary transmission mechanism, by affecting the repricing rate and the Phillips curve.[1] The volatile pandemic environment may thus provide evidence on the strength of non-linearities in the euro area.

Our analysis is based on three different but complementary microdata sources, which reflect heterogeneity across countries and sectors: micro price data underlying the official consumer price indices (CPIs) in Germany, Italy, Latvia and Slovakia; (scanner) data from German and Italian supermarkets and online (web-scraped) prices for food, hygiene products and electronics in Poland. These datasets also reflect the heterogeneous impact of the COVID-19 pandemic, which brought about a sharp increase in demand for supermarket goods and for goods sold online more generally, while reducing the availability of hygiene and electronic products.

This paper documents heterogeneous responses to the COVID-19 shock concerning countries, sectors, and even products, also depending on the severity of the pandemic situation. National CPI microdata 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 affected price setting in the summer of that year. Thus, in Italy, the change in the repricing rate in 2020 was at least as large as the change observed during the Global Financial Crisis in the euro area in 2008-09. At the product level, contact-intensive services, such as hairdressing and restaurants, showed more price increases, while clothing and footwear goods showed more price decreases after the first lockdown, consistent with a differential demand effect and reopening costs. Likewise, web-scraped data for Poland reflect considerable heterogeneity in the price-setting response of products, with a lower frequency of price changes for food and electronics (laptops), whereas the frequency of price changes increased for hygiene products. Finally, evidence based on supermarkets, which faced a positive demand shock during the first wave of the pandemic, signals a significant sales-inflation response in Italy and Germany during the first COVID-19 wave in 2020. This was again substantially stronger in Italy, which has structurally more flexible supermarket prices than Germany.

Moreover, a common finding of the micro price studies in this paper is that state dependence significantly contributed to the price-setting response to the COVID-19 shock. The evidence based on German and Italian supermarkets indicates that state dependence mainly characterised the behaviour of sales prices, which are usually not affected by aggregate conditions. The change in the repricing

1 See Dedola et al. (2023).

rate in Germany suggests that non-linearities 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 particularly salient shocks, such as the change in German VAT. Future research could aim to apply the evidence presented on price setting during the pandemic to test theoretical models incorporating price-setting features.

Our work is in line with early literature that analyses price setting during the pandemic based on micro price data. Recent studies report sectoral differences in price setting for Switzerland (Alvarez and Lein, 2020; Rudolf and Seiler, 2022)[2] and across German firms (Balleer et al., 2022, based on German business survey data). Most recently, Montag and Villar (2022) document evidence of sectoral shocks in US CPI microdata during the pandemic, with little relationship between pre-pandemic sectoral flexibility and how firms within sectors responded during the pandemic. They also find that firms primarily adjusted the size of price changes during the pandemic, whereas the frequency of price change was relatively constant.

The structure of the paper is as follows: Section 2 reviews the main challenges for inflation measurement, mainly due to missing ("imputed") prices and shifts in consumer expenditures. Section 3 discusses price-setting behaviour during the pandemic by means of three different, but complementary, data sources: micro price data entering the official CPI; online (web-scraped) product prices; and transactional (scanner) data from supermarkets. Section 4 concludes.

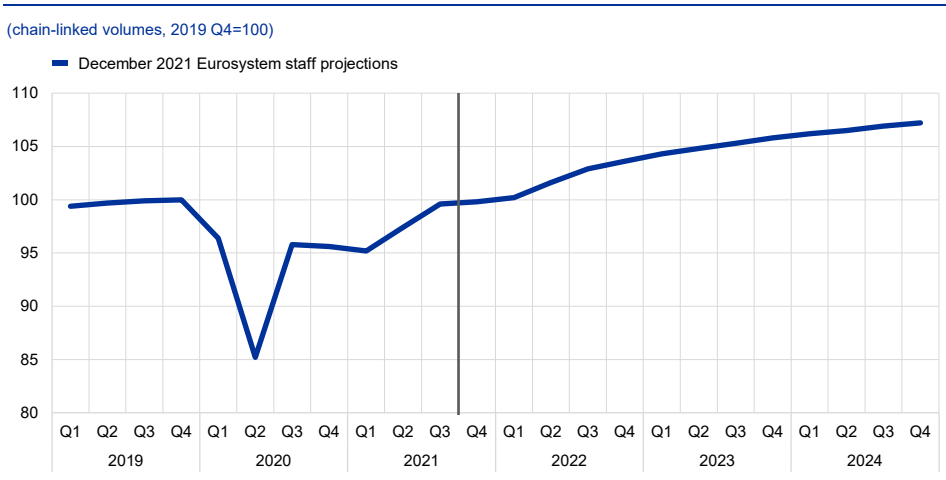
[2] For Swiss online stores, Alvarez and Lein (2020) document an increase in the repricing rate for food products and a lower rate for recreation and culture items. Likewise, analysis of Swiss CPI micro price data by Rudolf and Seiler (2022) shows that the frequency of price adjustments varies considerably across sectors, with temporary sales responding countercyclically to the respective demand conditions (i.e. an increase in temporary sales in the non-energy industrial goods (NEIG) sector, and a decrease in the food sector).

2 Challenges in inflation measurement during COVID-19

The COVID-19 pandemic shock and the associated lockdown measures implemented to contain the spread of the virus led to a dramatic decline in economic activity in 2020 (Chart 1). The first wave of the pandemic mainly hit euro area countries between March and April 2020, with unprecedented speed and intensity, and was accompanied by strict economy-wide containment measures in most countries. The containment of the pandemic and the lifting of the containment measures after the first wave, as of May 2020 in most countries, led to a strong rebound in activity in the third quarter of 2020. However, by the autumn, economic activity had started to decelerate again, with the new spike in infections generating a further round of lockdowns in the fourth quarter of 2020 (which were, however, more targeted than in the first wave). Nevertheless, the economic impact of the pandemic, as well as the timing and the stringency of containment measures, was heterogeneous across countries.[3]

Chart 1

Euro area real GDP



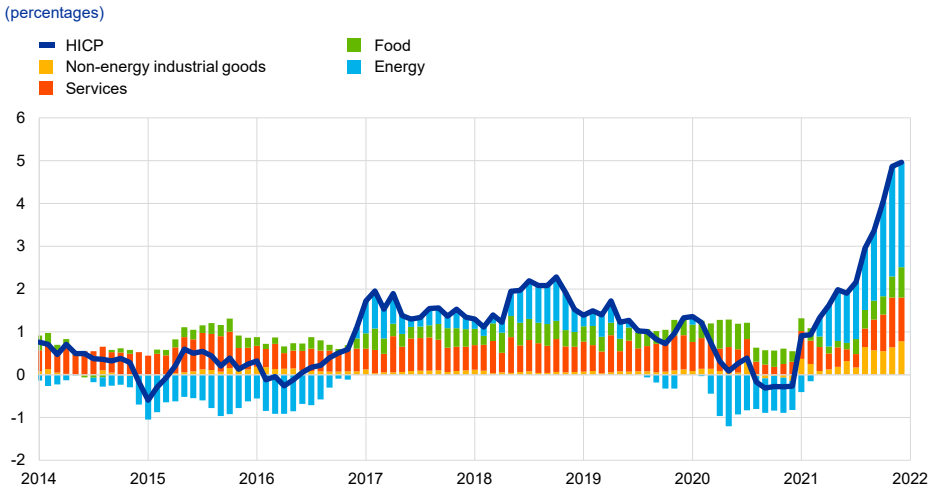
Sources: Eurostat and Eurosystem staff macroeconomic projections for the euro area, December 2021.
Notes: The vertical line indicates the start of the December 2021 projection horizon.

Headline inflation in the euro area fell sharply throughout 2020 (Chart 2). In terms of its driving factors, the disinflationary process took place in a context of sharp contractions in economic activity, which significantly weakened consumer demand and posed severe downside risks to the economic outlook. Disinflationary pressures also reflected some factors specific to the economic implications of, and responses to, the COVID-19 pandemic. For example, the further decline in inflation in the second half of the year was partly due to the drop in the prices of travel-related services (particularly transport and hotels), which were hit hardest by the crisis, and to the impact of the temporary reduction of the VAT rate in Germany (see also

[3] For more details, see Muggenthaler et al. (2021).

Box 1). On the other hand, food inflation temporarily increased during the first wave of the pandemic.

Chart 2
Euro area HICP inflation



Sources: Eurostat.
Last observation for Euro Area HICP: December 2021.

The severe recession of 2020 was followed by a swift rebound in economic activity in 2021, accompanied by a sharp increase in inflation rates. Growth dynamics in 2021 were still very much shaped by the evolving COVID-19 pandemic. The recovery was to some extent uneven across sectors and countries, as the pandemic spread. In line with the subsequent recovery, inflation rates in the euro area increased sharply, mainly reflecting the marked rise in energy prices. In addition to this surge in energy prices, demand outpaced constrained supply in some sectors, adding to inflationary pressures, following the easing of pandemic restrictions and the strong rebound of global and domestic economies.

Overall, the economic consequences of the COVID-19 pandemic have posed severe challenges for inflation measurement. The pandemic, and the associated containment measures undertaken by governments to combat it, have caused considerable changes in consumption patterns. Most people were encouraged[4] to stay at home as much as possible, while some activities were restricted or even completely prohibited, making it impossible to observe and collect prices in certain sectors. This has had direct implications for inflation measurement.

This section focuses on two main challenges for inflation measurement during the pandemic year 2020 concerning price collection and HICP expenditure weights. First, particularly during the lockdowns, price collection in brick-and-mortar shops was avoided, in order to protect the health of the price collectors. Consequently, prices were collected online or by telephone. For some categories, it was even impossible to observe monthly prices, as some categories – mostly services – could not be offered, and hence their prices were not observable. For

4 In some countries, at some points, it was even forbidden to leave home for non-essential reasons.

example, the price of travelling, cultural activities, personal services (such as hairdressers and gyms) and prices in bars and restaurants could not be quoted. A second problem arises from the fact that the annually updated HICP weights attributed to the various items of the consumption basket represent the previous year's t-1 consumer spending, based on national accounts data from t-2, as the HICP is a Laspeyres-type index. In normal times, the previous year's spending is a good proxy for the current year's spending (conditioned on relative prices and consumers' preferences not changing much).[5] During the pandemic, however, consumers were forced to change their consumption patterns drastically: hence, the HICP weights for 2020 differed substantially from actual consumption in that year.

These measurement challenges have caused more persistent problems with an impact beyond 2020. For example, price imputations in 2020/2021 caused (upwards) base effects on the following calendar year. In addition, in 2021, the HICP weights were indeed more representative, as the preliminary national accounts data for the previous year had been used to compile them (see Eurostat, 2021).

The structure of this section is as follows: Section 2.1.1 will describe how national statistical institutes (NSIs) tackled the first problem of unavailable prices due to COVID-19. Section 2.1.2 will provide a review of studies that have dealt with the second problem of the unrepresentativeness of HICP weights. In Section 2.1.3, an alternative (ex post) inflation rate for 2020 will be recalculated, using a more representative weighting scheme, based on the consumption pattern of the same year.

2.1 Price imputations for compiling the HICP

NSIs tackled the first measurement problem of unavailable price quotes according to Eurostat guidelines.[6] The prices of products that are usually collected in brick-and-mortar stores were collected online, or by telephone and email enquiries, whenever possible. This approach could have introduced many product replacements and substitutions, raising the issue of comparison with the prices previously collected: for example, online prices may also include delivery costs if they are not billed separately. Moreover, online prices may behave differently from offline prices, resulting in changes in measured inflation dynamics.[7]

Missing prices had to be estimated ("imputed") by NSIs for various reasons. If prices could not be collected by the alternative means described above, the missing prices of those products had to be imputed, using price changes of similar products or the nearest price aggregate. For products that typically follow a seasonal pattern, such as package holidays or flight tickets, NSIs had to ensure that the seasonal pattern was not distorted when imputing the prices (Eurostat 2020a).

5 See Osbat et al. (2023).

6 See Lamboray et al. (2020) for an overview.

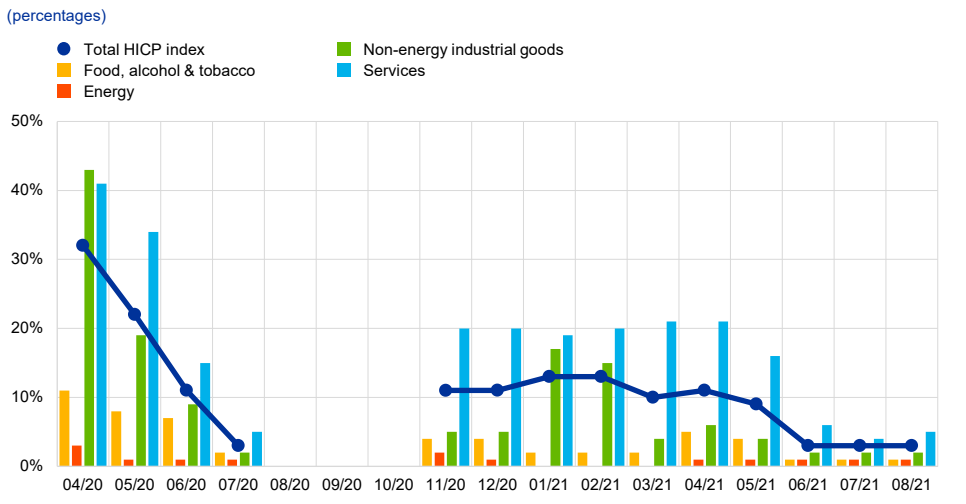
7 See Strasser et al. (2023).

The choice of imputation method and its extent may have a noticeable impact on the inflation rate of a given product category. For example, imputation by carrying forward the last observed prices may imply an underestimation of the inflation rate (as prices generally tend to increase). On the other hand, in some sectors under lockdown, demand would probably have been lower due to health concerns, implying lower prices than previously. In any case, imputations would imply a base effect for the following year. O'Brien et al. (2021) note that price imputations have probably brought about a short-lived increase in inflation persistence, particularly for items that typically exhibit relatively low persistence. They use the example of package holidays and air fares, whose inflation persistence in "normal times" (measured over the period 1999-2019) is low. As the share of imputed prices surged in the second quarter of 2020, the related inflation persistence increased. In other words, the published price index partly reflects price movements carried over from normal times.

The overall share of imputed prices in the HICP peaked in the spring of 2020. Based on the input of the NSIs, Eurostat estimated the share of price imputations due to COVID-19 for the periods April to July 2020 and November 2020 to August 2021 (Chart 3). In the first period, the share of imputed prices peaked at 32% of the total euro area HICP basket in April 2020, and this figure declined to only 3% in July 2020. In November 2020, the share of imputations increased again to 11%, a share that was more or less maintained up to April 2021. It started to decline again as of May 2021, falling to 3% from June 2021 onwards.

Chart 3

Share of imputations in euro area HICP due to COVID-19



Source: Eurostat.

2.2 Shifts in consumer expenditures in 2020: evidence from the literature

In conceptual terms, the HICP is a Laspeyres-type index with annual chain linking, implementing the cost of goods index (COGI) concept.[8] It is designed to measure the expenditure required to purchase a fixed basket of goods and services. To be more precise, the HICP is a COGI within each calendar year,[9] as its weights are updated on an annual basis. The procedure for updating weights is laid down in the HICP regulations.[10] They are computed based on national accounts of two years before, reviewed and updated so as to be representative of year t-1, and finally "price-updated"[11] to December of year t-1. In this way, the current year's HICP weights represent the consumer spending of the previous year.[12]

However, consumers were forced to change their expenditure patterns drastically during the pandemic. For example, the strict lockdowns in March and April 2020 led to an increase in the relative share[13] of food (and of goods in general) in the consumption basket. Given these unusual temporary changes in consumption, an index with more frequently varying weights might, temporarily, be more representative.[14]

Various studies have been conducted to calculate alternative inflation rates in 2020, with weights deemed more representative of the actual changes in consumption spending during this period. In most cases, the weights vary on a monthly basis, since the situation changed rapidly throughout the pandemic. These alternative weights have been estimated using data sources other than the usual one (national accounts), such as bank and credit card transactions, which are available in a timely manner. Nevertheless, these data have to be interpreted with caution, as they may not fully reflect actual spending. Credit card data, for example, are less reliable for expenses such as food, as credit cards are less frequently used for this type of consumption. Moreover, they do not provide the necessary granularity of information (e.g. credit card data do not usually include the type of product that was bought, but only information on the type of outlet). Official statistics on turnover have also been used. These data may be more reliable, as they comply with statistical

8 One alternative price index concept is the cost of living index (COLI): see Osbat et al. (2023).

9 See Work stream on inflation measurement (2021).

10 See Commission Implementing Regulation (EU) 2020/1148 of 31 July 2020 laying down the methodological and technical specifications in accordance with Regulation (EU) 2016/792 of the European Parliament and of the Council as regards harmonised indices of consumer prices and the house price index (OJ L 252, 4.8.2020, pp. 12–23), Article 3.

11 The expenditure of year t-1 is adjusted for any price changes between the average of year t-1 and December of year t-1.

12 This is, according to Eurostat (2020b), "in line with the Laspeyres philosophy of the HICP. (…) In normal times, structural changes between t-2 and t-1 are limited, so that t-2 data can be used to estimate t-1".

13 In relative terms, because in absolute terms, food spending did not necessarily increase. This was mainly due to the lack of spending in other categories, such as cultural activities or restaurants and bars.

14 During lockdowns, consumers were also forced to buy the more expensive brand of a type of product in some cases, because the cheaper version was not available. Jaravel and O'Connell (2020) calculate a (COLI-like) inflation rate based on a consumer utility function. They show that during the first month of the lockdown, there was a reduced product variety in the United Kingdom, which contributed significantly to the inflation rate. The HICP methodology does not capture the effects of changes in product on utility: see Osbat et al. (2023) for a discussion.

standards. The disadvantage here, however, is that these data are published with a time lag of about two months. In addition, as different classification systems are used and not all consumption categories are covered, quite strong assumptions have to be made in order to match turnover series with consumption categories (for example, turnover data also include sales to other businesses that are not part of a CPI).

Comparison of results across these different studies should therefore be taken with a pinch of salt. That is, they all apply a different methodology, hence the results are not directly comparable. Moreover, the comparison of an index with monthly varying weights with the officially published HICP also has shortcomings, since a COGI index with a fixed weight throughout the year (HICP) is conceptually different from an index with monthly varying weights. Therefore, these studies should mainly be interpreted as attempts to reproduce an inflation rate that is more in line with the actual consumption pattern of these times, but they should not necessarily be regarded as more correct measures of HICP inflation.

Cavallo (2020) uses credit and debit card transactions to calculate a "COVID inflation rate" for the United States for the first five months of 2020.[15] His alternative measure is higher than the officially published CPI inflation, with the related gap between both series increasing throughout 2020. In January and February 2020, there is no difference, since there were no major expenditure shifts at that time. The gap increases from 0.1 percentage points in March to 0.7 percentage points in April, and eventually 0.8 percentage points in May.

Gautier et al. (2021) calculate an inflation rate in a similar manner for France from January to December 2020, also using monthly varying weights based on bank card transactions. The biggest gap between the published HICP and their alternative inflation rate is in April 2020 (1.1 percentage points); after that, it diminishes. It starts to rise again from September; in November 2020, it is about 0.4 percentage points. In 2020 as a whole, the authors estimate that the alternative inflation rate is 0.2 percentage points higher than the published HICP inflation rate in France. Their findings are similar to those published in a study by the French National Institute of Statistics and Economic Studies (INSEE) (2020).[16]

Using debit card data, Jonckheere and Zimmer (2020) calculate an alternative inflation rate for Belgium for the period from February to July 2020. They find that the inflation rate in April and May 2020 would have been 0.4 percentage points higher with monthly varying weights, after which the difference between the alternative and actual HICP inflation rate diminishes.

Kouvavas et al. (2020) undertake a similar exercise for the euro area, for the period from January to August 2020, using (publicly available) aggregate turnover data to estimate changing consumption patterns. They find that the inflation rate in the euro area would have been about 0.2 percentage points higher

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15 Cavallo (2020) also conducts this exercise for 17 other countries. Since the author does not have bank card transaction data for these countries, he supposes that expenditure changes are the same as in the United States.

16 Note that INSEE is one of the few statistical offices in the world that publishes an alternative official inflation measure that captures expenditure changes due to COVID-19.

from April to August 2020. In April to June 2020, this is almost entirely explained by food and energy items, but in July and August 2020, core items also help to explain the difference. The authors have updated their research for this present report, with data to December 2020 (Chart 4). Based on the turnover data, the biggest changes in consumption patterns took place around April 2020 (with a hike in relative food expenditures). Since then, the consumption spending pattern has been more similar to the situation before COVID-19, although relative expenditures for recreation remained significantly smaller until the end of 2020.

Table 1

Selected studies dealing with alternative inflation measures during COVID-19

(impact in percentage points, pp)

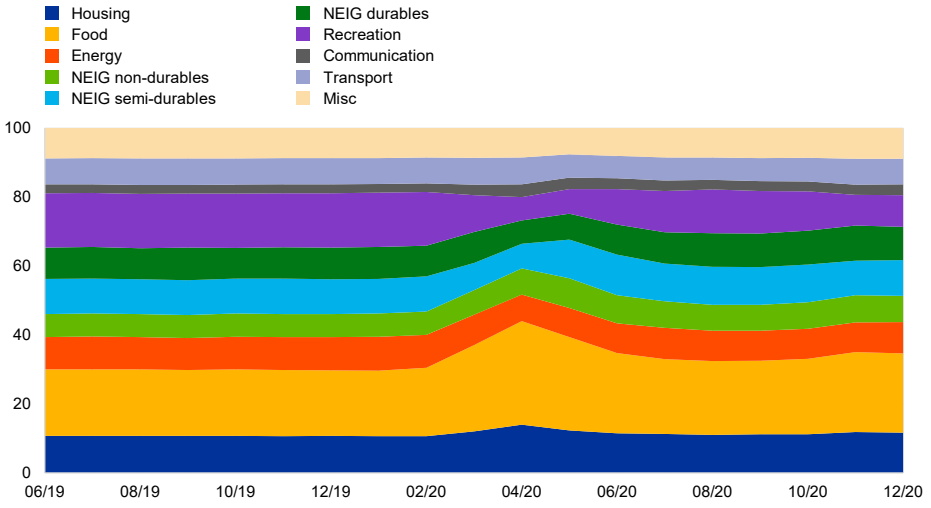
Authors	Cavallo (2020)	Gautier et al. (2021)	Jonckheere and Zimmer (2020)	Kouvavas et al. (2020)
Region	**United States**	**France**	**Belgium**	**Euro area**
Data used for monthly weight update	Credit and debit card transactions between Jan 2020 and May 2020	Bank card transactions between Jan 2019 and Dec 2020	Debit card transactions between Feb 2020 and July 2020	Nominal turnover data for the retail trade and for other services between Jan 2018 and Dec 2020
Main findings	Alternative inflation rate is higher from March 2020; the difference is even larger in April and May 2020.	Alternative inflation rate is higher from March 2020 onwards until the end of the investigation period (December 2020), with a peak in April 2020 (difference of 1.1 pp).	Alternative inflation rate is higher from March 2020 until the end of the investigation period (July 2020), with a peak in April and May 2020 (difference of 0.4 pp).	Alternative inflation rate is higher from March 2020 until the end of the investigation period (it is calculated from January 2020 to December 2020). The difference reaches a peak in May 2020 (0.25 pp).

Notes: Non-exhaustive list; more examples are cited in Box 5 of European Central Bank (2021), "Inflation measurement and its assessment in the ECB's monetary policy strategy review", Occasional Paper Series, No 265, ECB, Frankfurt am Main, September.

Chart 4

Share of household consumption by category, euro area

(percentages)

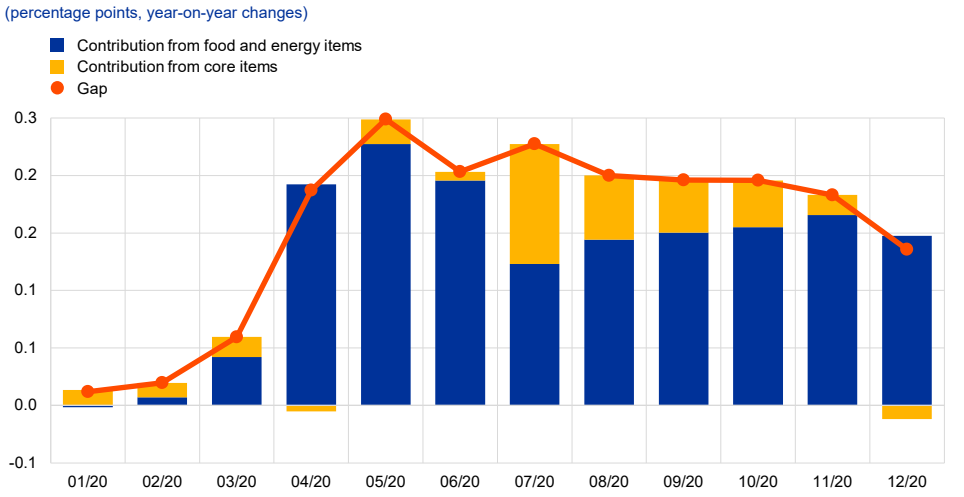


Source: Authors' update of Kouvavas et al. (2020), based on Eurostat data.
Notes: The chart shows the evolution of estimated relative spending. Spending patterns are calculated using the 2020 HICP weights as a starting point and applying growth rates based on turnover data for the retail trade and for other services. "NEIG" stands for "non-energy industrial goods". "Food" refers to food items and does not include eating out.
Some of the turnover series on the euro area level are discontinued on Eurostat, which is why the authors had to compile a euro area aggregate themselves, based on the series of the different countries and using their country weights. The calculations of the euro area aggregates of the different series provide a good approximation of those published for the dates that are available on Eurostat.

According to an update of the approach of Kouvavas et al. (2020), the difference between the alternative inflation rate and actual HICP inflation was largest in May 2020. Chart 5 shows that this difference amounted to 0.25 percentage points in May 2020, meaning that the conclusions of Kouvavas et al. (2020) remain valid. It stayed at around this level until November 2020 (0.18 percentage points), after which it started to decline significantly. In April and December 2020, core items even contributed negatively to the inflation difference.

Chart 5

Difference between annual rates of a monthly-reweighted index and the HICP, euro area



Source: Authors' update of Kouvavas et al. (2020), based on Eurostat data.
Notes: The orange line shows the difference between year-on-year HICP inflation and the year-on-year change in our alternative index. The bars show the contributions of food and energy items (blue bars) and core inflation items (yellow bars).
The alternative inflation rate for the months January to August differs slightly from those published in Kouvavas et al. (2020), due to the forced re-estimation of the euro area aggregates of turnover data for the discontinued series on Eurostat.

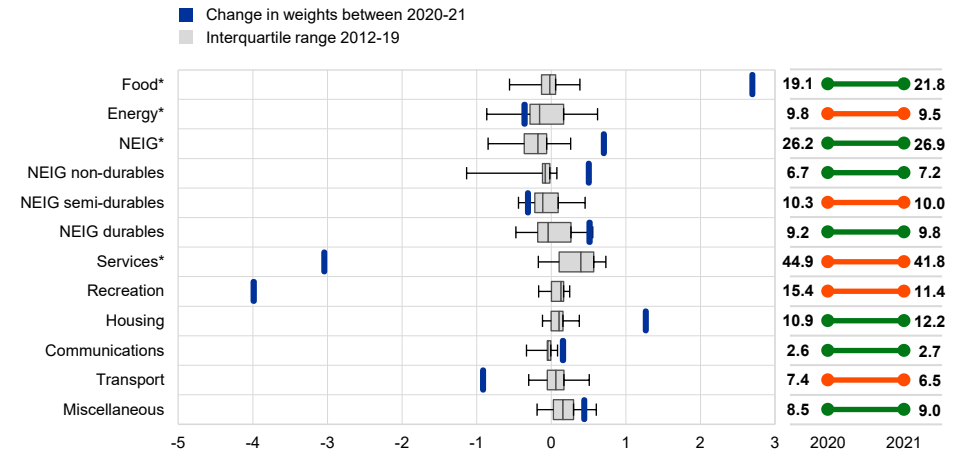
2.3 Euro area inflation in 2020 recalculated using 2021 weights

The COVID-related changes in HICP weights as of 2021 were more pronounced than during normal times, notably for food and services. In order to ensure better representativity of the 2021 weights in the HICP, Eurostat asked the NSIs to update the weights based on national accounts data for 2019 with the preliminary national accounts information of 2020.[17] Hence, the weights for 2021 are based on the consumer spending of the 2020 pandemic year. As shown in Gonçalves et al. (2021), the weight changes in the euro area were quite substantial, particularly for the HICP special aggregates food (increase) and services (decrease), when compared with weight changes in previous non-pandemic years (Chart 6).

[17] These data are preliminary, since at the time of the determination of the weights for the year 2021, the national accounts data for 2020 were not yet published: the NSIs therefore used preliminary results based on the first three quarters of 2020.

Chart 6

HICP weights: levels and historical changes distributions



Source: Chart taken from Gonçalves et al. (2021).
Notes: The chart shows the HICP weights in 2020 and 2021 (right-hand side). A green/red line indicates whether the weights increased/decreased. The chart also shows the weight changes (blue markers on left-hand side) and their historical distributions (grey "whiskers" on left-hand side). Categories highlighted with "*" denote main special aggregates. Categories not highlighted are sub-aggregates, included in the main aggregates. The grey "whiskers" report the median, 25th percentile, 75th percentile, minimum, and maximum of the historical distribution. NEIG stands for "non-energy industrial goods". Historical ranges are based on the sample from 2012 (the first year in which annual HICP weights became available) to 2019.

Given the considerable difference between the HICP weights in 2020 and 2021, it is useful to calculate an alternative inflation rate for 2020 based on the 2021 HICP weights. For this purpose, we use HICP weights that are applied to 2021 and are based on the consumer spending of 2020, and are hence fully representative of the year concerned. We perform a re-calculation of the inflation rate for 2020, according to a fully HICP-consistent COGI concept, but we replace the 2020 weights with the more representative 2021 weights.[18] Note that this is an ex post exercise, in the sense that it could only be conducted once the 2021 HICP weights became available.

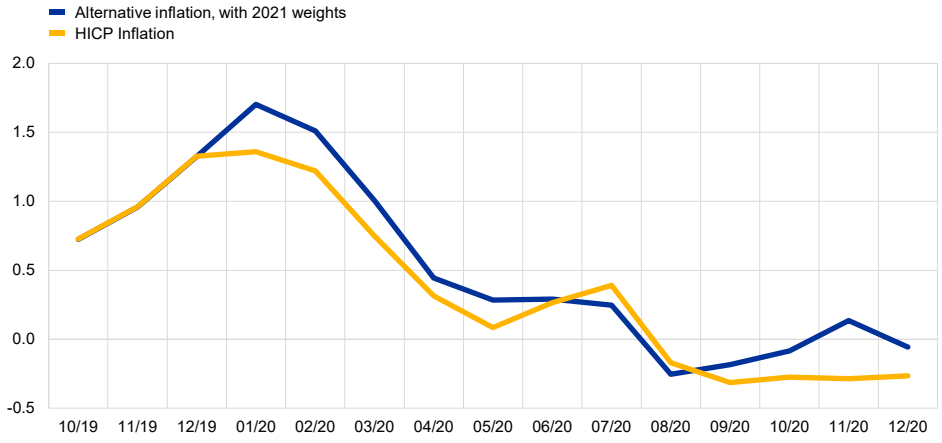
Our alternative inflation measure is, on average, 0.2 percentage points higher in 2020 than official euro area inflation (Chart 7). This is in line with evidence from the literature cited above, which uses monthly varying weights to estimate alternative inflation rates. The alternative inflation rates are particularly high at the start and end of the 2020 pandemic year, but even lower in the middle of the year.

[18] More precisely, the total HICP index is re-calculated using the published ECOICOP five-digit item-level indices. However, rather than using the 2020 HICP weights to aggregate the total HICP index in 2020, the 2021 HICP weights are used, following the standard HICP calculation procedure of un- and re-chaining sub-indices. Finally, year-on-year changes are then calculated for this newly aggregated index.

Chart 7

Euro area HICP inflation and alternative inflation measure

(year-on-year price changes, percentages)



Sources: Eurostat and own calculations.
Note: The inflation rate with 2021 weighting scheme is the ex post calculated inflation rate, in which the weighting scheme of 2021 is applied to calculate the total index of 2020.

Note that the difference between the official HICP and the alternative measure is time-varying, notably due to seasonal components, such as package holidays. For the latter, price increases during the summer months matter less, due to a smaller 2021 HICP weight. This contrasts with alternative inflation measures based on monthly changing weights, which were generally higher than (or at least equal to) official inflation during most of the months of the investigation period, including the summer months. The monthly weights of items such as package holidays increased again during the summer months of 2020, as lockdown measures were relaxed somewhat. Therefore, the usual price increases that occur each year in those seasonal items were (almost) fully captured in those indices with varying weights.[19]

The contribution to overall inflation of a given product group depends on the combination of the change in its expenditure weight and its price dynamic. For example, as shown in Chart 8, food prices – whose weight increased in 2021 – contributed positively to the gap between the alternative inflation rate and HICP inflation, but particularly during the spring of 2020, when food inflation was relatively high.

Services with a strong seasonal pattern, such as package holidays, have a big impact on the gap between the alternative inflation measure and HICP inflation. The weight of seasonal services such as package holidays (part of "recreation and culture"), air transport (part of "transport") and hotels, cafés and restaurants is typically lower according to the 2021 scheme, but their seasonal pattern exerts important effects. The weight of package holidays, for example, decreased from 1.6% in 2020 to 0.6% in 2021. The significant changes in weights in 2021, in combination with the way the HICP is constructed (i.e. chain linking to

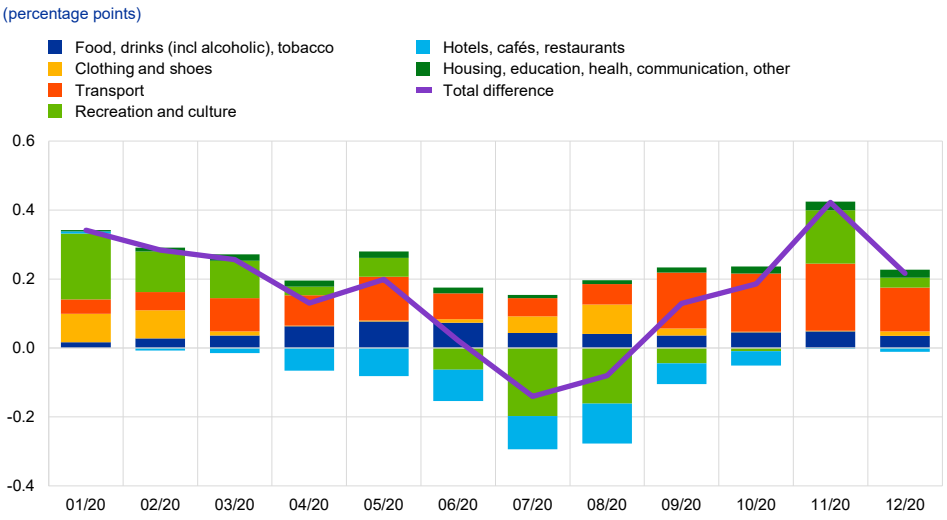
[19] It should be noted that such indices may be prone to chain drift, if price and weight development are correlated in the short run, as can be observed for package holidays: see, for example, Kurtzon (2021).

December of the previous year) and the fact that prices in that category fluctuated substantially throughout the year, had a major impact on the overall inflation rate.[20] In some cases, this statistical effect was even counterintuitive. For example, in January 2021, the package holidays category exerted a strong upwards pressure on German inflation, despite a negative year-on-year growth rate (Deutsche Bundesbank, 2021a).

Lastly, transport inflation contributed positively to the gap, due to its smaller weight in the 2021 scheme than in 2020. The decrease in the weight of transport, combined with the slowdown in inflation in this item (mainly due to diesel and petrol inflation) contributed to the positive impact on the gap.

Chart 8

Contribution to differences between the alternative inflation measure and euro area HICP inflation



Sources: Eurostat and own calculations. A positive value means that the alternative inflation measure is higher than euro area HICP inflation in that month.

These results illustrate that, in times of sudden economic shifts, changes in expenditure weights can have non-negligible effects on inflation rates. To keep HICP weights representative, more up-to-date information on expenditure patterns, which has been used since the onset of the COVID-19 pandemic in official price statistics,[21] is crucial. Looking ahead, the relevance of more recent expenditure weights in the HICP also applies to the current high-inflation environment, which is mainly being driven by high energy prices and may bring about considerable (forced) changes in consumers' expenditure patterns in the next few years.

[20] That is, the contribution of a given HICP sub-component also takes into account the price growth during the previous year, using the previous year's weight. As the weight of package holidays in 2020 was greater than in 2021, the previous year's price developments account for a large part of the contribution.

[21] See, for example, Eurostat (2021).

3 Price-setting behaviour during COVID-19

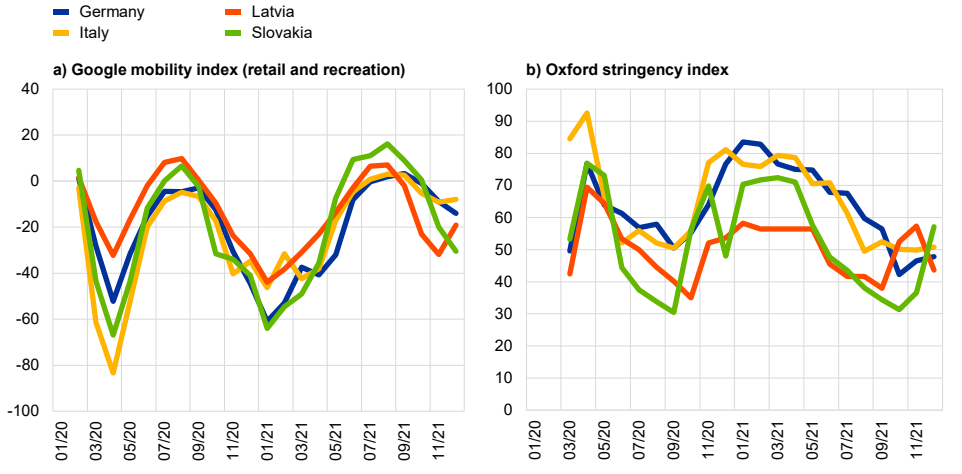
In this section, we analyse price-setting behaviour during the COVID-19 pandemic, based on three different microdata sources: Section 3.1 deals with micro price data underlying the official CPI in four countries (Germany, Italy, Latvia and Slovakia); Section 3.2 presents evidence from online (web-scraped) price data for Poland; and Section 3.3 analyses price-setting behaviour by means of supermarket scanner data for Germany and Italy.

3.1 Price setting in official CPI data

In this section, we extend the analysis of price-setting statistics based on the official CPI microdata for euro area countries presented in Gautier et al. (2022) to the 2020 and 2021 pandemic years. Notably, we analyse the frequency and size of price changes in response to the pandemic using the CPI microdata of four euro area countries for which more recent data are available, namely Germany, Italy, Latvia and Slovakia. For the subsequent analysis, we follow both a time and a disaggregate sectoral perspective, since the COVID-19 pandemic represented a highly dynamic and sector-specific shock.

The countries in our sample were affected differently by the pandemic. The severity of lockdown restrictions (as captured by the Oxford stringency index in panel b) of Chart 9) differed across countries, and, particularly during the first wave of the pandemic, the ensuing decline in mobility was highly heterogeneous (panel a) of Chart 9).

Chart 9
Severity of the COVID-19 pandemic in 2020 and 2021 in selected countries



Sources: Own calculations based on data for the Google mobility index and Oxford stringency index.
Note: This chart shows the average monthly value for the Google mobility index and Oxford stringency index.

We find that price-setting adjustment during the first wave of the pandemic in 2020 was mostly affected in Italy, whereas it stayed roughly in line in the second half of 2020. One exception is the temporary VAT change in Germany, effective from July to December 2020, which triggered a more marked response than the first wave of the pandemic. Overall, the aggregate fall in inflation mainly materialised through a higher frequency of price decreases and a smaller size of price changes; for Italy, where the pandemic situation was more severe, the frequency of price increases also seemed to be affected. At the product level, contact-intensive services, such as hairdressing and restaurants, showed more price increases, while clothing and footwear goods showed more price decreases after the first lockdown, consistent with a differential demand effect or reopening costs. In 2021, the second pandemic year, no significant impact on the frequency of price changes could be observed for Italy and Germany, whereas it increased slightly in late 2021 in Latvia and Slovakia, when overall inflation was picking up again.

The structure of this section is as follows: Section 3.1.1 describes the underlying CPI micro price datasets. Section 3.1.2 presents evidence on the overall frequency and size of price changes. Section 3.1.3 analyses price-setting mechanisms by sector. Finally, Section 3.1.4 focuses on the price-setting response for selected products (clothing and footwear, hairdressing and restaurants) that were hit hardest by lockdown measures during the first wave of the pandemic.

3.1.1 CPI microdata for the pandemic period

The stylised facts documented in this section are based on evidence from official CPI micro price data recorded at the outlet level by the NSIs in Germany, Italy, Latvia and Slovakia. Together, these four countries cover about 46% in terms of euro area consumption expenditures. In the individual countries, the country-specific share of HICP expenditures ranges from 60% to 90% for the years 2017-19 (Table 2).

On-site price collection was severely hampered due to lockdown restrictions and the temporary unavailability of certain products ("out-of-stock", see also Eurostat, 2020a). This resulted in a decrease in price quotes in some countries and a higher share of price imputations in all countries. The highest share of imputed prices was in April 2020, during the peak of the first wave of the pandemic.

The CPI micro databases for Slovakia and Italy have some limitations. The Slovakian dataset does not contain any price quotes for food and only a small fraction for non-energy industrial goods (NEIG) and services in April-June 2020: hence, this time period is excluded from the analysis for this country. Moreover, the Italian CPI micro dataset reflects changes in price collection in 2020 which were not a direct consequence of the pandemic, since in that year, the prices of processed food products were mainly collected from scanner data. This significantly reduces the number of comparable food categories available in the CPI micro dataset for Italy

and introduces a sample composition bias in 2020, which mainly affects processed food, since supermarkets were dropping out as an outlet type in the dataset.[22]

In measuring monthly price-setting statistics, we compute price changes at the individual product level; our aggregate monthly frequency measure indicates how many prices changed in a given month. This is the same approach as that of Gautier et al. (2022). Likewise, we exclude micro prices which were imputed (as flagged by the NSI), since they do not reflect actual price setting by stores and firms.[23] Note that – in contrast to the results of Gautier et al. (2022) – we do not select a common product sample across countries, but a stable product composition per month by country, i.e. only products available in 2015-20 for a given month are considered.[24] Moreover, we exclude very few energy items, since they cover only a minor share of the corresponding HICP component. Finally, we also distinguish price changes with and without sales, either based on an NSI flag (DE, IT, LV) or – if unavailable in the country micro price dataset – on a sales filter approach (SK). Our baseline statistics include price changes due to sales.[25]

22 The sample of processed food products in the Italian dataset is limited (16% of processed food compared with the years 2015-19) and represents prices in small stores only. For unprocessed food, few products are available, as most unprocessed product prices are collected bi-monthly and are therefore not included in the Italian CPI micro dataset.

23 Since the Eurostat guidelines introduce some new imputation methods, the current structure of the micro database for Germany in 2020 does not allow complete tracking of all imputed prices; for this purpose, we also exclude ECOICOP-5 groups that are flagged as "low reliability" by Eurostat ("u" flag when the share of imputations for an aggregate exceeds 50%, see Eurostat, 2020a). Based on this definition, the resulting respective expenditure shares of products that underwent temporary lockdown measures in the spring of 2020 are 16.3% for Germany, 26.8% for Italy, 5.7% for Latvia and 34.3% for Slovakia.

24 Table A1 in the appendix provides some details of the product sample with respect to the coverage of major product groups and corresponding sub-groups. Since most prices in the national databases were collected on-site in stores, our datasets miss some centrally collected prices or administered prices (e.g. airfares, housing services, package holidays and communication services). Table A2 shows the share of all products by country that were consistently available in the period 2015-20.

25 See Gautier et al. (2022) for more details on the national micro price databases and the computation of price rigidity statistics. Concerning the aggregation to sub-sectors and total figures, we abstract differences in consumption structures across countries and apply the euro area ECOICOP-5 weight (average for 2017-20) for each country.

Table 2
National HICPs during the pandemic

Countries	% of euro area aggregate	% of imputed prices in national HICP*	Country response measures to COVID-19	National CPI micro dataset***	
				% of euro area HICP basket covered in 2020 (av. of 2017-19 in brackets)	Number of observations in 2020 (av. of 2017-19 in brackets)
Germany	27.6	13	• Stay-at-home orders (incl. partial): Dec 20-May 21 • Closure of non-essential shops: Mar-Apr 20, Dec 20-Mar 21 • Closure of restaurants/cafés: Mar-May 20, Nov 20-Apr 21	88.0 (88.0)	5,071,312 (5,658,333)
Italy	17.0	15	• Stay-at-home orders (incl. partial): Mar-May 20, Oct 20-June 21** • Closure of non-essential shops: Mar-Apr 20, Dec 20-Jan 21 • Closure of restaurants/cafés: Mar-May 20 (partial), Dec 20-Jan 21	50.4 (60.0)	1,511,763 (2,795,403)
Latvia	0.3	5	• Stay-at-home orders (incl. partial): Dec 20-Feb 21, Oct 20-Nov 21 • Closure of non-essential shops: partial only • Closure of restaurants/cafés: Nov 20-May 21	92.5 (89.9)	229,944 (223,557)
Slovakia	0.8	16	• Stay-at-home orders (incl. partial): Nov 20, Jan-May 21, Nov 21-Jan 22 • Closure of non-essential shops: Mar-Apr 20, Nov 21-Feb 22 • Closure of restaurants/cafés: Jan-Apr 21	76.9 (86.8)	705,971 (933,699)

Sources: Eurostat, European Centre for Disease Prevention and Control (ECDC) and own calculations based on national CPI micro price data.
Notes: *) Average value of April-July 2020 and November 2020-June 2021, as reported by Eurostat. **) In Italy, the second lockdown restrictions in 2020 were region-specific only. ***) before taking out the "low reliability" European Classification of Individual Consumption According to Purpose (ECOICOP)-5 groups according to Eurostat.

3.1.2 Overall price setting in 2020 and 2021

The overall frequency of price changes increased temporarily in most countries, mainly during the first wave of the pandemic and with the strongest reaction in Italy (Chart 10).[26] Based on a constant sample of products, which were available during all months of 2015-21, the frequency of price changes increased during the first wave of the COVID-19 pandemic from March to June 2020 (the shaded grey area in the chart), but the magnitude of those changes differed across countries. Moreover, the severity of the crisis correlates with the size of the change in frequency. The reaction was strongest in Italy, the country most affected by the first wave of the pandemic, with an increase of around 10 percentage points in the overall frequency of price changes in May and June 2020. A similar pattern emerges

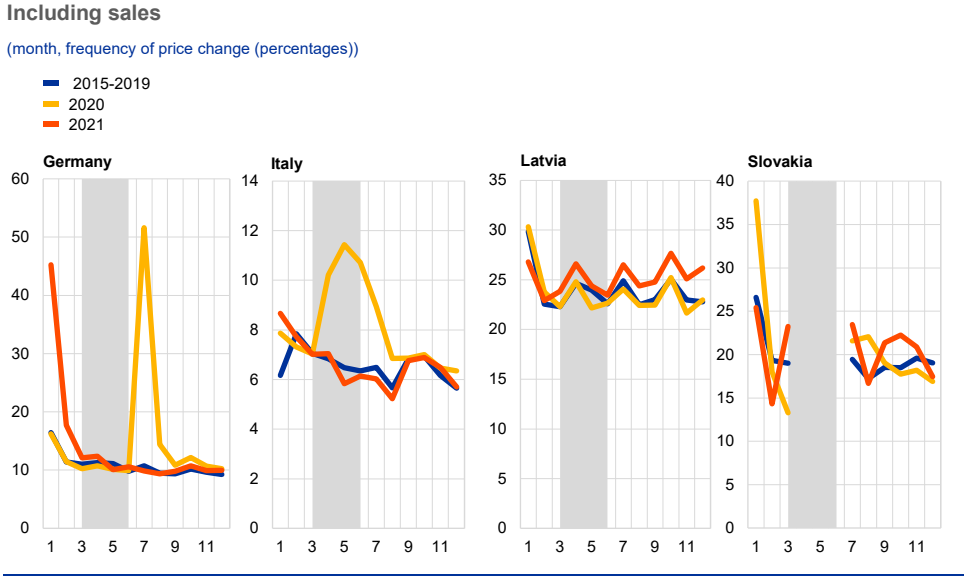
[26] For each country, only those ECOICOP-5-level products that were available in the particular country during all months of 2015-21 were used. To control for differences in consumption structures across countries, the euro area ECOICOP-5 weight (average of 2017-20) was applied.

when excluding price changes due to sales. In 2021, no significant changes in overall frequency can be observed, except for an increase in Latvia, and to some extent in Slovakia, in the second half of 2021, when headline inflation was picking up due to supply chain disruptions.

In the summer of 2020 and in early 2021, the increase in the frequency of price changes in Germany clearly reflects the temporary VAT cut. This government measure was introduced with effect from 1 July to 31 December 2020, with a reduction from 19% to 16% in the regular VAT rate and from 7% to 5% in the reduced VAT rate. Consequently, the frequency of price changes in Germany increased to more than 50% in July 2020. Likewise, it rose to 45% in January 2021 with the re-implementation of standard VAT rates (see also Box 1).

Chart 10

Overall frequency of price changes by month (2021 and 2020 vs 2015-19)



Source: Own calculations based on national CPI micro price data.
Notes: 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 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).

In a month-by-month comparison, a simple ordinary least squares (OLS) regression helps to evaluate the significance of the impact of the first wave of the pandemic on price setting. Subsequently, the price-setting statistics at the product-country level are related to month-fixed effects. In contrast to the above comparison, the product sample is constant only in the same months of 2019 and 2020 (e.g. April 2019 and April 2020). Chart 11 plots the respective coefficients and confidence intervals, comparing the pandemic year 2020 with 2019 in terms of the frequency and size of price increases and decreases, as well as the share of sales.[27] Note that, in this exercise, we consider the absolute size of price increases and

[27] We compare the pandemic year with the previous year, rather than a period average, here and in the following charts, to control for changes in the share of sales in the recent years of the analysis, so as not to mistakenly attribute this effect to the COVID-19 pandemic.

decreases, such that a decline in the coefficient represents a decline in the absolute magnitude of a price increase or decrease.

According to our regression approach, no significant changes in the frequency and size of price changes are observed in Germany during the first wave of the pandemic, but the VAT cut becomes evident in the microdata in July 2020. As shown in the first row of Chart 11, the reduction of the VAT rates in July 2020 is reflected by a sharp increase in the frequency of price cuts (red dot in Chart 11) and a substantial drop in their absolute size, respectively. The frequency of price decreases rose by roughly 40 percentage points relative to July 2019, driving the overall increase in the repricing rate.[28] The absolute size of price decreases fell by over 12 percentage points, i.e. price cuts happened in July 2020 much more often and were on average less negative than in July 2019,[29] but more in line with the magnitude of the size of the VAT cut.[30] In the subsequent months, price cuts in Germany continued to be only marginally more frequent, while price decreases and increases both continued to be significantly smaller in terms of absolute size. The impact of the temporary VAT cut is discussed further in Box 1.

In Italy, the increase in the frequency of price changes was accompanied by a significant decrease in the absolute size of price changes. To some extent, this was also the case in Latvia, whereas changes in price setting were largely insignificant in Slovakia. In Italy, the frequency of both price increases and decreases rose sharply during the first wave of the pandemic, accompanied by a significant decrease in the absolute size of positive and negative price changes. In Latvia, the most significant effect materialised through a lower size of price adjustments in April and May 2020. In Slovakia, no significant changes in the frequency or size of price changes during the post-COVID period can be observed. Finally, some non-systematic changes in the share of sales (excluding services)[31] can be seen for all four countries, as shown in the last column of Chart 11.[32]

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28 Fewer than 5% of all prices are lowered in a typical month in Germany, see Gautier et al. (2022).

29 In July 2020, the median price cut was only -4.6%, with a frequency of price cuts of 44.5%, compared with a median price cut of -19% in July 2019 and a frequency of price cuts of only 5.2%.

30 Note that, when comparing with the actual German HICP, the average size of price changes, rather than the median size of price decreases, should be considered (see Box 1).

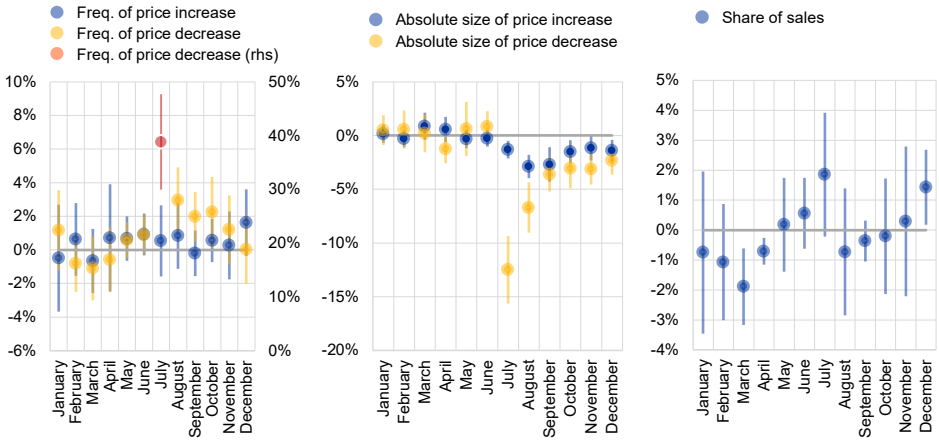
31 See also Chart A1, which plots the level of the share of price changes due to sales in 2019 and 2020.

32 In Slovakia, the share of sales in November and December was unusually high for clothing and footwear, furnishings and culture and recreation. The share of sales in other product categories was roughly in line with the pre-COVID period.

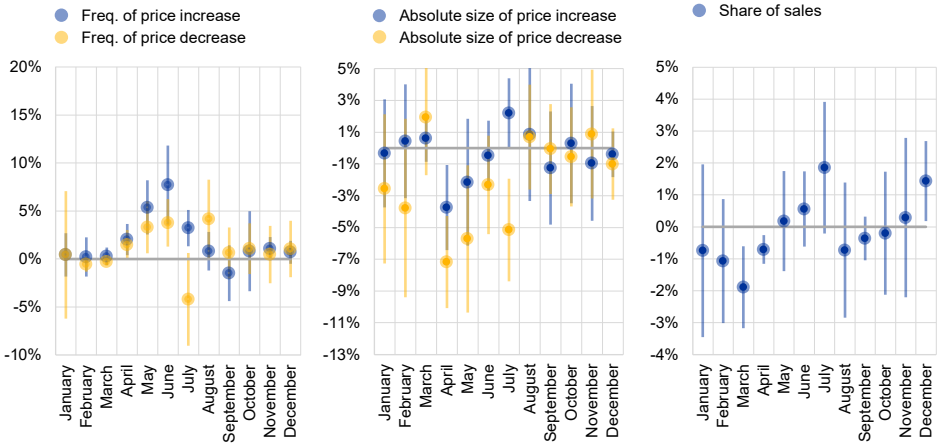
Chart 10

Variability of change in frequency and size by month (2020 vs 2019, incl. sales)

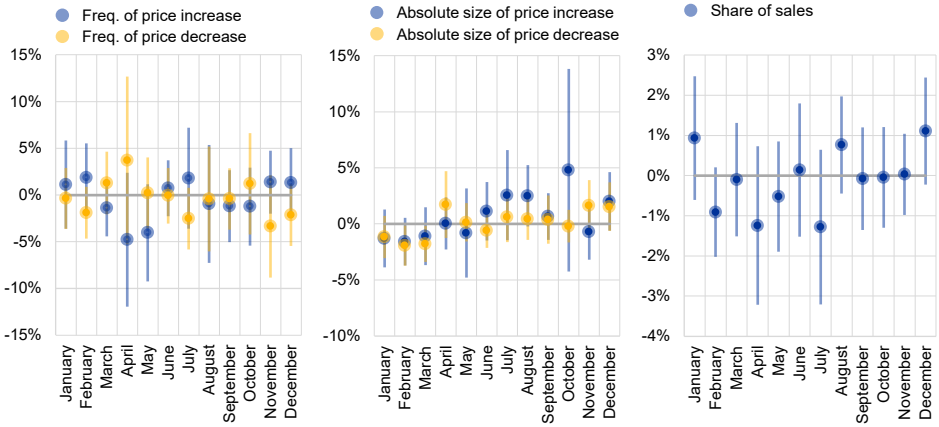
a) Germany



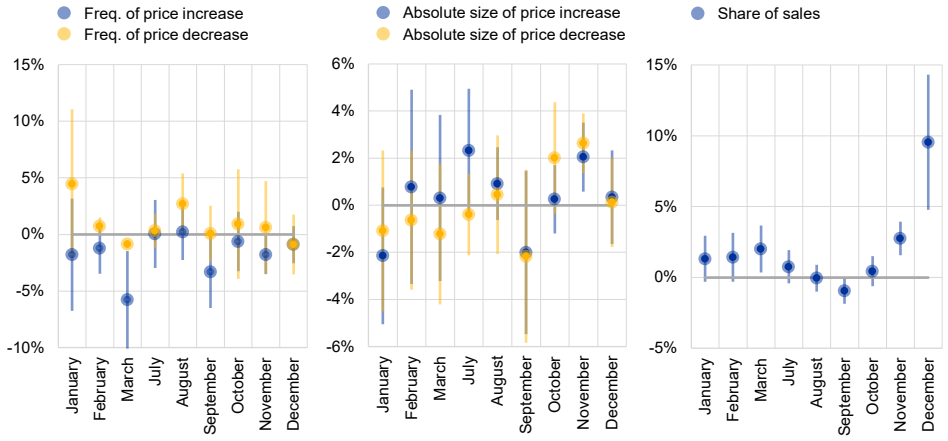
b) Italy



c) Latvia



d) Slovakia



Source: Own calculations based on national CPI micro price data.
Notes: The coefficients plot month-specific time effects of 2020 compared with 2019, derived from country-specific weighted regressions with ECOICOP-5 fixed effects and euro area HICP weights (2017-20 average), and the bars represent 95% confidence intervals. Dependent variables are frequency and absolute size of price changes (including sales) as well as the share of sales. A negative value indicates a decline in the frequency/absolute size of price changes/share of sales in 2020 compared with 2019. Only products available during the sample 2015-20 for a chosen country and corresponding month are selected. No observations for Slovakia for April-June 2020. The red dot in the first panel denotes the frequency of price decrease in July 2020 in Germany (due to scaling issues).

To put our findings in context, the change in the frequency observed in Italy in 2020 is at least as large as the change in the frequency observed during the Global Financial Crisis (GFC) in the euro area during 2008-09. According to the regression estimates in Figure 3 of Gautier et al. (2022), the average monthly frequency of positive and negative price changes in the euro area during the GFC in 2008-09 was significantly higher (+1 percentage point) than in the base year 2013. For Italy, we obtain a similar number (+1.1 percentage points) when computing the average change in the frequency during all 12 months of 2020 (compared with 2019). This evidence thus suggests that state dependence and ensuing non-linearities in price setting in the euro area matter in periods of elevated aggregate volatility.

3.1.3 Price setting across sectors

The economic impact of the COVID-19 pandemic has been very heterogenous across sectors. Moreover, sectoral heterogeneity in the price-setting effects of the GFC is also apparent, with services being affected the least and goods the most, whereas sectoral differences are also an inherent part of overall price setting (see Gautier et al., 2022). This section analyses price setting during the first year of the pandemic in four main sectors: processed food, unprocessed food, NEIG and services.

The largest changes in frequency of price changes were observed in the goods sector, particularly in Italy during the first wave of the pandemic, and in Germany, due to the temporary VAT reduction. Chart 12 shows the change in the frequency of price increases and decreases in each sub-sector separately, comparing a given month in 2020 with the corresponding month in 2019, whereas

Chart A3 in the appendix provides details on the significance of the effect.[33] In Germany, no significant changes can be observed at the sectoral level during the first wave of the pandemic. In contrast, the effect of the VAT reduction is especially notable for food and NEIG products, where the frequency of price decreases picked up by 60 percentage points in July 2020. The relatively lower effect of the VAT reduction on services (where the frequency of price reductions nevertheless increased by about 15 percentage points) is consistent with findings at the aggregate price level (see Deutsche Bundesbank, 2020, and Box 1 for further details). In Italy, frequencies of price changes (both positive and negative) increased strongly between April and June 2020 for NEIG, as well as processed and unprocessed food.[34] Moreover, the services repricing rate increased markedly in June 2020, by 8 percentage points. In Latvia and Slovakia, frequencies during 2020 were more or less similar to those observed in 2019, with higher occurrences of price decreases.[35]

The absolute size of price increases and decreases seemed to decline somewhat during 2020 across most sectors and countries (Chart 13). A decline in the absolute size of price changes (both increases and decreases) can be observed, mainly for food and NEIG products.[36] In Germany, no major impact is found during the first wave of the pandemic, whereas the effect of the VAT cut in July 2020 resulted in a smaller absolute size of both negative and positive price changes in processed food and NEIG. In contrast, in Italy, the absolute size of positive and negative price changes became considerably smaller for food items and NEIG from April to June 2020. In Latvia, the absolute size of price changes also declined somewhat during the first wave of the pandemic. In contrast, for Slovakia, in the second half of 2020, increased volatility in the size of price changes becomes apparent, with no clear pattern.

The share of sales underwent some unsystematic changes in the individual months of the 2020 pandemic year. As reflected in Chart A3 in the appendix, a lower share of sales in unprocessed food can be observed for Italy in the first half of 2020 and for Germany in April 2020. In Italy, the share of sales in processed food declined in March and May 2020; moreover, the share of sales in NEIG dropped in July, due to a change in the timing of the summer sales in Italy. In Slovakia, the share of sales in NEIG increased strongly in the fourth quarter of 2020.[37] Altogether, these idiosyncratic shifts in sales may have introduced additional volatility in HICP inflation, but overall do not seem to have led to persistent changes.

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33 Chart A3 in the appendix plots the respective coefficients and confidence intervals from the OLS regression, comparing the 2020 pandemic year with 2019 for each sub-sector.

34 Note the data limitations concerning food prices in the Italian CPI micro dataset stated above.

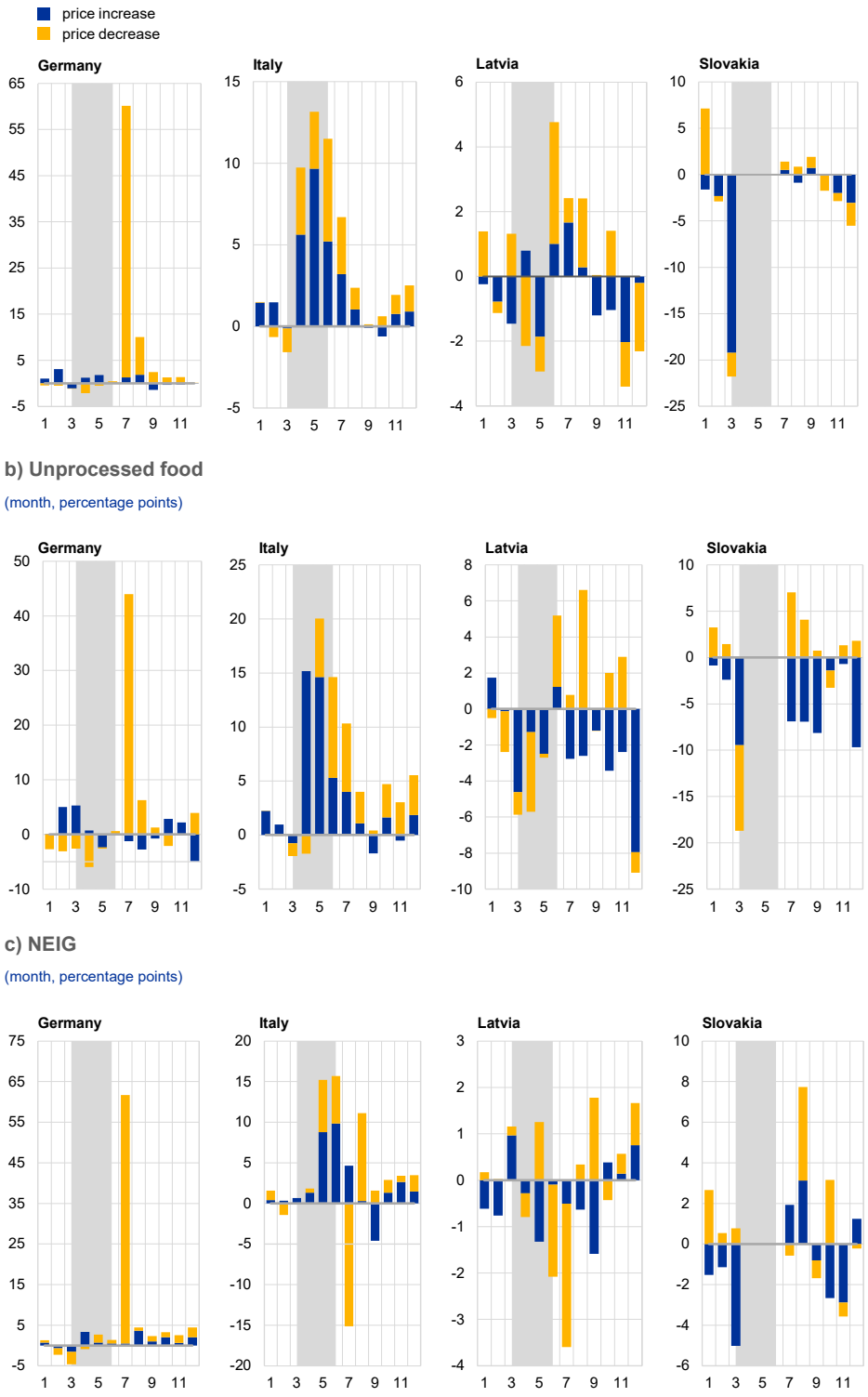
35 These conclusions also hold for frequencies excluding sales.

36 Again, this finding holds for frequencies excluding sales.

37 See Chart A1 on the level of the share of price changes due to sales in 2019 and 2020.

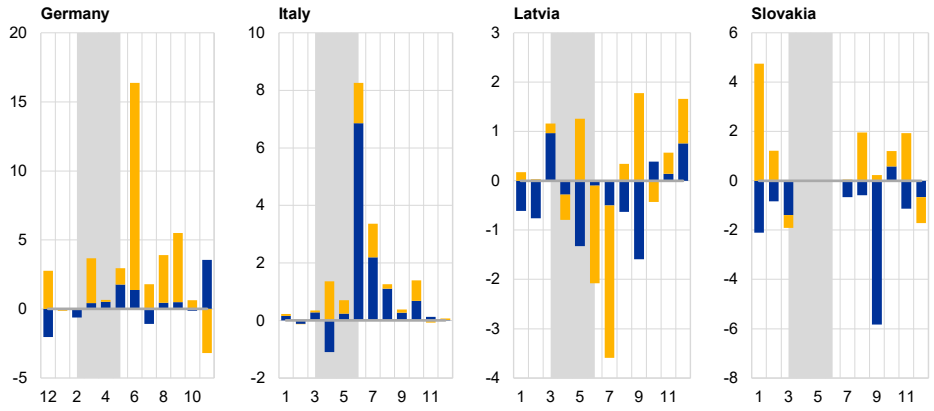
Chart 11

Annual change in the frequency of price increases/decreases by month (2020 vs 2019, incl. sales)



d) Services

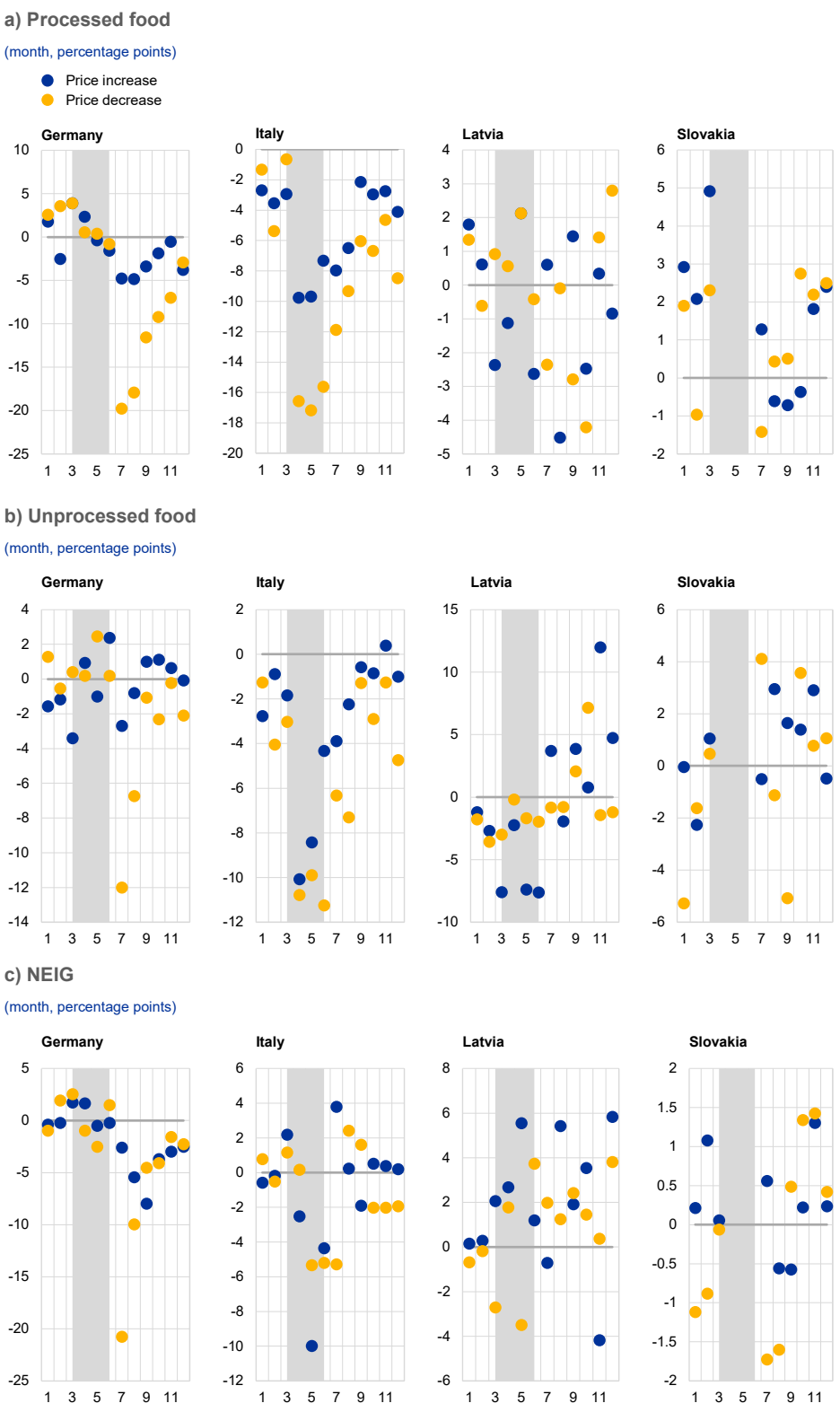
(month, percentage points)



Source: Own calculations based on national CPI micro price data.
Notes: This chart shows the difference between the frequencies in 2020 compared with 2019 (including sales). A positive value indicates an increase in the frequency of price changes. The 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 2020. The statistics are weighted using euro area HICP weights (2017-20 average). Only products available during the sample 2015-20 for a chosen country and corresponding month are selected.

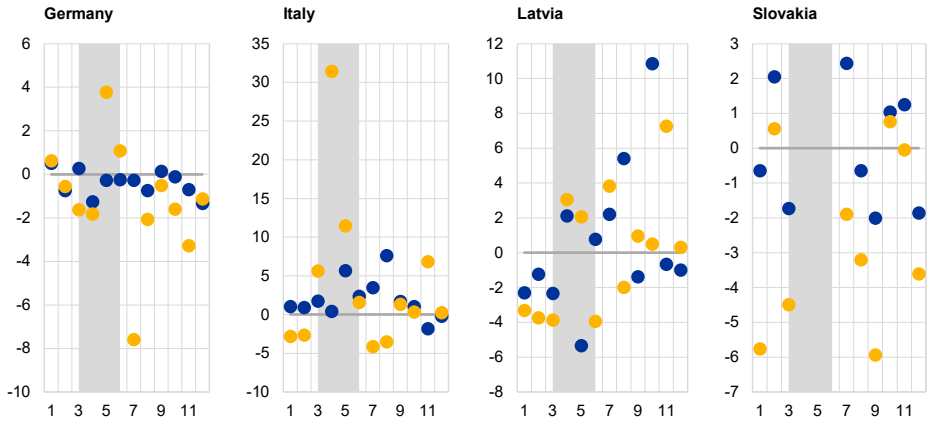
Chart 12

Change in median absolute size of price increases/decreases by month (2020 vs 2019, incl. sales)



d) Services

(month, percentage points)



Source: Own calculations based on national CPI micro price data.
Notes: This chart shows the difference between the absolute size of price changes in 2020 compared with 2019 (including sales). A positive value indicates an increase in the absolute size of price changes, whereas a negative value indicates a reduction in the absolute size of price changes. The 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 2020. The statistics are weighted using euro area HICP weights (2017-20 average). Only products available during the sample 2015-20 for a chosen country and corresponding month are selected.

3.1.4 Price setting for selected COVID-19-affected products

The COVID-19 pandemic and the related lockdown measures most notably hit contact-intensive services and stationary retailers of non-food items, such as clothing and footwear. Examples of sectors which underwent temporary closures during the first wave of the pandemic were services, such as restaurants and hairdressers, as well as brick-and-mortar retailers of non-food goods, such as clothing and footwear. Moreover, demand may have remained lower for fashion goods even after the lifting of the lockdowns, for example, due to the still widespread working-from-home arrangements. Below, we analyse whether price setting changed for these selected products after the first wave of the COVID-19 pandemic, analysing price setting from August to October 2020.

Overall, contact-intensive services, such as hairdressing and restaurants, tend to show more price increases, while clothing and footwear goods tend to show more price decreases, consistent with a differential demand effect or reopening costs. Chart 14 displays the change in the monthly frequency of price increases and decreases for selected products in August, September and October 2020, compared with the corresponding month in 2019. According to the frequency of price changes including sales, repricing in services such as hairdressing and restaurants marginally increased upon reopening, with the main effect coming from slightly more frequent price increases. Conversely, the absolute size of price changes in these services did not change or even declined (Chart A2 in the appendix). The main exception is Latvia, with a somewhat lower share of upward price adjustments in the hairdressing sector, but a more pronounced decline in the absolute size of adjustment.

In clothing and footwear, the main effect concerns the change in the timing of sales in Italy, which started later in 2020 compared with 2019,[38] **and also to some extent in Germany.** When excluding sales (see also Chart 14), prices of clothing and footwear in Germany and Italy were adjusted downwards more frequently, accompanied by smaller absolute price adjustments. For Germany, a delayed pass-through in the light of the VAT cut in July might well be at play. Moreover, prices of clothing and footwear in Germany were also changed upwards more frequently than in 2019. In Latvia, frequencies for clothing and footwear remained quite stable, with the main adjustment coming from a larger size of price increases and a smaller size of price decreases. In Slovakia, the main driver was a lower frequency of price decreases (the opposite of what can be observed in Italy and Germany).

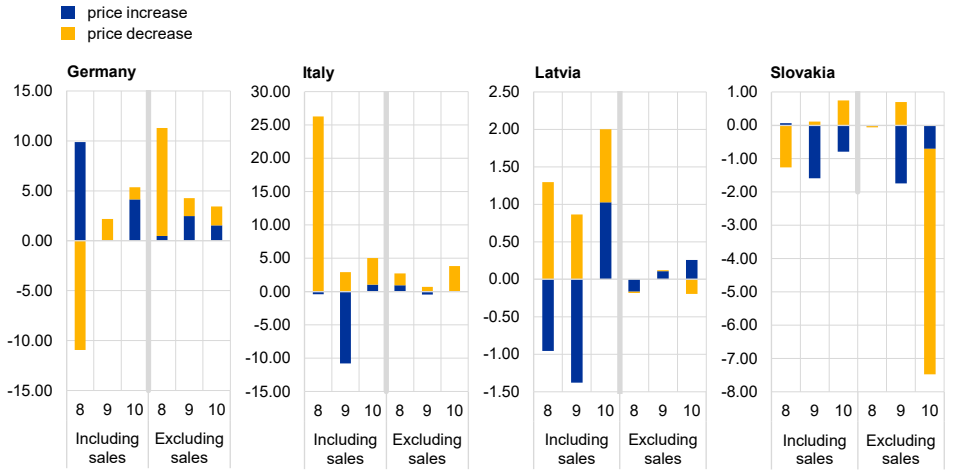
[38] In Italy, the summer season sales period started later, from August to September 2020, when it usually lasts from July to August.

Chart 13

Annual change in the frequency of price increases/decreases at the product level after lockdown measures in August-October 2020

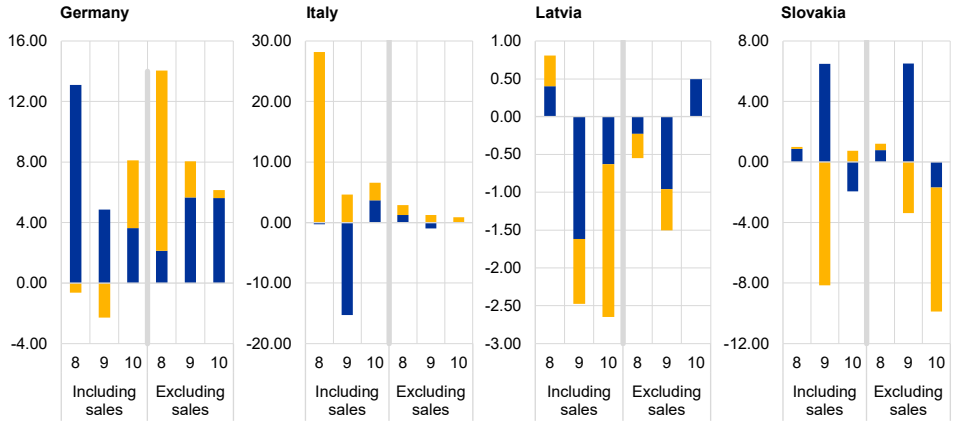
a) Clothing

(month, percentage points)



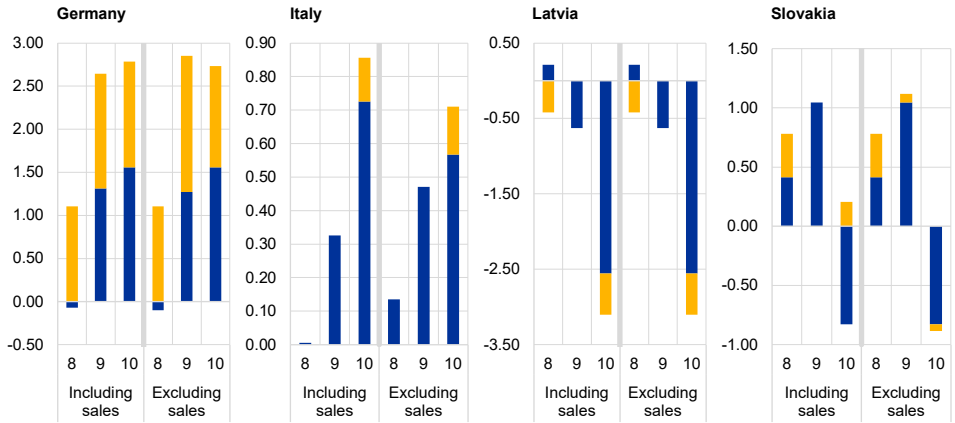
b) Footwear

(month, percentage points)



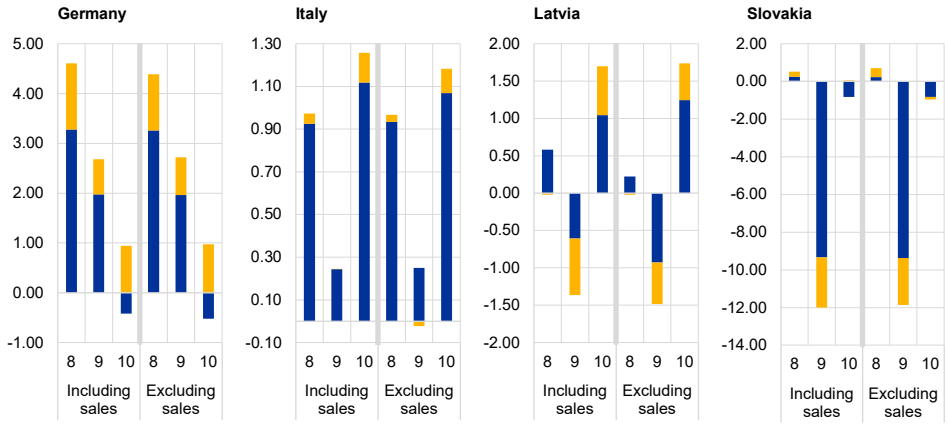
c) Hairdressing

(month, percentage points)



d) Restaurants

(month, percentage points)



Source: Own calculations based on national CPI micro price data.
Notes: This chart shows the difference between the frequencies in the corresponding month of August to October 2020 and 2019 (including and excluding sales). A positive value indicates an increase in the frequency of price changes.

Box 1

Price setting in Germany in the light of the temporary value added tax cut in 2020: evidence from micro price data

As an economic stimulus response to the coronavirus (COVID-19) pandemic, on 3 June 2020, the German Federal Government announced that it would lower value added tax (VAT) rates temporarily from 1 July to 31 December 2020. Consequently, the regular rate was decreased from 19% to 16%, and the reduced rate, which mainly applies to food (excluding beverages), newspapers and books, was lowered from 7% to 5%.[39] The size and the temporary nature of the tax cut were unprecedented in Germany and also remarkable in an international context. Assuming an immediate and complete pass-through of the cuts across the different VAT rates applied to the various categories of the Classification of Individual Consumption According to Purpose (COICOP) would have implied an inflation rate that was 1.8 percentage points lower in every month in the second half of 2020 (see Deutsche Bundesbank, 2020). This box analyses how evidence from official CPI microdata and web-scraped data complements evidence from disaggregate figures of the Harmonised Index of Consumer Prices (HICP) concerning the actual pass-through of the temporary VAT cut.

Analysis based on aggregate HICP data showed that the temporary VAT cut was reflected less strongly in inflation than would have been expected in the case of a full pass-through. In July 2020, the HICP headline rate fell from 0.8% to just zero. Nevertheless, when controlling for relevant cost factors within a regression-based approach, around two-thirds of the VAT cut seemed to be passed on to consumers (see Deutsche Bundesbank, 2020 and 2021b). A full and immediate pass-through could be observed for food prices and a partial pass-through for non-energy industrial goods (NEIG). For some of these goods, the aggregate price reduction even exceeded the VAT cut. In contrast, just one-third of the lower tax rate seems to have been passed on to services, which were facing high revenue losses and extra costs due to COVID-19 measures. Altogether, the VAT change seems to have been passed on by just over 60% to headline HICP inflation on average. Moreover,

[39] The reduced rate is also imposed on water supply, pets and related products and some services (accommodation, passenger transport by railway and combined passenger transport). Overall, the reduced rate applies to about 15% of the underlying HICP basket.

price adjustments in July 2020 and January 2021 seem to have mostly cancelled each other out, implying that the temporary VAT cut had no long-lasting impact on the aggregate price level.[40]

Analysis of German consumer price index (CPI) microdata sheds some light on the price-setting mechanism by outlet type, which is available until December 2021, and also forms the basis of the German HICP.[41] In total, we consider seven different types of outlets: discounters, supermarkets, specialist shops, department stores, other retailers, online stores and service companies. We also consider six different HICP categories: unprocessed food, processed food, NEIG (non-durables, semi-durables and durables) and services. Note that we restrict our sectoral analysis to those outlet types that cover a significant share (at least seven product groups) of a given HICP category; this yields roughly 450 product groups in total.[42] Moreover, the analysis of the reinstatement of VAT rates in January 2021 is hampered by the fact that non-essential shops had to close during that period (Table 2). After dropping any estimated (imputed) prices from the dataset, the number of price spells for specialist shops and department stores drops substantially: hence, these two store types are mainly excluded from the analysis in January 2021.

Evidence from the CPI microdata shows that the degree of pass-through of the temporary VAT cut varies significantly across sectors and outlet types. Chart A shows the frequency of price changes in July 2020, when the VAT cut was introduced, and January 2021, when regular VAT rates were reinstated, together with their historical monthly average (2015-19). Concerning food, nearly full pass-through can be observed for the "discounters" and "supermarkets" outlet types in July 2020, with a frequency of price changes well above 90% and 80%, respectively. In contrast, only every second food price in German specialist shops was lowered in July 2020. Concerning non-durables, discounters and supermarkets also registered the highest frequency of price changes, with 91% and 77%, whereas only two-thirds of prices changed in online stores and specialist shops. For semi-durables and durables, supermarkets – which only cover a relatively small expenditure weight in these HICP categories – had the highest share of price cuts, with more than 80%. Notably, the share of price changes in July 2020 is lower for online stores than for most offline stores. This finding contrasts strongly with the historical average frequency in July, which is generally higher for online stores than for offline stores. Finally, service companies exhibit the lowest pass-through in terms of the share of price changes, with only one-tenth of prices being changed in the first month of the VAT cut.

Likewise, the reinstatement of standard VAT rates in January 2021 triggered a rather non-uniform reaction across outlet types. Whereas supermarkets and discounters showed a weaker reaction in terms of the frequency of price changes, with less symmetric price increases in January 2021 than price decreases in July 2020, a fairly symmetrical response can be observed for online stores. For services, the frequency of price changes in January 2021 was similar to the historical average of that month, which typically shows a higher repricing rate than other months (see also Gautier et al.,

40 This evidence, taken from a regression-based approach using CPI data at the ECOICOP-5 level, was also backed up by survey evidence from firms in the Bundesbank Online Panel (BOP): see Deutsche Bundesbank (2021b).

41 German micro price data are provided by the Research Data Center (RDC) of the Federal Statistical Office and Statistical Offices. See "Verbraucherpreisindex für Deutschland", EVAS 61111, 2015 - 2021, DOI: https://doi.org/10.21242/61111.2015.00.00.3.1.0 to https://doi.org/10.21242/61111.2021.00.00.3.1.0.

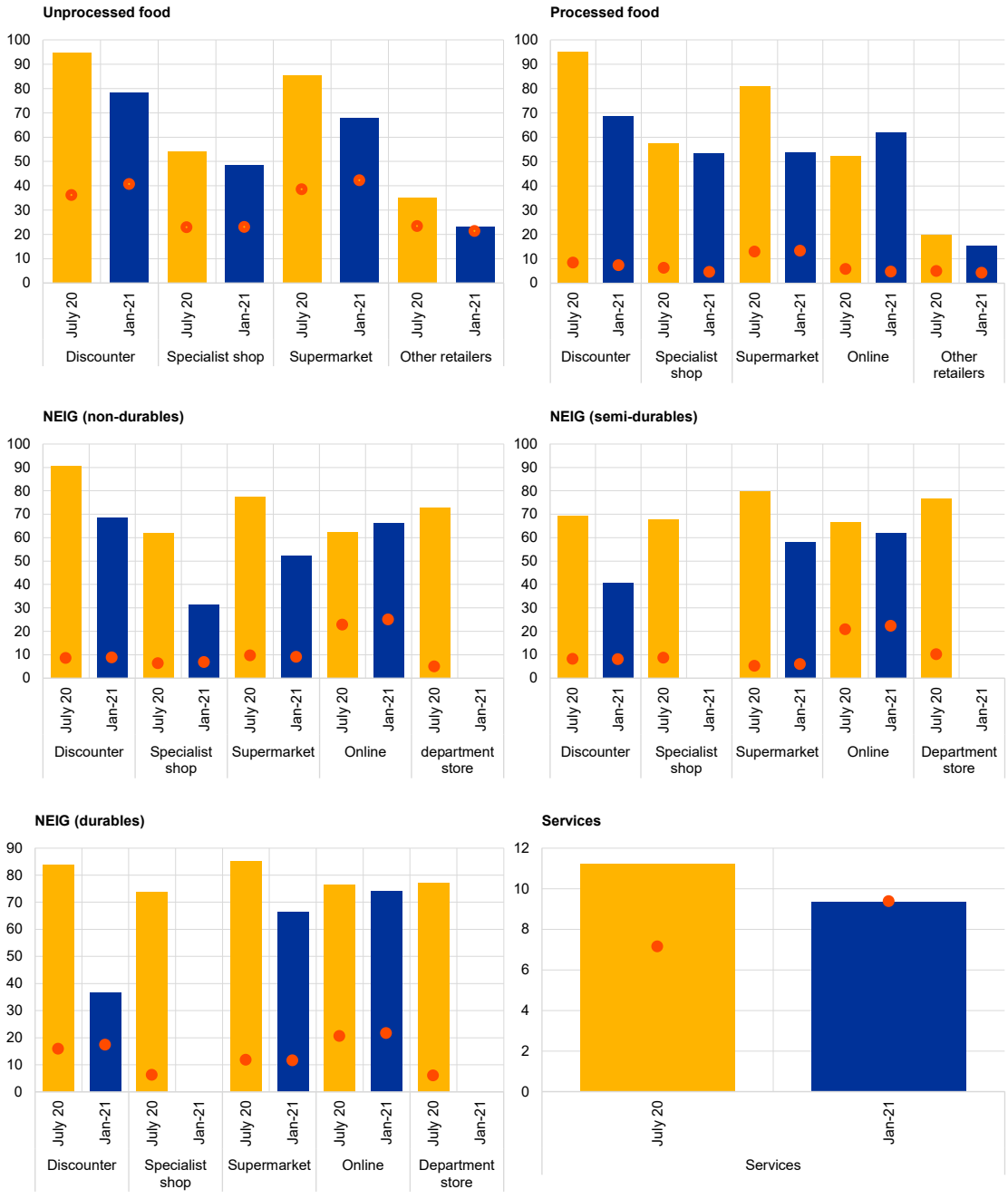
42 Nevertheless, even within a given HICP category, the sample of products covered may differ strongly across outlet types (e.g. the "online" outlet type also captures online-traded goods with no brick-and-mortar counterpart). See Strasser et al. (2023) for a detailed explanation of the outlet type-weighting in the German CPI and a comparison of consistent samples of online and offline goods at the product level.

2022). Across sectors, the highest pass-through in terms of the frequency of price changes is again found for food items.

Chart A

VAT change in Germany: frequency of price changes in July 2020 and January 2021

(percentages)



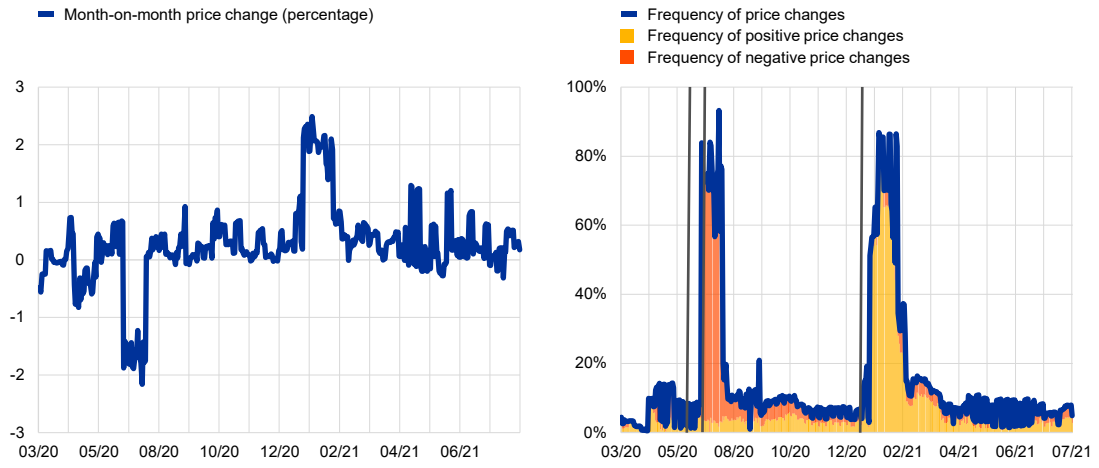
Source: Bundesbank staff calculation based on German CPI microdata.
Notes: The chart shows the frequency of price changes in July 2020 (cut in VAT rates, yellow bars) and in January 2021 (reinstatement of VAT rates, blue bars), together with their historical averages (2015-19). For each HICP category, only those outlet types which cover at least seven product groups are selected. The statistics are based on a constant sample of product groups by store type in July 2020 and January 2021 (446 product groups in total). The statistics for specialist shops and department stores in January 2021 are missing, due to a relatively low number of prices.

Web-scraped data from the ECB “Daily Price Dataset” (DPD) project show that online supermarkets lowered their food prices quickly in response to the VAT tax cut, but, again, the pass-through seems

to be less than full. The database covers German online supermarkets, containing information mainly on food, beverages and personal care items, which would correspond to roughly 20% of the German HICP basket. While there was no visible reaction of online supermarkets to the announcement of the VAT change in early June 2020, the price reaction to the VAT cut was quick and substantial (Chart B). Online supermarkets had already started lowering prices a few days before the implementation of the VAT cut, and by July 1, a substantial pass-through could be observed. The frequency of negative (month-on-month) price changes jumped to over 70%, indicating a substantial, but not fully complete, pass-through. The average size of (month-on-month) price changes also dropped to around -1.8% in July, in line with the average full pass-through for the overall HICP.[43] A reversed picture emerges at the beginning of January 2021: with the reinstatement of VAT rates to their previous levels, online supermarkets increased their prices again, in a way that was broadly symmetrical to the price decreases observed in July 2020, indicating a quick and full reversal of previous price cuts. The less-than-full pass-through of the VAT cut hides heterogeneity between online supermarkets: while some supermarkets decreased the prices of more than 90% of their products in the week of the VAT cut, other online supermarkets reacted more slowly and to a lesser extent, leading to less-than-full pass-through.[44]

Chart B

VAT change in Germany: assessing pass-through based on daily web-scraped data



Source: ECB staff calculations.
Notes: Web-scraped data from German online supermarkets, mainly containing information on food, beverages and personal care items. Data are collected daily. The left-hand chart shows the daily unweighted average of four-week price changes. Four-week price changes are calculated as the percentage change in the price of a product on a given day, compared with the price of the same product on the same weekday four weeks previously. The right-hand chart shows the daily share of products that experienced a price change by comparison with four weeks previously. Latest observation: 26 July 2021.

Overall, micro price data help us to understand the underlying mechanisms in the pass-through of macroeconomic shocks, such as Germany's temporary VAT cut. The micro price evidence presented above confirms the high, but incomplete, pass-through found in the aggregate inflation figures. The CPI microdata show that the pass-through of the VAT cut in terms of frequency varied widely across outlet types, with the highest pass-through in July 2020 for food and non-durable products at discounters, and the most symmetrical response to the reinstatement of VAT rates in January 2021 in online stores. Likewise, web-scraped data for online supermarkets reflect a broadly symmetrical reversal of price changes in January 2021. Moreover, given their high frequency, the

43 When considering only food prices, the assumption of full pass-through would have resulted in a figure of -2.1%.

44 The pass-through found here is higher than that reported by Fuest et al. (2021), who use data from only one online supermarket.

web-scraped data also provide a valuable tool in analysing the effects of economic shocks in real time (see Lane, 2021).

3.2 Online price setting during the pandemic

This section presents the development of the prices and availability of selected goods sold online since the outbreak of the COVID-19 pandemic in Poland.[45] Our analysis is based on online prices for processed and unprocessed food, hygiene and electronic products collected by Narodowy Bank Polski (NBP) using web-scraping techniques. Specifically, the data used constitute a relatively small excerpt from the database maintained for the E-CPI project developed at NBP since December 2009.[46] From the database, which contains almost 354 million quotations for 1.1 million products, a sample of around 43 million quotations for 108,275 products from 13 stores was selected.[47]

The real-time availability of web-scraped prices enables us to analyse developments in prices and availability, differentiating between the first (March-July 2020), second (August 2020-March 2021) and third (April-July 2021) wave of the pandemic in Poland. For this purpose, data of daily frequency spanning the period from 17 February 2020 to 26 July 2021 are aggregated to weekly frequency using weekly averages. In computing the availability of products in online stores, the reference point is set to the third week of February 2020, i.e. before the sharp increase in the number of COVID-19 infections in Europe. In turn, in computing statistics on price stickiness, the analysis is based on monthly data.[48] Data on the frequency of price changes and the size of price changes for food products cover the period from January 2017 to July 2021.[49] In other product groups, such as hygiene and electronics, the data on price stickiness range from September 2019 to July 2021.

Our main finding is that, despite the substantial pandemic demand and supply shocks, online price setting did not change significantly. Web-scraped data for Poland indicate that the outbreak of the COVID-19 pandemic contributed to a strong decline in the availability in food, hygiene, and electronic products, but did not trigger significant price increases. Concerning price setting, for food, the monthly frequency of price changes declined during the pandemic, while the regular price increases and decreases were somewhat higher than their long-term averages. In contrast, for hygiene products, both the frequency and size of price changes increased, mostly

45 Throughout the analysis, a product is assumed to be available in a specific store, if it is presented on the store's website with no indication of unavailability.

46 A description of the E-CPI project can be found in Macias et al. (2023).

47 This stems from the selection of products, as well as limitation of the time span of the sample. Further notes on product selection can be found in Box 3 in Strasser et al. (2023).

48 For online data within the E-CPI project, one price from the middle of the month was chosen in order to achieve comparability with the CPI data and avoid problems related to a higher frequency than the official price collection. However, prices in online stores often change more than once a month.

49 A detailed comparison of E-CPI food inflation with official CPI food inflation in Poland can be found in Strasser et al. (2023).

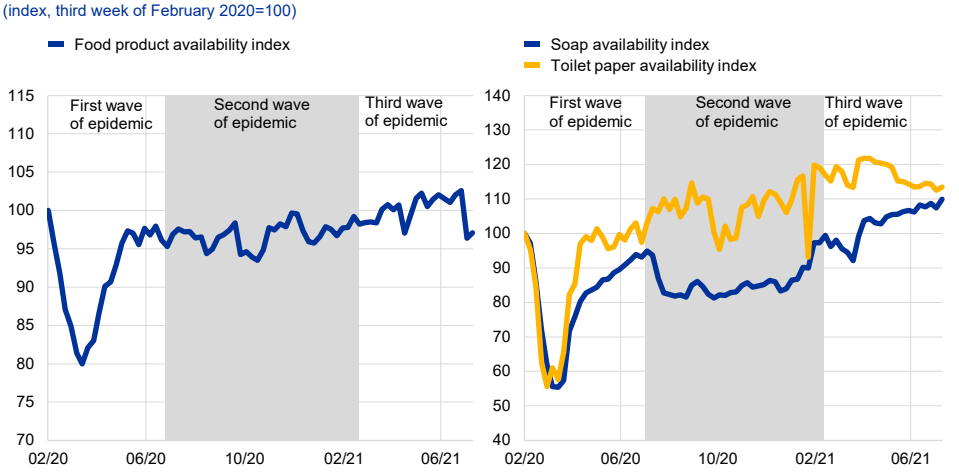
due to COVID-19. A similar reaction was observed for electronics, where the frequency and size of price changes for printers slightly increased during the pandemic, but mostly decreased for laptops. [50]

The discussion is organised as follows: Section 3.2.1 describes the evidence on availability and price setting for food and hygiene products. Section 3.2.2 analyses these aspects for electronic products.

3.2.1 Food and hygiene products

From mid-February to early April 2020, even before the onset of the first wave of the pandemic, the availability of food and hygiene products in online stores in Poland swiftly declined. This drop resulted from supply shortages, mass over-purchasing and panic-buying, triggered by the declaration of the state of epidemic (20 March) and lockdown (31 March). In late March and early April 2020, the number of food and hygiene products decreased by about 20%[51] and more than 40%, respectively, compared with the third week of February 2020 (Chart 15).

Chart 14
Change in the availability of food and hygiene products



Source: Narodowy Bank Polski.
Notes: The charts show the weekly single-base indices, which provide information about changes in the number of products during the COVID-19 pandemic compared with their number before the outbreak of the pandemic (third week of February 2020). The most recent observation is the last week of July 2021.

Since mid-April 2020, the availability of food and hygiene products started to improve. In the case of food, this mainly resulted from changes in offers due to the Easter season (in the second week of April) and a decline in precautionary demand (in the last two weeks of April), as socio-economic restrictions were being gradually

50 For Austria, Beer, Rumler and Tölgyes (2021) also analysed web-scraped prices for the period April to August 2020. They find only small price changes for most product categories over the observation period. For food, non-alcoholic beverages, personal care products and IT equipment, they find small price decreases.

51 At a lower level of aggregation, the greatest decreases in availability were related to the products suitable for long storage, especially frozen fish (67%), wheat flour (61%), frozen fruits (58%), rice (57%), groats (51%) and frozen vegetables and mushrooms (49%).

lifted. The latter factor also contributed to the increase in the availability of hygiene products. Consequently, the availability of toilet paper returned to the level of the third week of February in early May 2020. In the case of soap, this level was achieved in the second half of July 2020. During the second and third wave of the COVID-19 pandemic, there were no significant shortages in the availability of food and hygiene products. This was supported by an adjustment of online store offers, which increased the stock of necessary products. As a result, the number of food products remained relatively stable, at a level similar to that observed in the third week of February 2020. In turn, the number of hygiene products gradually increased, and in late July 2021, online stores were offering about 14% more toilet paper products and 10% more soap products than in February 2020.

Prices of food and hygiene products did not show a contemporaneous reaction to changes in availability during the period being analysed, according to model estimates. The decline in the availability of food and soap was associated with an overall increase in their prices, while the lower availability of toilet paper was accompanied by price decreases on average (Charts A4 and A5 in the appendix). While the direction of change in prices following shortages is as expected for the first two product groups, for the third it is counterintuitive. However, all these dependencies are statistically insignificant, according to OLS estimates (Table 3).[52] In turn, Cavallo and Kryvtsov (2023) have analysed links between stock-outs and inflation using a detailed micro dataset. They show that food product shortages were significantly associated with rising prices in the United States, whereas for other goods (including personal care products), stock-outs and inflation move in opposite directions.

The monthly frequency of price changes for food, including sales, declined during the COVID-19 pandemic. In particular, during the first and second wave of the pandemic, the frequency of price changes was 25.0% and 23.6%, respectively, slightly below their average level for 2019 (27.8%) and their long-term average (30.7%; Chart 16). In addition, the frequency of sales decreased from 9.3% in March 2020 to 6.7% in July 2021 and remained constantly below the 2019 average (10.0%). The absolute size of sales price increases and decreases during the pandemic remained relatively unchanged at 27.4% and 19.9% (compared with 28.6% and 19.5% in 2019). Also, the frequency of price changes excluding sales was relatively stable after the COVID-19 outbreak and equal to the 2019 average (17.7%). The absolute size of regular price[53] increases and decreases for food products during the pandemic was somewhat higher than their long-term average (18.3% and 14.7%, compared with 13.6% and 11.0% in 2017-19; Chart 17).

Concerning hygiene products, both the frequency and the absolute size of price changes mostly increased during the COVID-19 pandemic. Around 24.8% of regular soap prices and 14.1% of regular toilet paper prices changed from March 2020 to July 2021, more than in the second half of 2019 (14.7% and 12.0%; Chart

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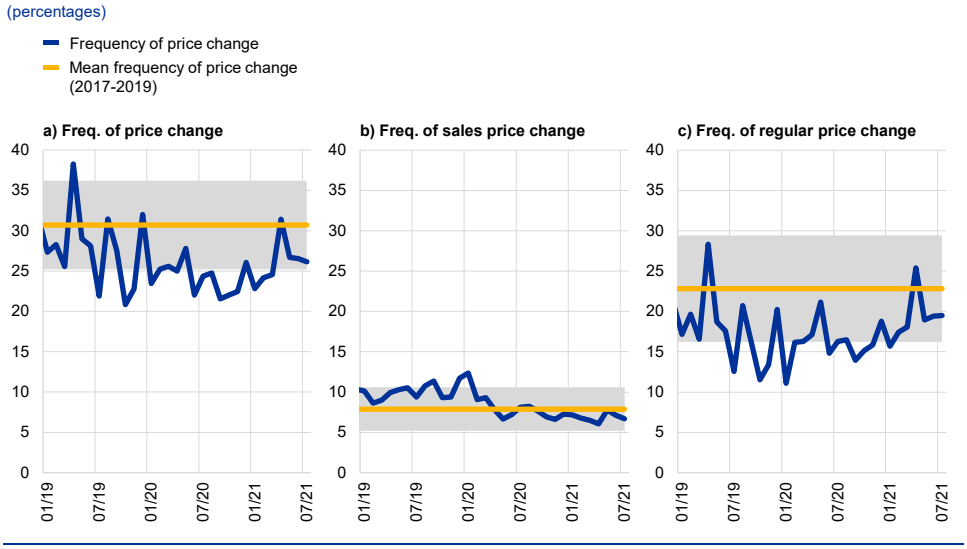
52 One possible explanation is related to the market structure in Poland. The food market in Poland is highly competitive, due to the expansion of modern sales channels, mostly discounters and supermarkets. Their commitment to retain their market share by pledging to fix the prices of basic necessities could attenuate the volatility of the prices of many primary products.

53 Regular prices are defined as prices excluding sales prices.

18). During the pandemic, the absolute size of regular price increases of soap and toilet paper was 13.4% and 14.7%, whereas in 2019 it amounted to 10.4% and 15.3% (Chart 19). Conversely, the absolute size of regular price decreases was 12.8% and 13.7%, compared with 11.3% and 10.2% in 2019. In addition, the frequency of sales of soap and toilet paper amounted to 15.4% and 16.7%, respectively (17.0% and 16.1% in the second half of 2019). During the pandemic, sales price increases fell in comparison with 2019 (35.1% and 29.4%), to 31.7% and 28.8% for soap and toilet paper. The sale price decrease was also slightly lower than in 2019.

Chart 15

Frequency of price changes for food products (including and excluding sales)

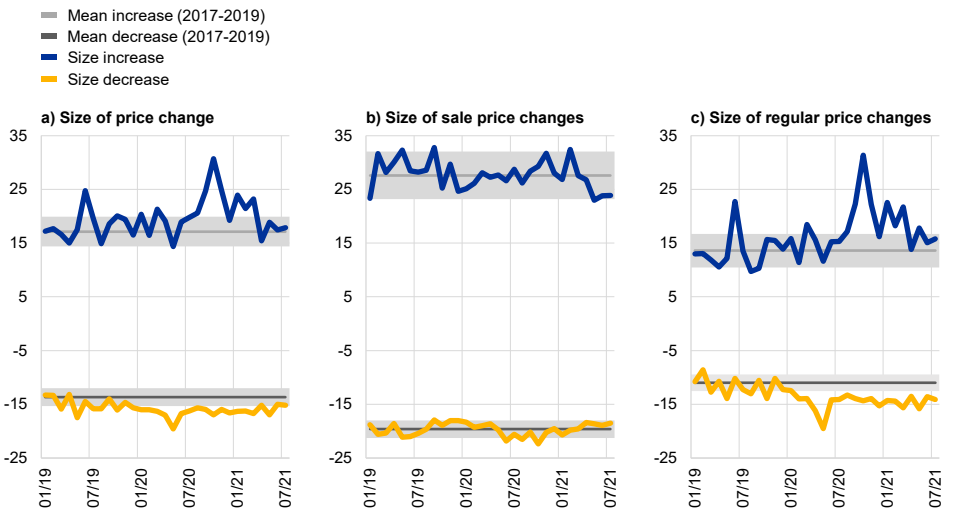


Source: Narodowy Bank Polski.
Notes: The charts show monthly frequencies (blue line). To calculate the frequency of price changes, one price was chosen, observed around the middle of the month. The mean frequency was calculated for 2017-19 (yellow line). The range of ±1 standard deviation is shown as a grey box and is calculated using data from 2017-19. The latest observation is in July 2021.

Chart 16

Size of price changes for food products (including and excluding sales)

(percentages)

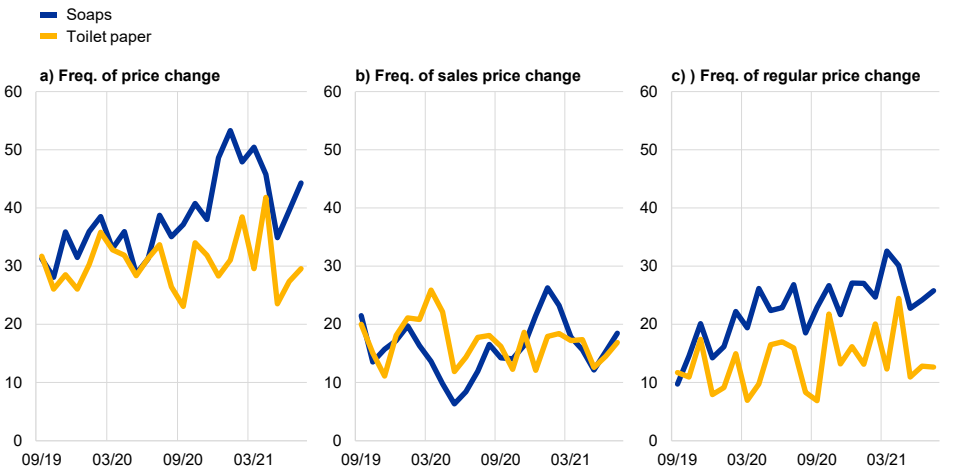


Source: Narodowy Bank Polski.
Notes: The charts show the size of monthly price changes. To calculate the size of price changes, one price was chosen, observed around the middle of the month. The mean frequency was calculated for 2017-19. The range of ±1 standard deviation is shown as a grey box and is calculated using data from 2017-19. The latest observation is in July 2021.

Chart 17

Frequency of price changes for soap and toilet paper (including and excluding sales)

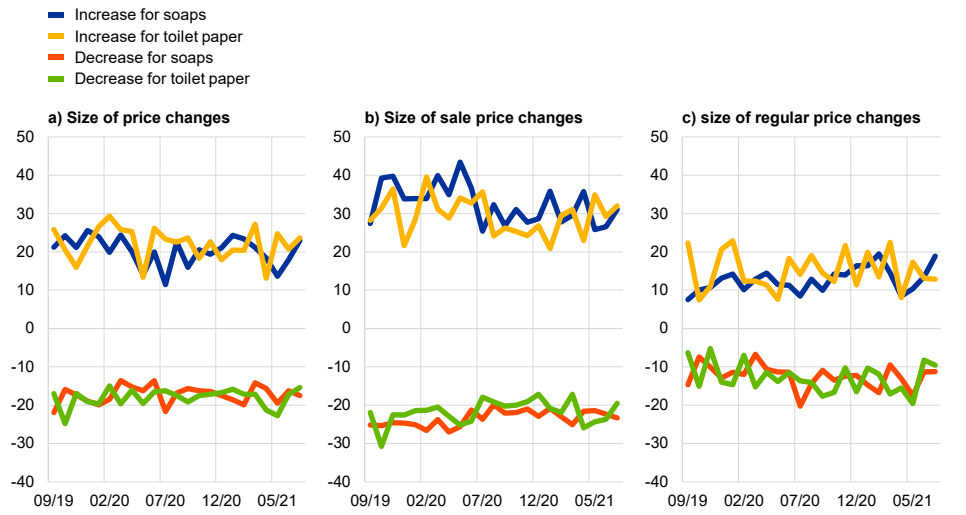
(percentages)



Source: Narodowy Bank Polski.
Notes: The charts show monthly frequencies. To calculate the frequency of price changes, one price was chosen, observed around the middle of the month. The data start in September 2019. The latest observation is in July 2021.

Chart 18

Size of price changes for soap and toilet paper (including and excluding sales)



Source: Narodowy Bank Polski.
Notes: The charts show the size of monthly price changes. To calculate the size of price changes, one price was chosen, observed around the middle of the month. The data start in September 2019. The latest observation is in July 2021.

3.2.2 Electronic products

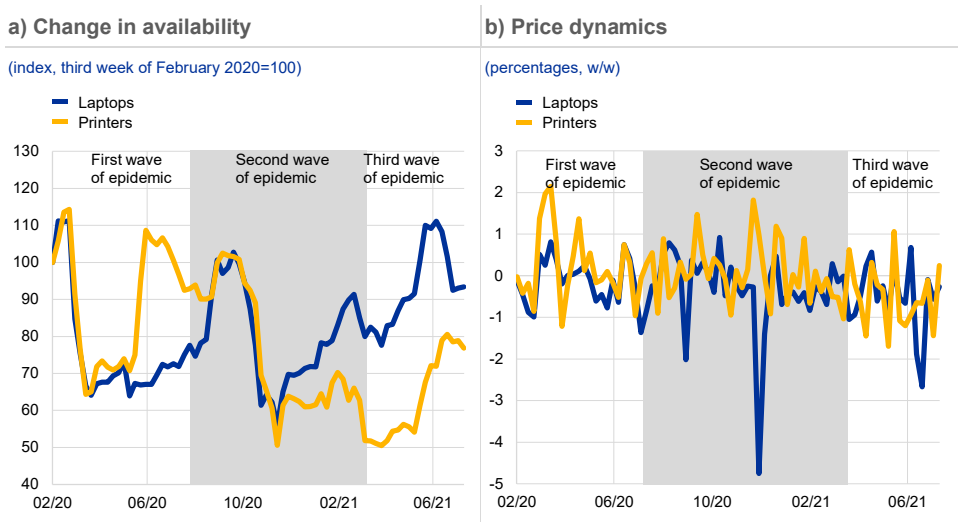
From mid-March to early April 2020, there was a significant decline in the availability of laptops and printers, accompanied by price increases. In the first half of April 2020, in particular, the availability of these electronic products was 35% lower than in February 2020 (Chart 20), mainly due to supply-side developments related to the situation in China and the enforcement of remote working and online learning. The reduced availability of selected electronic products was accompanied by price increases of about 1-2% per week, which is not a substantial increase at first sight. However, given that, before the outbreak of COVID-19, it was usual for electronic products to become cheaper, we can conclude that price increases in the early weeks of the pandemic were relatively high. Apart from supply bottlenecks and increased demand, the rise in prices of electronic products was also to some extent caused by the depreciation of the Polish zloty against the US dollar.

The decline in the availability of selected electronic products and the rise in their prices slowed in April 2020, but the pace of recovery to pre-pandemic levels differed between devices. The extended limited availability of laptops resulted from ongoing high demand for these products as well as persistent supply bottlenecks. From mid-October to early December 2020, another decline in the availability of electronic products was observed, as the pandemic situation worsened and restrictions were re-introduced throughout Poland on 25 October. In the first week of December 2020, the number of laptops and printers decreased by an average of about 47% compared with February 2020 (Chart 20). Moreover, as the validity of government vouchers for electronic equipment for education staff was about to expire, a surge in orders followed, leaving the market unbalanced. During

the third wave of the pandemic, the availability of electronic products gradually increased until June 2021, when the number of laptops in online stores exceeded the level of the third week of February 2020, while the number of printers came close to this level. In July 2021, the availability of electronic products deteriorated, due to the shortage of essential components and persistently high demand.

Chart 19

Change in the number of available electronic products and their price dynamics



Source: Narodowy Bank Polski.
Notes: Panel a) shows the weekly single-base indices which provide information on changes in the number of products during the COVID-19 pandemic compared with their number before the outbreak of the pandemic (third week of February 2020). Panel b) shows weekly price dynamics. The most recent observation is in the last week of July 2021.

Again, model estimates show that prices of electronic products were insensitive to changes in availability from mid-February 2020 to July 2021. In the case of both laptops and printers, the decrease in availability was accompanied by a price increase, in line with expectations (Chart A6 in the appendix). However, neither link is statistically significant (Table 3). In turn, Cavallo and Kryvtsov (2023) conclude that monthly inflation for electronics is significantly negative due to changes in stock-outs, whereas estimates for annual inflation imply a positive link.

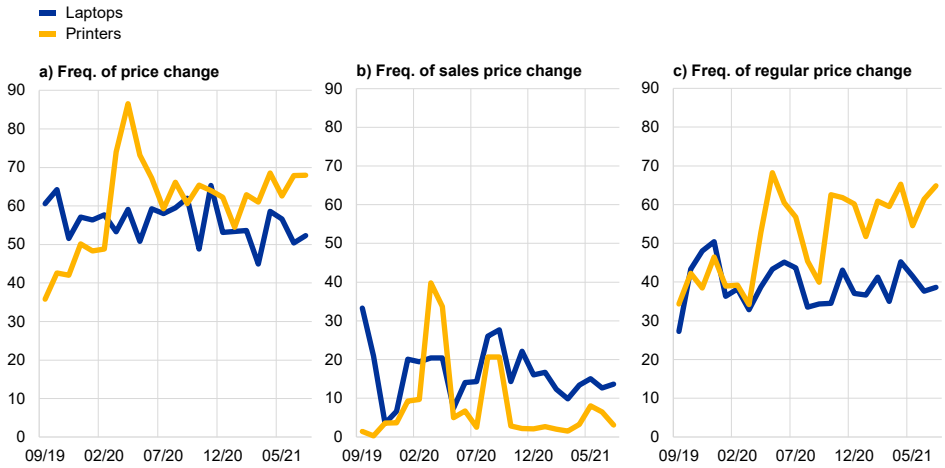
The frequency and the size of price changes increased slightly for printers during the pandemic, while the frequency and size of laptop prices mostly decreased. Around 39.0% of regular prices for laptops and 56.5% of regular prices for printers changed every month from March 2020 to July 2021, compared with 42.3% and 40.4% in the second half of 2019 (Chart 21). The respective price increases of laptops and printers (excluding sales) were 7.1% and 11.5% during the pandemic, whereas in 2019 these increases were 8.6% and 7.0%, respectively (Chart 22). Conversely, the regular price decreases of laptops and printers were slightly greater than in 2019 (7.9% and 8.4%, compared with 6.7% and 6.4%). In addition, the respective sales frequencies for laptops and printers were 16.3% (16.1% in 2019) and 9.6% (2.2% in 2019) after the pandemic. The respective sale price increases of laptops and printers during the pandemic were 11.8% and 11.0%, whereas the increases in these items in 2019 were 12.5% and 10.1%. The sale price

decreases were 11.0% and 11.6%, compared with 11.3% and 16.0% in the second half of 2019.

Chart 20

Frequency of price changes for laptops and printers (including and excluding sales)

(percentages)

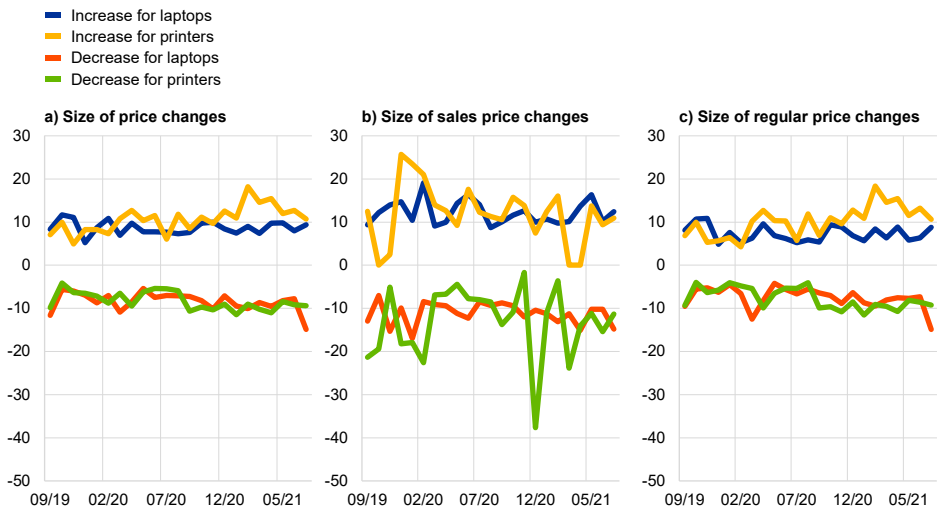


Source: Narodowy Bank Polski.
Notes: The charts show monthly frequencies. To calculate the frequency of price changes, one price was chosen, observed around the middle of month. The data start in September 2019. The latest observation is in July 2021.

Chart 21

Size of price changes for laptops and printers (including and excluding sales)

(percentages)



Source: Narodowy Bank Polski.
Notes: The charts show the size of monthly price changes. To calculate the size of price changes, one price was chosen, observed around the middle of month. The data start in September 2019. The latest observation is in July 2021.

Table 3

OLS estimates from regressing price dynamics on changes in availability

(percentages, w/w)

		Price dynamics				
		Food	Laptops	Printers	Soap	Toilet paper
Availability	**Food**	-0.019 (0.019)				
	Laptops		-0.020 (0.015)			
	Printers			-0.010 (0.012)		
	Soap				-0.028 (0.019)	
	Toilet paper					0.009 (0.010)
	Observations	76	76	76	76	76
	R^2	0.014	0.024	0.010	0.028	0.010
	F(1.75)	1.095	1.823	0.770	2.185	0.724

Notes: For food and soap, the Newey-West (NW) robust estimation of the covariance matrix was used, due to the autocorrelation and heteroskedasticity issues. *** denotes significance at 0.01, ** denotes significance at 0.05, * denotes significance at 0.1.

3.3 Price setting in supermarket scanner data

This section analyses the response of supermarket prices to the major change in demand caused by the COVID-19 pandemic, characterising price setting in German and Italian supermarkets during the lockdown. The lockdown generated a strong demand shock in supermarkets, both by restricting access to Food Away From Home (FAFH) and by sheltering the sector from the lockdown. We ask how flexibly supermarkets adjusted their prices, either by changing temporary discounts or reference prices.

We find evidence of a significant price response in supermarkets to the COVID-19 lockdown in both countries. Supermarkets increased their prices by adjusting both their temporary sales and their regular (reference) prices. The inflation response was stronger in Italy, where supermarket price flexibility is structurally greater than in Germany.[54] The shock did not significantly increase the frequency of regular price changes but increased the share of price increases relative to price decreases.

The discussion is organised as follows: Section 3.3.1 describes the underlying dataset. Section 3.3.2 describes the real expenditure growth experienced by supermarkets during the first wave of the pandemic. In Section 3.3.3, we show that inflation measures for German and Italian supermarkets evolved quite heterogeneously with respect to this aggregate demand shock. Subsequently, we analyse some features of price setting that contributed to the inflation impact of the COVID-19 shock on temporary sales (Section 3.3.4) and reference prices (Section 3.3.5).

54 See Chapter 1.3 of Gautier et al. (2023).

3.3.1 Scanner data

We use a store-level scanner dataset of German and Italian supermarkets. The data have been newly acquired by the ECB in the context of the Price-setting Microdata Analysis Network (PRISMA) from marketing company IRi. The dataset is a weekly panel of total revenues and quantities sold of all products in uniquely identified large supermarkets in Germany and Italy.

Products are identified at the most granular, barcode level. The dataset includes the European Article Number (EAN) identifier of most products, and stores and chains are uniquely identified, but their identity is masked to protect their anonymity. The dataset covers 20 two-digit postal code areas out of around 100 postal code areas in each country.[55] It covers a time span of three months, encompassing the first wave of the COVID-19 pandemic, from mid-February until mid-May in 2020. The dataset also includes the analogous period in 2019, which we will use as the base period in our index calculations. We also have access to an additional sample covering the full time span between January 2013 and December 2017, which we use to calibrate our benchmarks.

We transform weekly unit-value prices into estimated posted prices. First, to reduce the impact of mid-week price changes, we filter out same-direction consecutive price changes. We set the end-of-the-week posted price during this week as the unit-value price in the following week. Second, to mitigate the impact of buyer-specific discounts, we round fractional prices upwards to the nearest cent.

Our analysis uses the 2013-17 pre-COVID-19 sample as a benchmark to assess the significance of changes observed over the 2019-20 COVID-19 period. To minimise the impact of compositional shifts over time, we restrict our baseline sample to stores and products that appear with positive sales in both the first quarter in 2013 and the sample quarter in 2020. Most of the stores are such "established" stores[56]. A sizeable fraction of the products are such "established" products[57].

3.3.2 Supermarkets and the first wave of the COVID-19 pandemic

The COVID-19 pandemic and the accompanying lockdown measures had a large impact on supermarket demand. The Italian government imposed a national lockdown on 9 March, only gradually easing it after mid-May. In Germany, a federal lockdown was introduced on 22 March and was gradually eased from early May. During the lockdowns, access to FAFH was severely restricted in both countries, as restaurants, canteens and bars were deemed non-essential, and indoor dining and drinking were prohibited. In contrast, supermarkets stayed open, and demand for food-and-beverage products sold by them increased. Supermarkets were mostly sheltered from the impact of the lockdowns, but they also faced contemporaneous

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55 The postal code areas in the sample cover 16% and 40% of the population and a share of supermarket expenditures of 22% and 46% in the period of 2013-17 in Germany and Italy, respectively.

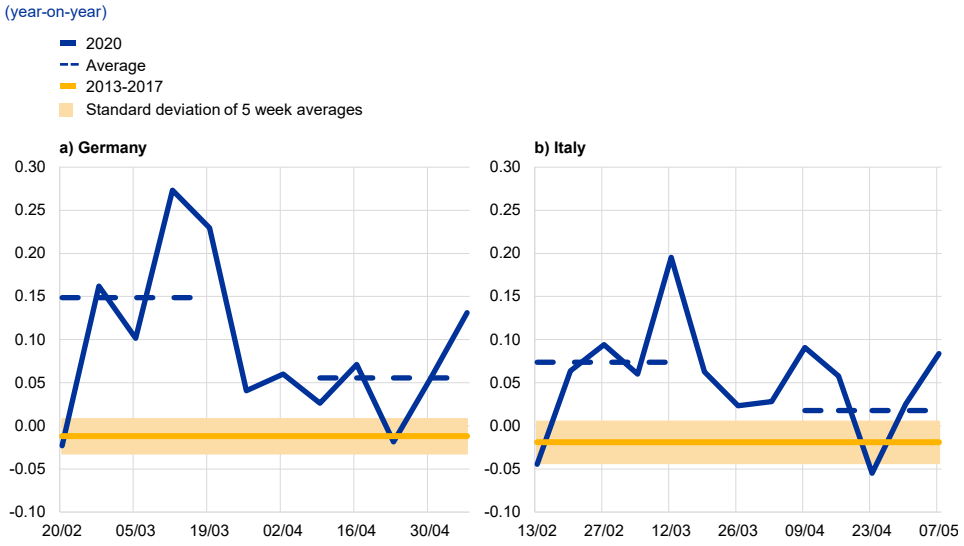
56 668 out of 815 unique stores in Germany and 1,486 out of 2,387 unique stores in Italy.

57 57,000 out of 266,000 unique products in Germany and 83,800 out of 535,500 unique products in Italy, with an expenditure share of 43.4% in Germany and 42.4% in Italy.

cost pressures due to new health regulations (e.g. restrictions in the number of customers) and disruptions to supply chains.

Chart 22

Real expenditure growth in supermarkets during the first wave of the COVID-19 pandemic



Source: Own calculations based on IRi supermarket scanner data.
Notes: The chart shows the weekly, year-on-year real expenditure growth (blue solid line) between mid-February and mid-May in 2020 in Germany and Italy. It shows that the five-week-average expenditure growth (dashed blue line) exceeded the average long-term expenditure growth (yellow lines) by more than a standard deviation in both Germany and Italy. The expenditure growth was particularly high in the weeks preceding the lockdowns ("stock-up shock"), but also stayed persistently high during the lockdowns.

Real expenditure growth in supermarkets increased considerably during the first wave of the COVID-19 pandemic in 2020. Our data allow us to quantify the magnitude of the change in demand in supermarkets, as the scanner data include quantitative information, not only price information. Chart 23 shows the evolution of real expenditure growth[58] (blue line) between mid-February to mid-May in German and Italian supermarkets. In line with the increase in the weight of food items documented in Section 1, the chart shows that the expenditure growth significantly exceeded its long-term average (yellow line). The increase was particularly pronounced in the weeks before the lockdowns. The growth rate reached as much as 18-28% during this "stock-up shock", as households increased their stocks of non-perishable groceries for precautionary reasons. The expenditure growth during the lockdowns stayed persistently well above average. It stabilised at around 7.5% in Germany and at 3.5% in Italy, which significantly exceeded the long-term real expenditure growth experienced over the 2013-17 period.[59]

58 We measure year-on-year nominal expenditure growth as the 52-week change in overall expenditure on items (which we define as product-store combinations), sold in positive quantities in both the current and the base weeks. Real expenditure growth is the difference between nominal expenditure growth and the inflation rate (for the details of inflation measurement, see the next section).

59 Long-term real expenditure growth is below zero among the "established products" that are available throughout 2013-20, which are the focus of our analysis.

3.3.3 Supermarket inflation

We measure inflation using the year-on-year change in the Tornqvist price index with quarterly expenditure weights. The Tornqvist index is a superlative price index with desirable welfare-theoretical properties[60]. Quarterly expenditure weights reduce the impact of high-frequency variation in the composition of products due to both seasonal factors and temporary sales. Additionally, concentrating on year-on-year indices minimises the impact of seasonal variation, as well as the potential impact of the "chain drift", which may be present with higher-frequency indices relying on scanner data (Ivancic et al., 2011).[61]

The increase in supermarket inflation was notably high in Italy and in line with the corresponding HICP inflation for both Italy and Germany.[62] We concentrate on the five-week-average inflation, which smooths out some high-frequency variability in the weekly series. Chart 24 shows that five-week-average inflation started at around its long-term average in 2020 in both Germany and Italy and increased throughout the quarter in both countries. The increase was higher and clearly exceeded a one-standard-deviation band[63] in Italy (1.89 percentage points), while it was smaller and stayed within a one-standard-deviation band in Germany (0.95 percentage points). The increases are comparable to the change in the annual HICP food-and-beverage sub-indices[64] between February and May in Italy (1.96 percentage points) and Germany (0.79 percentage points).

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60 It is the second-order approximation of the welfare-relevant price index under an arbitrary homothetic utility function.

61 Formally, we calculate inflation as

$$\pi_w = \sum_{ps} \gamma_{psw}\left(\log P_{psw} - \log P_{psw-52}\right), \quad (1)$$

where P_{psw} is the posted price of product p in store s in week w and the weights are

$$\gamma_{psw} = \frac{I_{psw,w-52}\left(\omega_{psq-4} + \omega_{psq}\right)/2}{\sum_{ps} I_{psw,w-52}\left(\omega_{psq-4} + \omega_{psq}\right)/2}, \quad (2)$$

where $I_{psw,w-52}$ is an indicator function that takes the value 1 if product p in store s is sold in strictly positive quantities in both w and $w-52$ and 0 otherwise (we match weeks with previous-year weeks based on their distance from the Easter week, the strongest seasonal factor over the mid-February-mid-May period for which we have data in 2019 and 2020), and ω_{psq} is the quarterly expenditure share of product p in store s in quarter q.

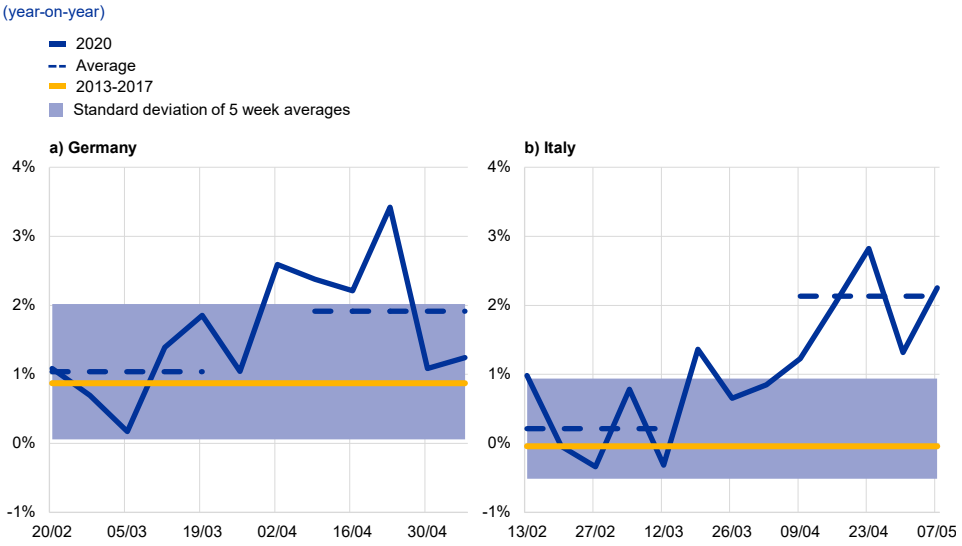
62 The ensuing supermarket inflation rates in both countries co-move with the respective HICP food and beverages sub-indexes. The correlation coefficients of the monthly inflation rates are 43% in Germany and 54% in Italy. The level of supermarket inflation is below the HICP sub-indexes. The main reason is that we concentrate on surviving products and ignore the impact of new product introductions, which generate a major share of trend inflation (Karadi et al., 2023).

63 The band shows the standard deviation of five-week-inflation rates over the first two quarters of the years between 2013-17.

64 The sub-index includes food and non-alcoholic beverages (ECOICOP category 01), alcoholic beverages (02.1) and tobacco (02.2), weighted with the respective expenditure weights.

Chart 23

Supermarket inflation during the first wave of the COVID-19 pandemic



Source: Own calculations based on IRi supermarket scanner data.
Notes: The chart shows the weekly, year-on-year supermarket inflation (blue line) between mid-February and mid-May in 2020 in Germany and Italy. It shows that the average inflation in the first five weeks (dashed blue line) stayed close to the average inflation rate during the first two quarters of 2013-17 (yellow lines). Over the course of the quarter, the five-week-average inflation increased sizeably in both Germany (0.95%) and Italy (1.89%). The change stayed within a ± one-standard-deviation band in Germany but exceeded this in Italy.

The evidence points to notable heterogeneity between Germany and Italy in price responses to large aggregate demand shocks, with Italy exhibiting higher short-term supply elasticity. If we attribute all the changes to a demand shift, the (reduced-form) short-term supply elasticities implied by the price and quantity indices are 0.95%/9.5%=0.1 for Germany and 1.89%/6.6%=0.29 for Italy. For these calculations, we measured the changes in the quantity indices as the difference between the real expenditure growth during the last five weeks of our sample relative to the long-term real expenditure growth. The short-term supply elasticity in Germany is comparable to the low elasticity (0.07) reported by Gagnon and López-Salido (2020) after large local demand shocks in the United States. However, the measured short-term supply elasticity is much higher in Italy, despite the similarity of the shock, the type of retailers and the basket of products. In the next two sections, we analyse some features of price setting that contributed to the inflation impact of the COVID-19 shock and may explain some of the differences between Germany and Italy.

3.3.4 Temporary sales

A sizeable proportion of the price changes in our sample is due to temporary sales, which are fully reversed within a short time span. Previous research has established that the nature of such high-frequency price changes is distinct from those of more persistent reference price changes (Nakamura and Steinsson, 2008). While reference prices are driven primarily by costs, sales are used as a marketing tool to trigger households to try out new products and stores and to gain the trade of bargain-hunter households (Eichenbaum et al., 2014; Coibion, Gorodnichenko and

Hong, 2015; Kehoe and Midrigan, 2015). Therefore, the frequency of sales-related price changes, mostly driven by cross-product and cross-store competition, has a more muted impact on the inflation effect of an aggregate demand shift than the frequency of reference price changes. Nevertheless, a key outstanding question in the literature is whether sales-related price changes remain an active adjustment margin that retailers use to respond to aggregate shocks.

Previous research has documented conflicting evidence on the flexibility of prices through adjustment in temporary sales. Anderson et al. (2017), for example, argue that sales are sticky and play an insignificant role as an adjustment margin to aggregate shocks, while Kryvtsov and Vincent (2021) challenge this view and show that temporary sales do vary over the business cycle. We contribute to this literature by assessing whether supermarkets responded by adjusting the frequency and the size of their temporary sales for the major demand shock caused by the COVID-19 lockdowns.

The definition of temporary sales goes hand in hand with a given reference price. We identify reference prices as the (highest) mode within a centred rolling window, and, in turn, we define sales as temporary downward deviations from this reference price (Kehoe and Midrigan, 2015; Eichenbaum et al., 2014).[65] We set the size of the rolling window at five weeks. This is a conservative choice. It categorises fewer price cuts as sales than Kehoe and Midrigan (2015) or Eichenbaum et al. (2014), who used 11- and 13-week windows, respectively. However, the shorter window has minimal impact on the time variation of the frequency and size of sales[66], and allows us to assess changes in reference prices over our 13-week sample period in 2020 (see next section).

Table 4

Average moments, 2013-17

	Annual change-frequency		Temporary sales	
	Posted	Reference	Share	Size
Germany	56%	48%	17%	13%
Italy	75%	68%	17%	12%

Source: Own calculations based on IRi supermarket scanner data.
Notes: The table lists some relevant moments of posted and reference prices and temporary sales. It confirms that reference price changes explain most of the posted price changes at the annual frequency. Price changes are more frequent in Italy than in Germany. Furthermore, a sizeable fraction of products are on sale at any given time in both Germany and Italy, and the frequency and the size of sales are similar in the two countries.

Both countries exhibit similar shares and sizes of sales. Table 4 shows some relevant price-setting moments in Germany and Italy, measured over the 2013-17 sample. Its third and fourth columns show the expenditure share of products on sale and the expenditure-weighted average size of sales. Both moments are very similar in the two countries. The share of sales is 17% in both countries and the size of sales are 12% and 13% in Germany and Italy, respectively.

65 There are also frequent temporary *upward* deviations from the reference price (spikes), but these are not the focus of the analysis (Karadi et al., 2023).

66 The correlations between the series based on five-week and 13-week reference-price filters are 0.78 for the frequency and 0.76 for the size of sales.

Supermarket retailers responded to the demand shock by cutting down the frequency and size of temporary sales. Chart 25 shows[67] the annual change in the frequency and the size of sales in Germany and Italy[68]. The panels show that the frequency and the size of the sales were already below their long-term average in the early weeks of the pandemic. This suggests that retailers responded promptly to the elevated demand during the stock-up shock by reducing both the frequency and the magnitude of their sales. Furthermore, both the frequency and the size of sales gradually declined further during the quarter in both Germany and Italy. The decline in the frequency and the size of sales contributed to the increase in inflation over our sample of 1.4 percentage points in Germany and 0.6 percentage points in Italy[69]. These results indicate that retailers actively adjusted their temporary sales in response to the strong demand shock. This is broadly in line with the findings of Gautier et al. (2022) using euro area CPI microdata of statistically significant sales-inflation responses to some large aggregate shocks.[70]

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67 The charts exclude the first and the last two weeks of the sample, because it is particularly difficult to estimate both reference prices and sales so close to the endpoints.

68 To assess how changes in sales contributed to inflation, we measure the annual change in sales frequency as

$$\Delta\xi_w = \xi_w - \xi_{w-52} = \sum_{ps} \gamma_{psw} I^s_{psw} - \sum_{ps} \gamma_{psw} I^s_{psw-52},$$

where γ_{psw} are the annual Tornqvist weights defined in equation (2) and I^s_{psw} is an indicator function that takes the value 1 in case product p in store s is on sale in week w, i.e. the posted price is strictly below the reference price $\left(P_{psw} < P^f_{psw}\right)$, and 0 otherwise. Additionally, we measure the annual change in the average size of sales as the 52-week difference between the average percentage distance between the reference and the posted prices among products on sale. Formally,

$$\Delta\psi^s_w = \psi^s_w - \psi^s_{w-52} = \frac{\sum_{ps} \gamma_{psw} I^s_{psw} \left(\log P^f_{psw} - \log P_{psw}\right)}{\sum_{ps} \gamma_{psw} I^s_{psw}} - \frac{\sum_{ps} \gamma_{psw} I^s_{psw-52} \left(\log P^f_{psw-52} - \log P_{psw-52}\right)}{\sum_{ps} \gamma_{psw} I^s_{psw-52}} \quad (3)$$

The contribution of changes in sales-related price setting can be expressed as a "sales inflation", formally defined as

$$\pi^s_w = -\left(\xi^s_w \psi^s_w - \xi^s_{w-52} \psi^s_{w-52}\right). \quad (4)$$

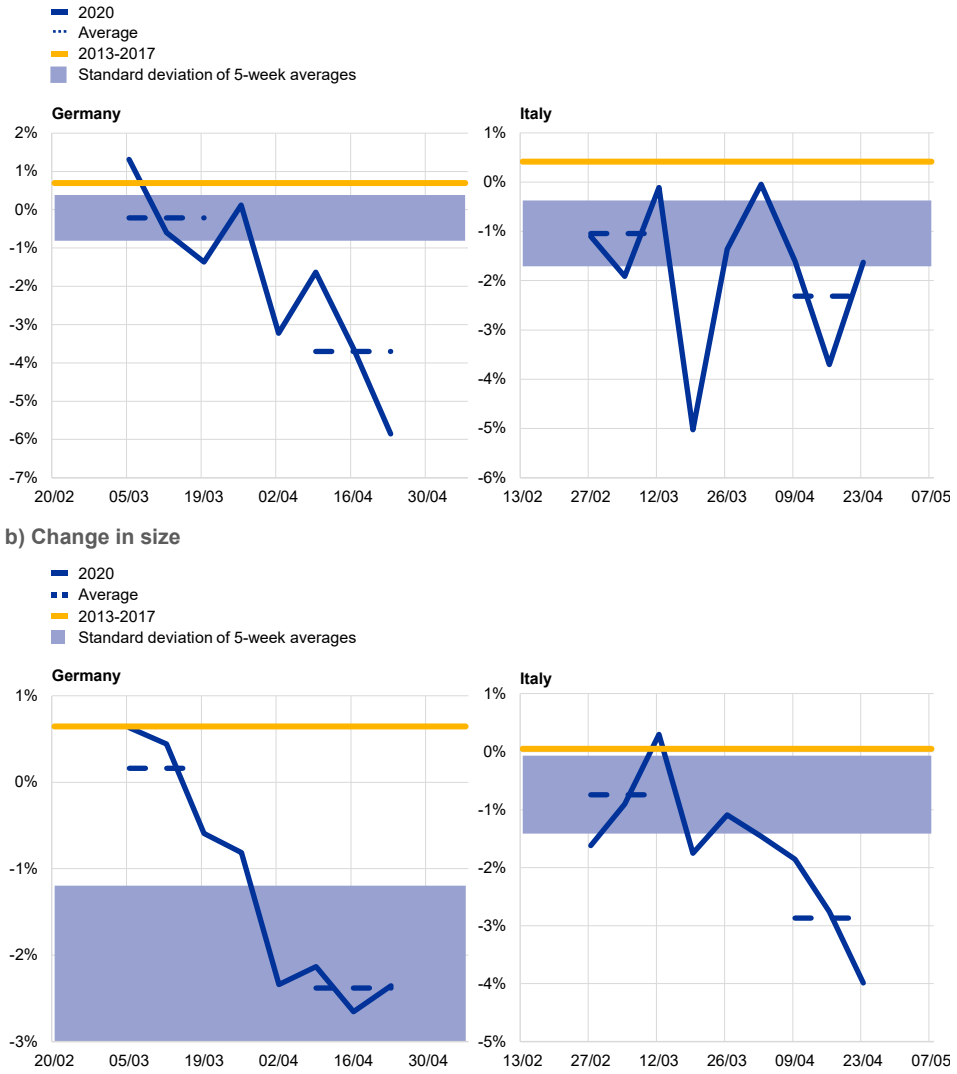
Fewer and smaller sales in the current week relative to the base period necessarily increase inflation, which explains the negative sign on the right-hand side of the expression.

69 The change in sales-related inflation is smaller in Italy than in Germany, primarily because it is already above its long-term average in mid-February, possibly already as a response to the ongoing stock-up shock.

70 Note that this is in contrast with the findings for Germany based on CPI microdata in Section 3.1, although the outlet types (different types including discounters vs supermarkets) and the underlying sales filter (NSI flag vs sales filter) differ between the two approaches.

Chart 24

Annual change in frequency and size of sales during the first wave of the COVID-19 Pandemic



Source: Own calculations based on IRi supermarket scanner data.
Notes: The chart shows the weekly evolution of the annual change in the frequency (top row) and size (bottom row) of temporary sales between mid-February and mid-May in 2020 (blue line) in Germany (left column) and Italy (right column). It shows that both the average frequency and the average size of sales in the first three weeks (dashed blue line) started out below their long-term average measured during the first two quarters of 2013-17 (yellow lines). Over the course of the quarter, both the sales frequency and the sales size declined markedly both in Germany and Italy, exceeding the ± one-standard-deviation bands in both countries.

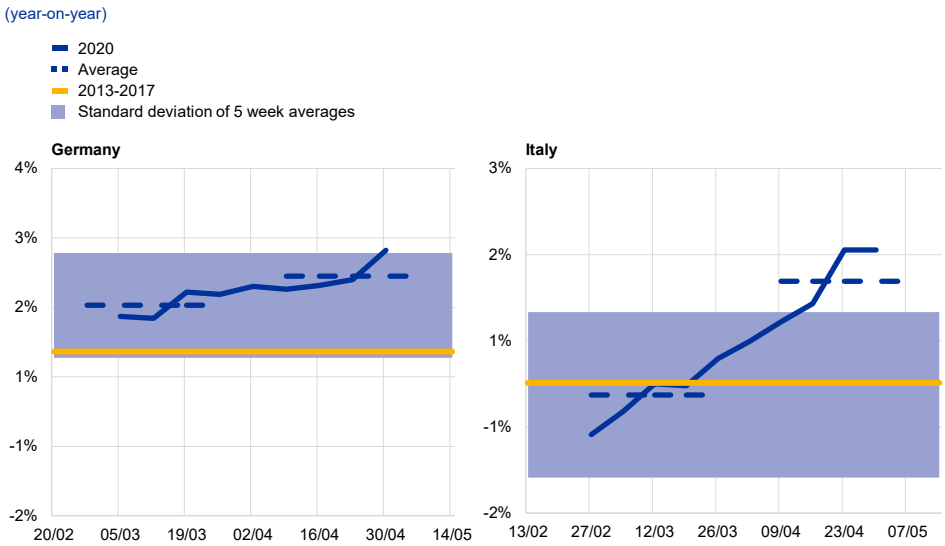
3.3.5 Reference price inflation

The more flexible inflation response to the COVID-19 shock in Italy relative to Germany is mainly attributable to differences in (sales-filtered) reference price inflation. As Chart 26 shows, the increase in reference price inflation in Germany (0.54%) was only around one-third of that in Italy (1.65%), albeit from a higher initial level.

The more flexible response in Italy is consistent with the structurally more frequent changes in supermarket reference prices during the benchmark period 2013-17 (Table 4). The frequency of reference price changes is a relevant statistic, determining the flexibility of the price level in most price-setting models (Calvo, 1983; Alvarez et al., 2022). The table shows that 48% of the reference prices change in Germany annually, but that many more – 68% – change in Italy. The difference between repricing frequencies remains robust if we restrict our attention to a sub-sample of goods that are sold in both countries, or if we measure reference price changes at the monthly frequency (Karadi et al., 2023, report 4.5% and 9.0% for Germany and Italy, respectively). The less frequent price changes in Germany may be partly related to differences in the competitive environment, as there are fewer and larger retailers in Germany (16 chains in our sample) than in Italy (466 chains).

Chart 25

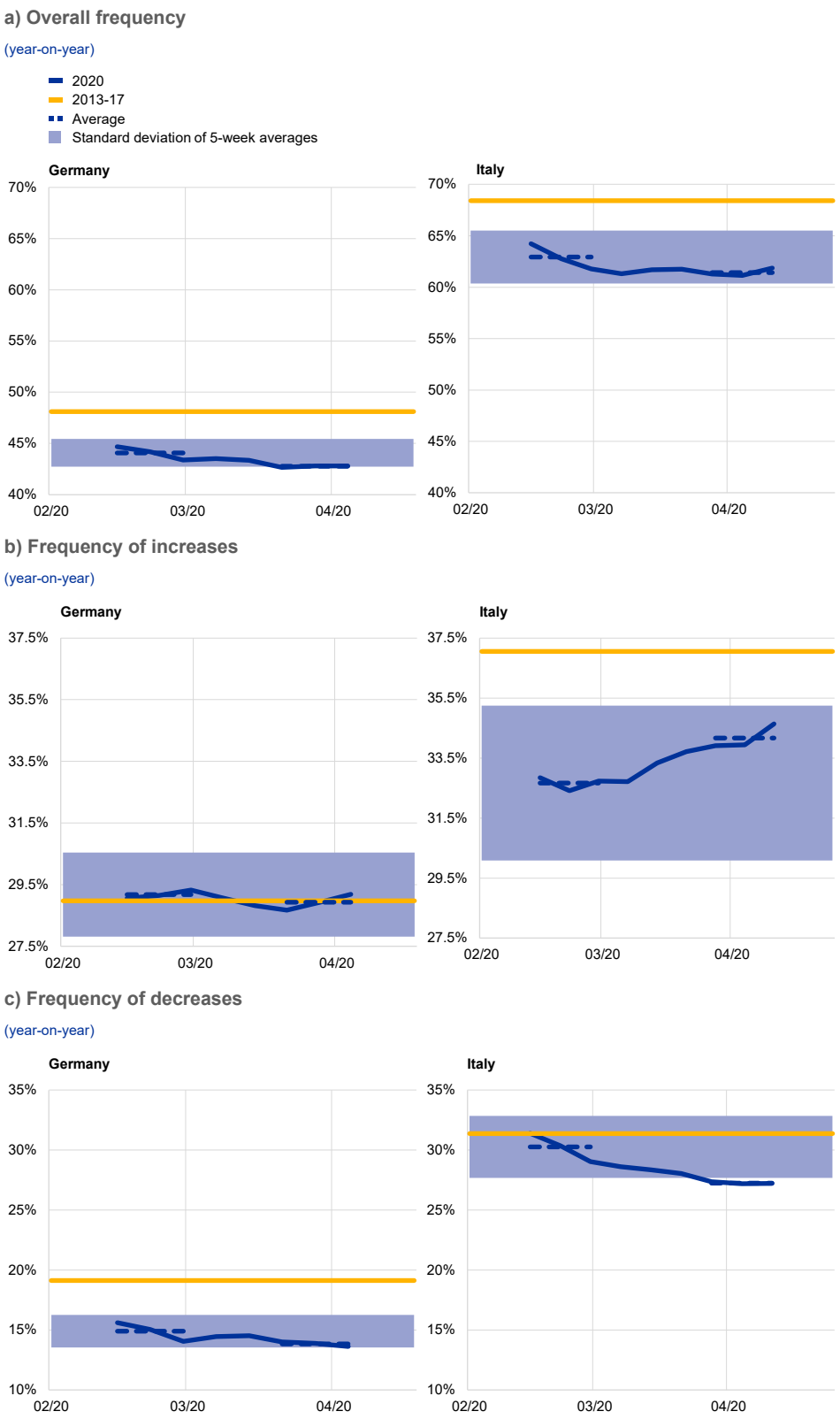
Sales-filtered (reference price) inflation during the first wave of the COVID-19 pandemic



Source: Own calculations based on IRi supermarket scanner data.
Notes: The chart shows the weekly, year-on-year reference price inflation (blue line) between mid-February and mid-May in 2020 in Germany and Italy. It shows that the increase in the average five-week-inflation (dashed blue lines) over the quarter was smaller (0.54%) and within a ± one-standard-deviation band in Germany, while it was three times as large in Italy (1.65%) and clearly exceeded the standard-deviation band.

Chart 26

Reference price changes, increases and decreases during the first wave of the COVID-19 pandemic



Source: Own calculations based on IRi supermarket scanner data.
Notes: The chart shows the weekly share of reference price changes between mid-February and mid-May in 2020 in Germany and Italy and decomposes it into the share of increases and decreases. The chart shows that the overall frequency declined, as the more frequent price increases could not offset the impact of the less frequent price decreases.

Both countries show a shift in the frequency of price changes, with more price increases than price cuts in the first wave of the pandemic. Chart 27 shows the evolution of the annual frequency of price changes during the COVID-19 shock. It reveals no significant change in the overall frequency of price changes in either Germany or Italy as a response to the surge in demand: if anything, the aggregate frequency declined in both countries. The lack of an increase in aggregate frequency indicates that even the substantial COVID-19 shock was insufficient to trigger sizeable state-dependent adjustment on the (net) extensive margin[71]. The constant aggregate frequency masks an apparent shift away from price decreases towards price increases in both countries.

[71] We should bear in mind, however, that remaining sales-related price changes, coming from the five-week window, as opposed to a more standard 13-week window in our implemented filter, might bias our estimates downward.

4 Summary and conclusions

This paper has discussed the challenges created by the COVID-19 pandemic for inflation measurement and provided micro price analysis of how price setting has reacted to the strong COVID-19 shock. To analyse the latter, we use three different microdata sources for specific countries and sectors: micro price data entering the official CPI; online (web-scraped) price data; and transactional (scanner) data from supermarkets.

From a statistical point of view, the COVID-19 pandemic posed a challenge in measuring nominal developments, such as consumer prices. This paper has highlighted two main challenges for inflation measurement in the euro area. First, at the peak of the first wave of the pandemic, nearly one-third of prices in the HICP baskets had to be estimated (imputed), since traditional price collection was facing restrictions, particularly during the strict lockdown periods. Second, the HICP weights did not reflect the radically changing consumption patterns during the COVID-19 pandemic, as they are constructed from consumer expenditures from previous years.

A re-calculation exercise of aggregate euro area inflation in 2020 – based on the more representative expenditure weights as of 2021 – shows that the resulting alternative inflation rates would have been, on average, 0.2 percentage points higher than the official rates. This is in line with previous studies using monthly varying expenditure weights, such as Cavallo (2020). Differences between the official HICP inflation series and our alternative measure notably emerge at the beginning and end of the 2020 pandemic year, and mainly arise from a higher-weighted increase in food prices and a less dampening effect of energy. In contrast, the seasonal pattern, notably of package holidays, contributes strongly to both lower and higher differences compared with official inflation; this can be attributed to the construction of the HICP as a chain-linked price index.

Analysis of national CPI microdata for Germany, Italy, Latvia and Slovakia shows a pronounced difference in the price-setting adjustment across countries and sectors. In Italy, the frequency of positive and negative price changes both increased strongly from April to June 2020, but the absolute size of price changes declined in almost all categories, except for the service sector. In Germany – apart from the spike in the price reduction frequency and decline in the absolute size of price adjustment due to the VAT cut in July 2020 –price setting did not change much during the initial months of the COVID crisis. In Latvia and Slovakia, the adjustment in frequencies and size of price changes in response to the COVID crisis was less pronounced in 2020. In Latvia, it was mainly carried out through a smaller absolute size of price changes. Overall, the aggregate fall in inflation materialised through a price-setting adjustment, working mainly through a higher frequency of price decreases and a smaller absolute size of price changes. In Italy, where the pandemic situation was more severe, the frequency of price increases also played a role in the price-setting mechanism. For 2021, the second pandemic year, no significant impact on the frequency of price changes could be

observed for Italy or Germany, whereas it increased slightly in late 2021 in Latvia and Slovakia, when overall inflation was picking up again.

Web-scraped data for Poland indicate that the outbreak of the COVID-19 pandemic contributed to a strong decline in the availability of food, hygiene and electronic products, but did not trigger significant price increases. In the light of higher demand and supply-side disruptions, the number of all product groups decreased markedly from mid-February 2020 to early April 2020. Except for electronics (laptops and printers), the observed shortages were only temporary. Interestingly, online stores expanded their hygiene product ranges (soap and toilet paper) in response to the pandemic. However, in contrast to previous findings by Cavallo and Kryvtsov (2023), the limited availability was not accompanied by significant price increases.

Evidence from online stores in Poland also show that the outbreak of the COVID-19 pandemic affected product groups differently in terms of price setting. For food, the monthly frequency of price changes declined during the pandemic, while regular price increases and decreases were somewhat higher than their long-term average. In contrast, for hygiene products, the frequency and the size of price changes both mainly increased in response to COVID-19. A similar reaction was observed for electronics, where the frequency and size of price changes increased slightly for printers during the pandemic, while the frequency and size of price changes for laptops mostly decreased. The share of sales decreased for food products after the COVID-19 outbreak, whereas for the other product categories it remained stable.

Finally, a case study based on supermarket scanner data for Germany and Italy provides evidence of a significant price response in both countries during the first COVID-19 wave in 2020. Facing increased demand as lockdown measures were imposed, supermarkets responded by reducing both the frequency and the magnitude of their temporary sales, as well as by changing their reference prices. Whereas the COVID-19-induced demand shock did not significantly increase the frequency of reference price changes, it increased the share of price increases relative to price decreases. As the evidence from CPI microdata also shows, the inflation response was substantially stronger in Italy, which also has structurally more flexible prices than Germany.

A common finding of the micro price studies in this paper is that state dependence contributed significantly to the price-setting response to the COVID-19 shock. Nevertheless, the extent and degree of responses varies widely by sectors and even countries, also depending on the severity of the pandemic situation. For example, evidence based on supermarkets, which experienced a positive demand shock during the first wave of the pandemic, signals a sales-inflation response which is in line with previous evidence only for a limited set of other aggregate shocks (see Gautier et al., 2022).

Overall, evidence from micro price data provides important insights into price setting during the COVID-19 pandemic. At this time, it became vital for central banks to closely monitor developments in consumer prices in real time. In this sense,

web-scraped data in particular can provide a valuable tool for nowcasting the price developments of certain inflation components (see Macias et al., 2023) and analysing the effects of economic shocks in real time (see Lane, 2021). Moreover, micro price data enable the extent to which the underlying price-setting mechanisms of an economy are affected by large shocks to be analysed, tracing the implications for inflation dynamics. The integration of these micro databases into a central bank's standard toolkit can help to increase understanding of the impact of unprecedented macroeconomic shocks, such as those experienced during the COVID-19 pandemic.

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Appendix

A1 Appendix to: Price setting in official CPI data

Table A1

CPI coverage of the country product sample (percentage)

Special aggregate / Countries	DE	IT	LV	SK
Food	24.8	12.9	21.9	19.6
Processed	18.9	9.3	16.8	15.3
Unprocessed	5.9	3.6	5.1	4.3
Non-energy	31.5	34.9	30.1	30.2
Durables	9.7	6.1	10.2	10.4
Semi-durables	13.1	18.7	12.0	11.2
Non-durables	8.7	10.1	7.9	8.5
Services	43.7	52.3	48.0	50.3
Housing services	11.4	3.9	11.8	10.6
Communication services			3.3	3.9
Transport services	7.1	11.7	7.7	9.0
Recreational services rel. to accommodation	2.5	3.1	3.6	4.6
Recreational services (other)	15.0	20.7	13.6	13.1
Miscellaneous services	7.7	12.9	8.0	9.1
Total	**100**	**100**	**100**	**100**

Source: Own calculations based on national CPI micro price data.

Table A2

Share of CPI products (ECOICOP-5 level) available both in 2015-19 and 2020 (percentage)

Special aggregate / Countries	DE	IT	LV	SK
Processed food	100	16.1	100	78.3
Unprocessed food	100	85.7	100	78.3
NEIG	100	86.9	100	81.3
Services	100	94.7	100	84.7
Total	**100**	**70.1**	**100**	**81.7**

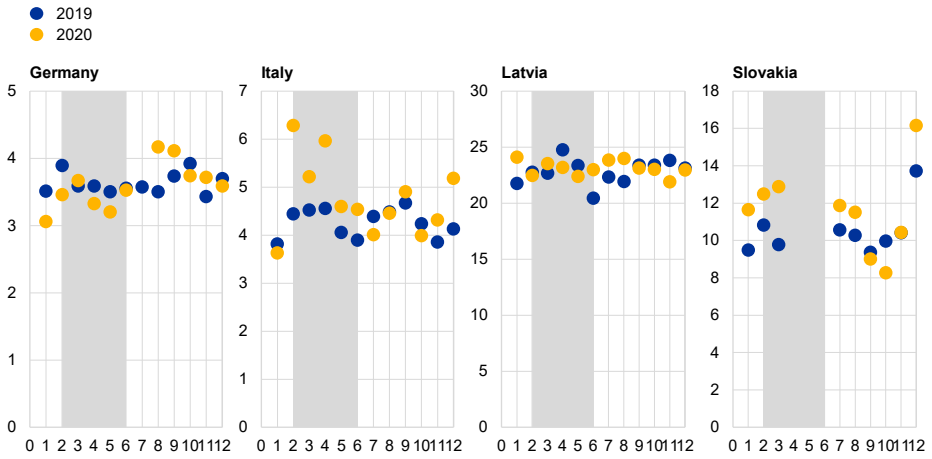
Source: Own calculations based on national CPI micro price data.

Chart A1

Share of price changes due to sales by month (2020 vs 2019)

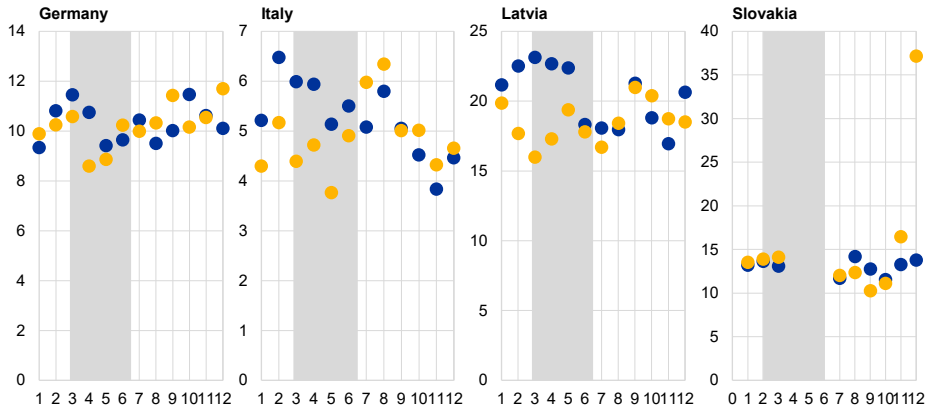
a) Food, processed

(months, frequency of price change as percentage)



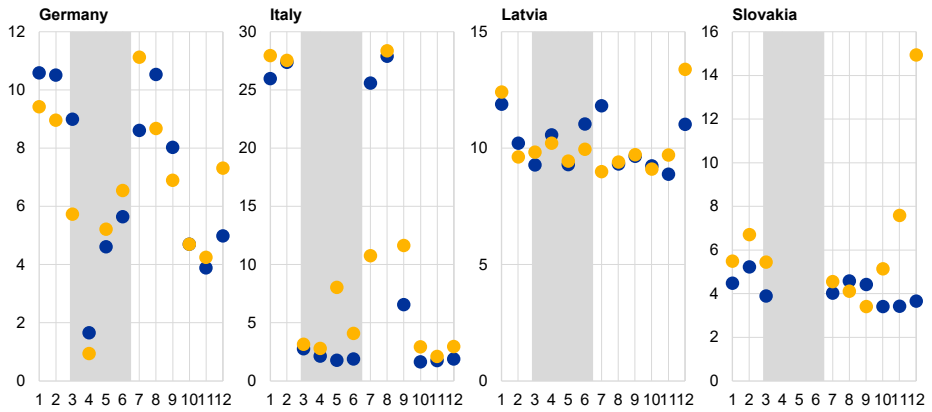
b) Food, unprocessed

(months, frequency of price change as percentage)



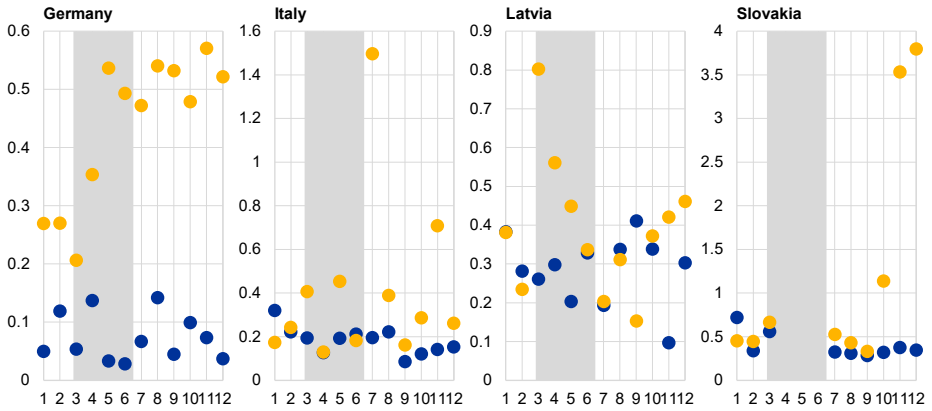
c) NEIG

(months, frequency of price change as percentage)



d) Services

(months, frequency of price change as percentage)



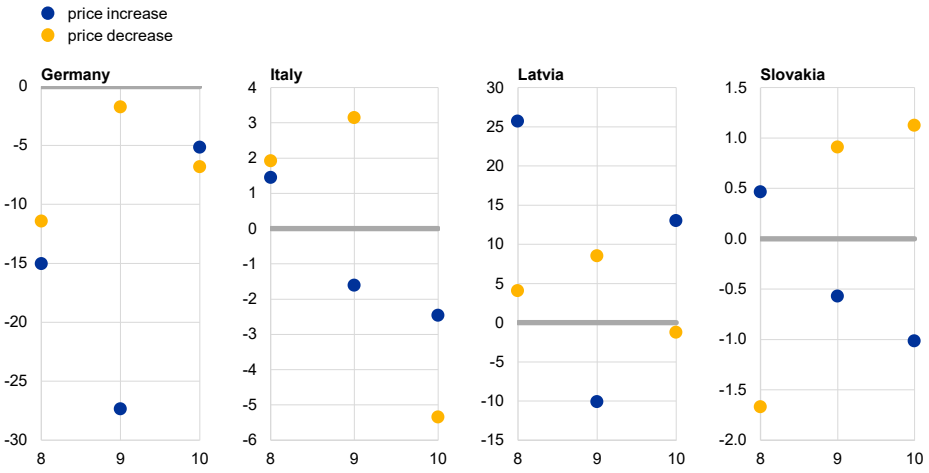
Sources: Own calculations based on national CPI micro price data.
Notes: Grey shaded area marks the first wave of COVID pandemic in Europe from March to June 2020. No observations for Slovakia for April-June 2020. Only products available during the 2015-20 sample for a chosen country and corresponding month are selected.

Chart A2

Change in the absolute size of price changes after lockdown measures at the product level

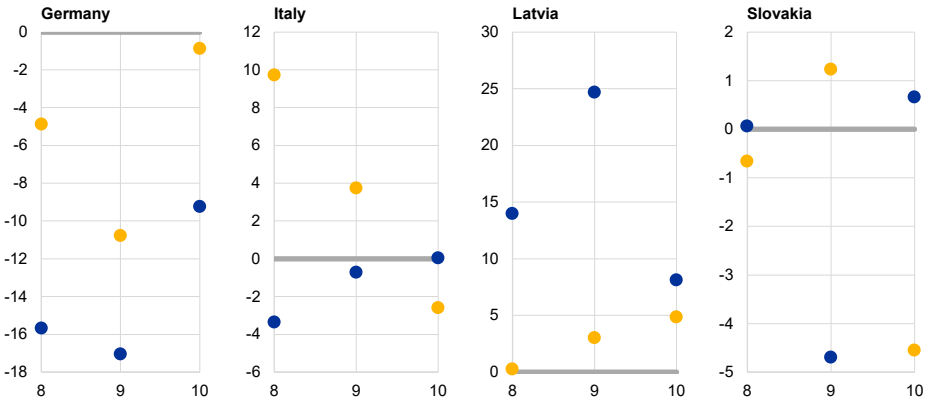
a) Clothing, including sales

(month, annual difference in absolute size of price change (percentage points))



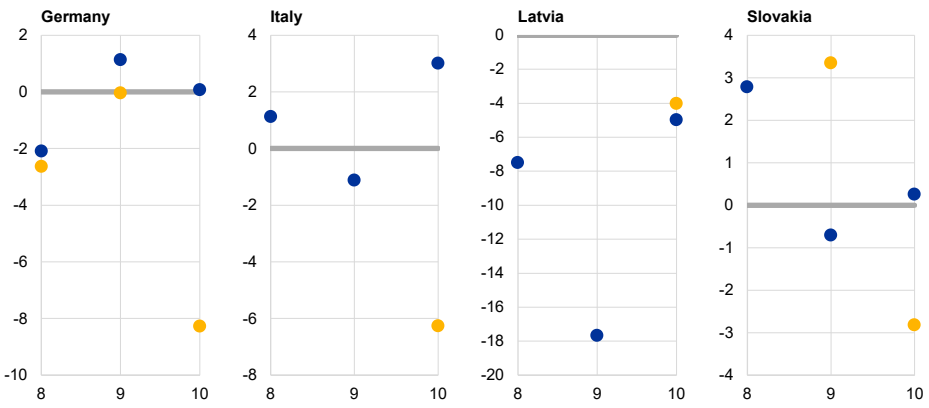
b) Footwear

(month, annual difference in absolute size of price change (percentage points))



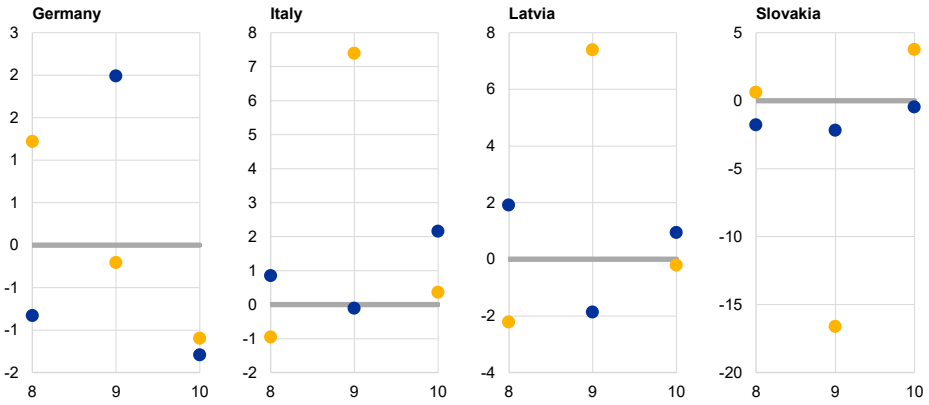
c) Hairdressing

(month, annual difference in absolute size of price change (percentage points))



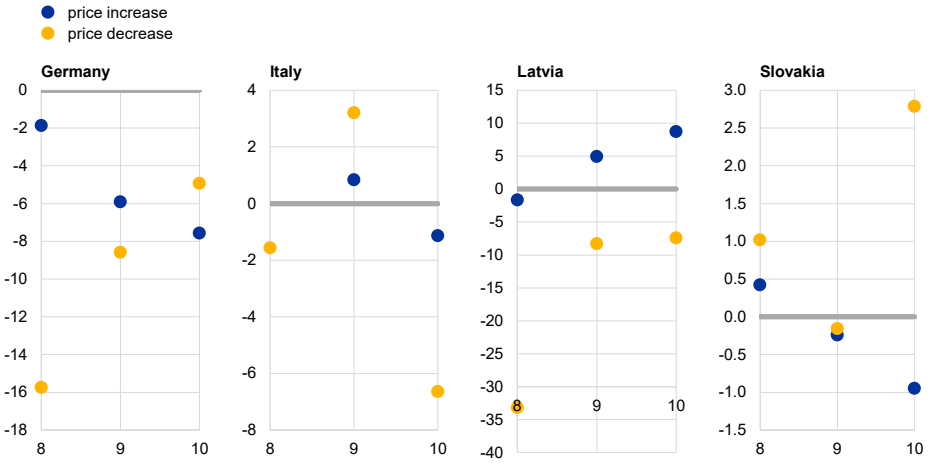
d) Restaurants

(month, annual difference in absolute size of price change (percentage points))



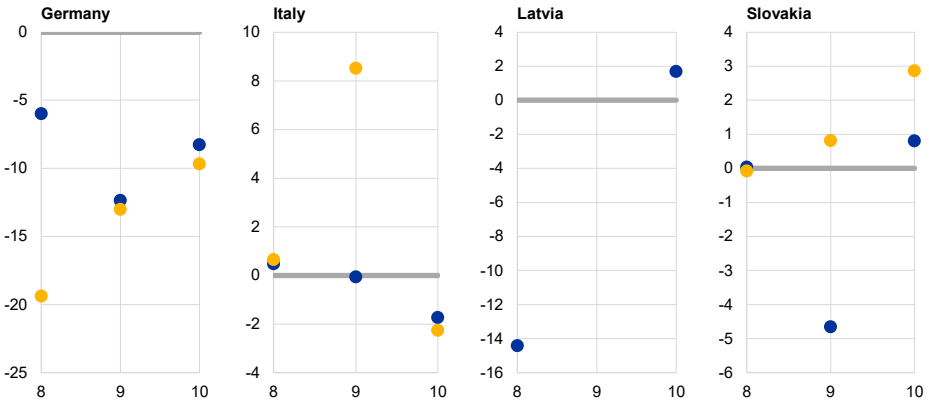
e) Clothing, excluding sales

(month, annual difference in absolute size of price change (percentage points))



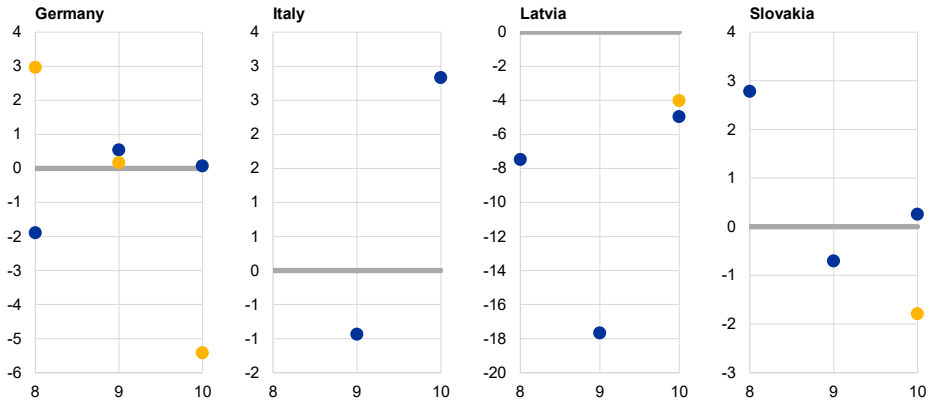
f) Footwear

(month, annual difference in absolute size of price change (percentage points))



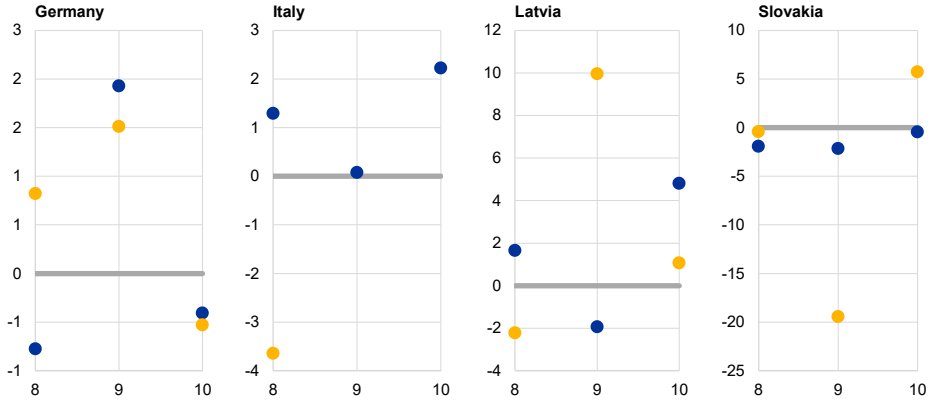
g) Hairdressing

(month, annual difference in absolute size of price change (percentage points))



h) Restaurants

(month, annual difference in absolute size of price change (percentage points))



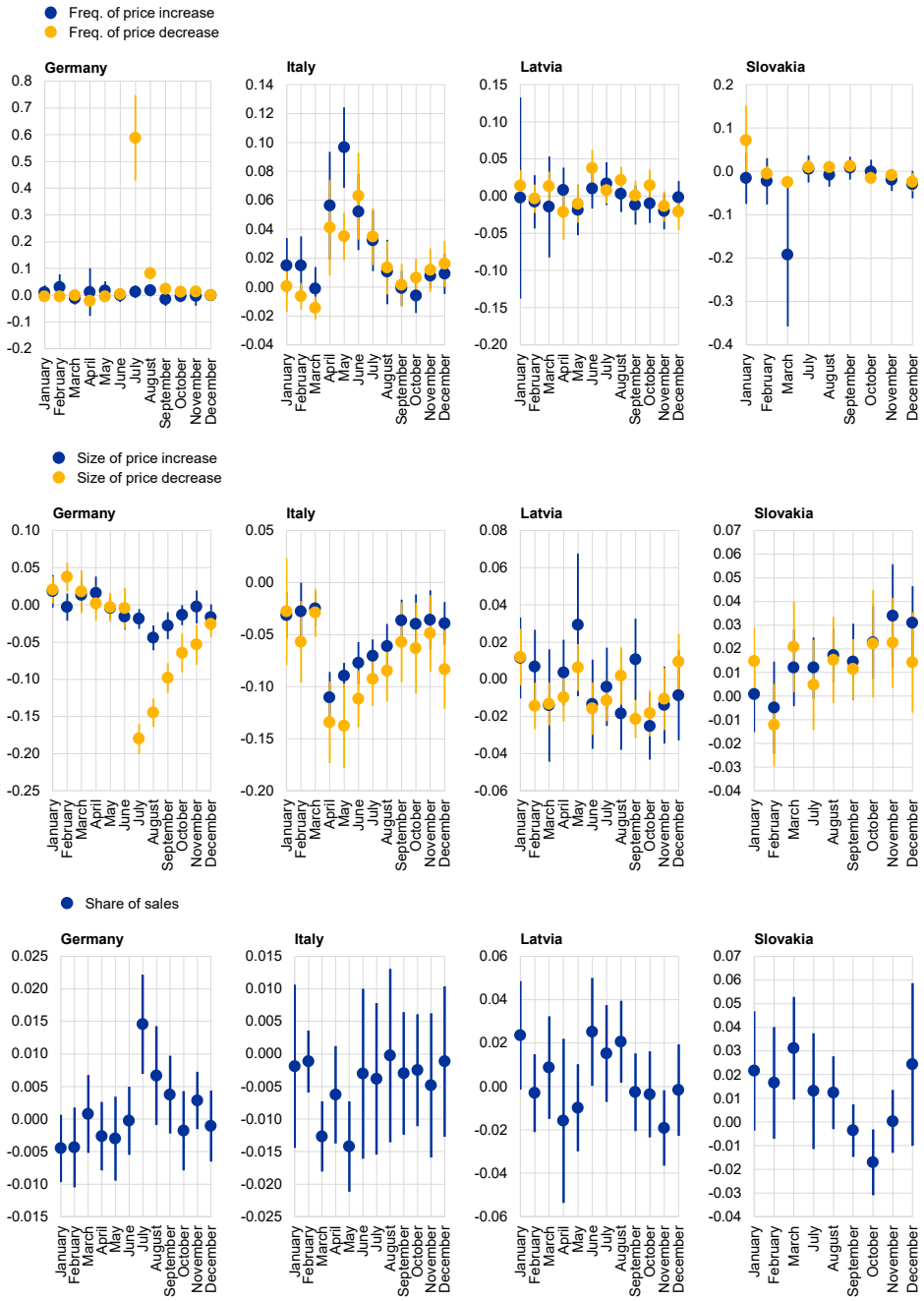
Sources: Own calculations based on national CPI micro price data.
Notes: This chart shows the difference between the absolute size of price changes in the corresponding month of 2020 and 2019. A positive value indicates an increase in the absolute size of price changes.

Chart A3

Variability of price decrease and increase changes (including sales) by month (2020 vs 2019)

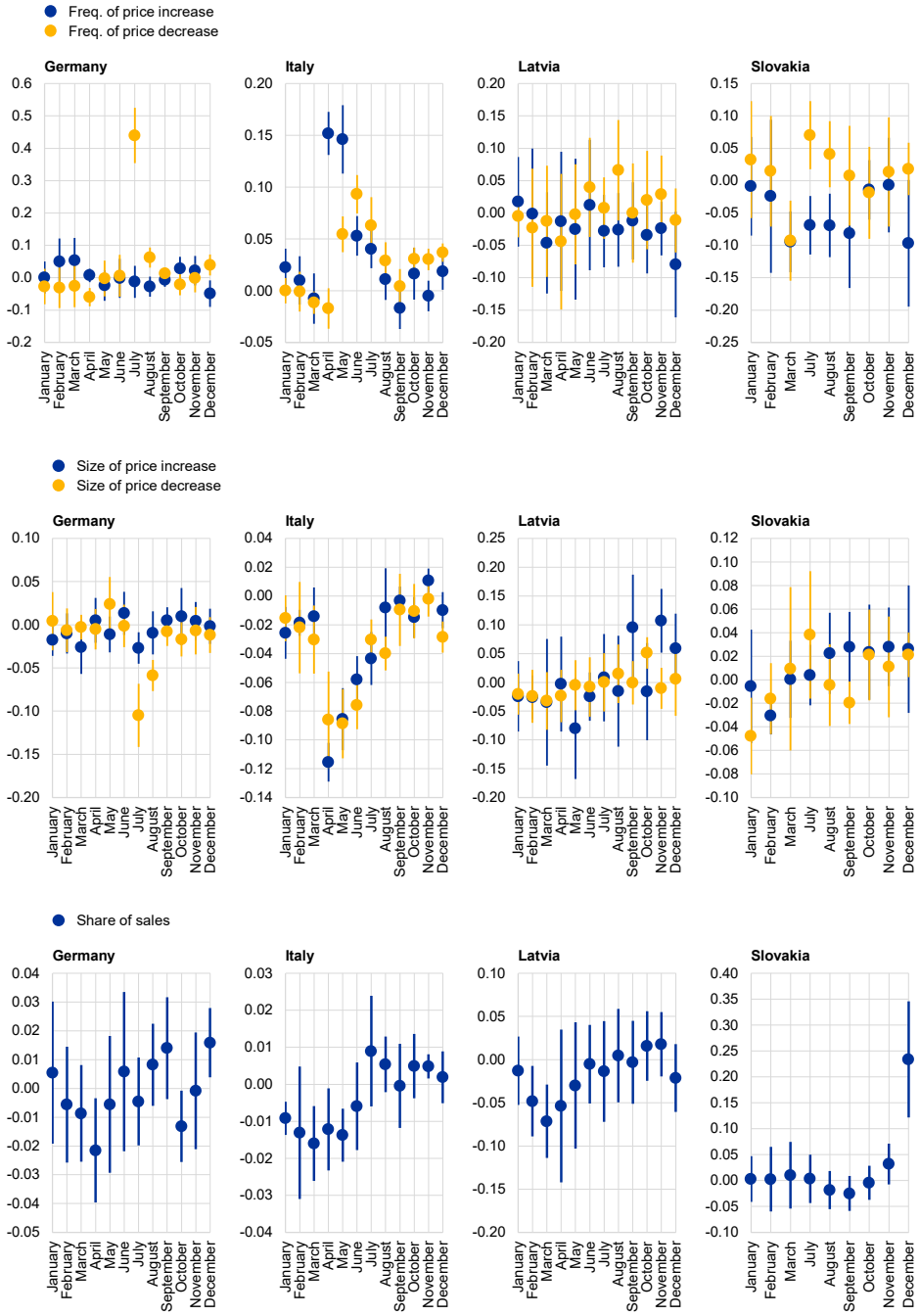
a) Processed food

(by subcomponent and country, in percentage points (pp, 1=100pp))



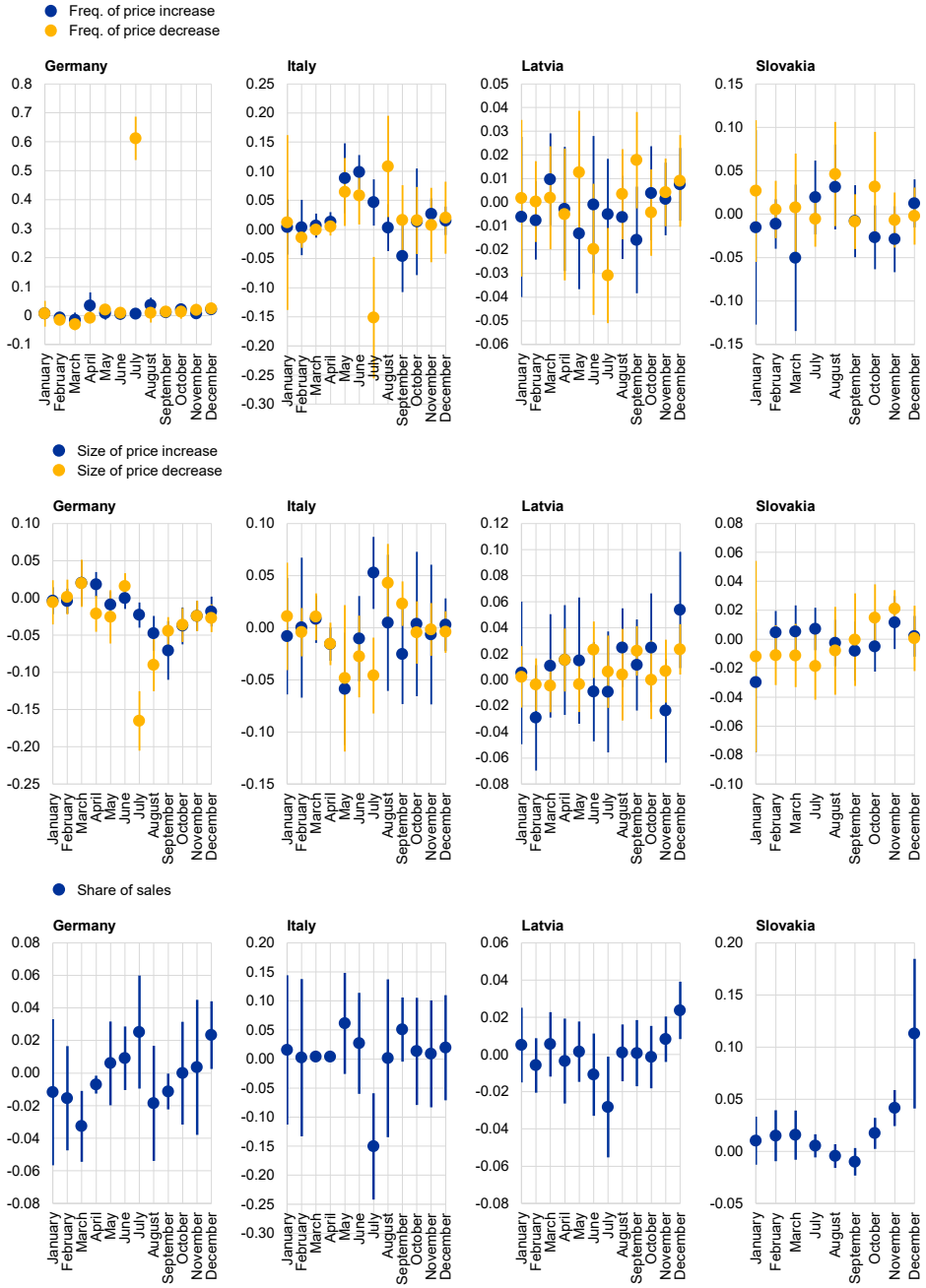
b) Unprocessed food

(by subcomponent and country, in percentage points (pp, 1=100pp))



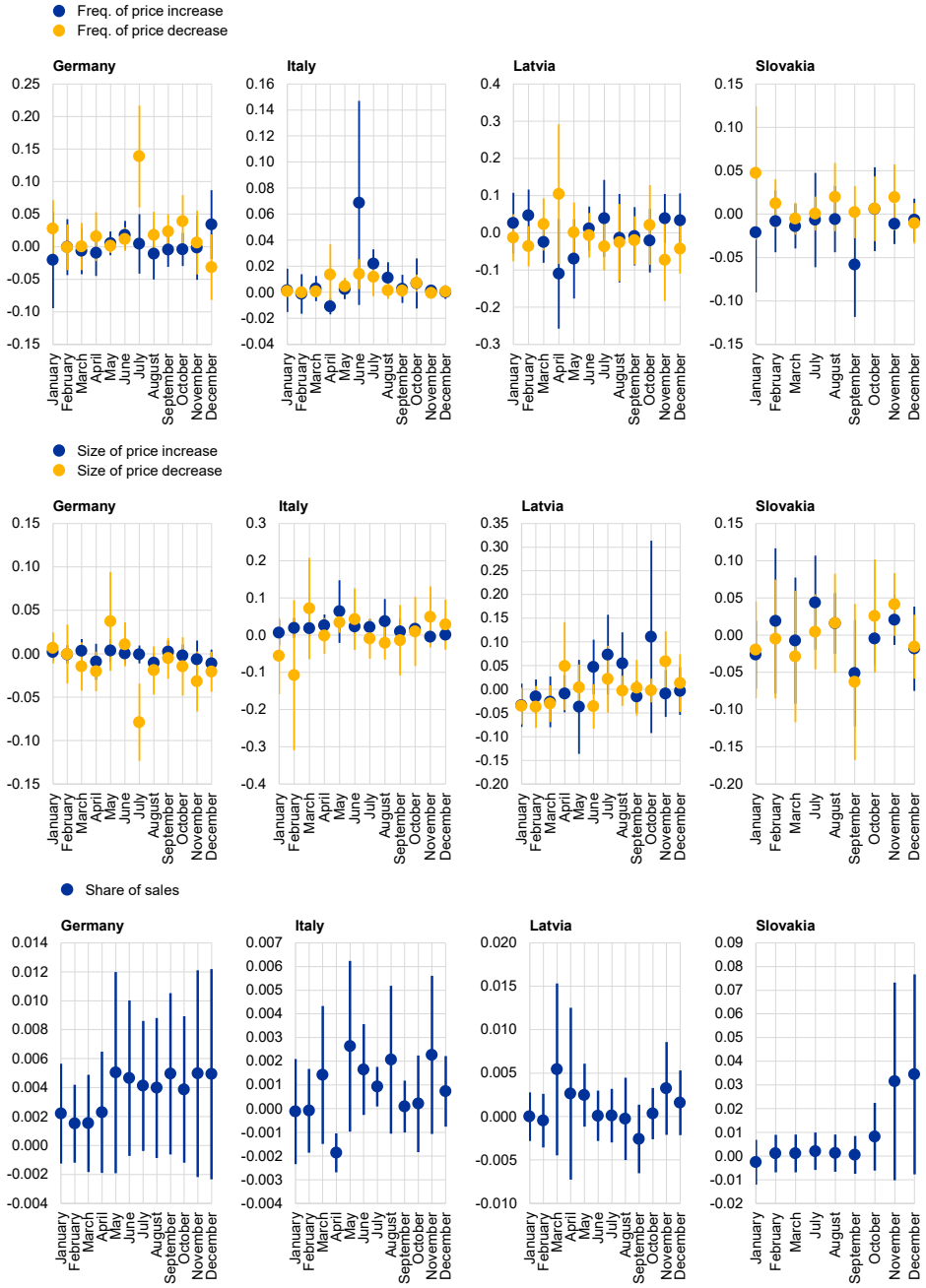
c) NEIG

(by subcomponent and country, in percentage points (pp, 1=100pp))



d) Services

(by subcomponent and country, in percentage points (pp, 1=100pp))



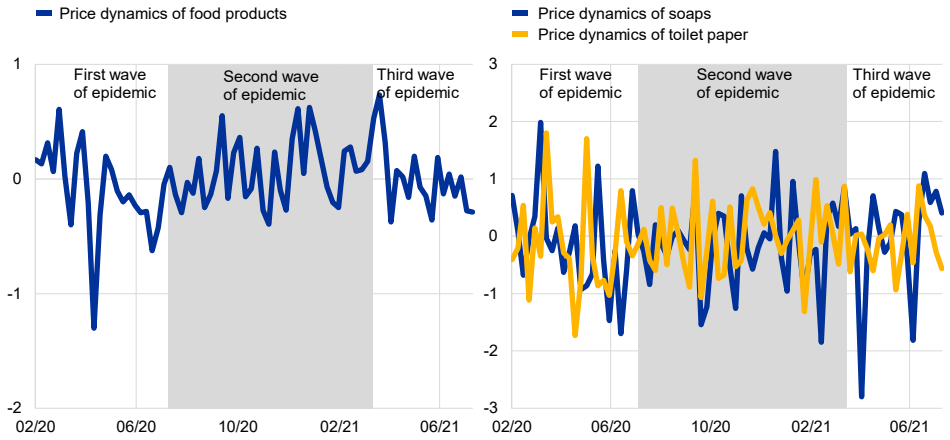
Source: Own calculations based on national CPI micro price data.
Notes: The coefficients plot month-specific time effects of 2020 compared with 2019 derived from country-specific weighted regressions with ECOICOP-5 fixed effects, euro area HICP weights (2017-20 average) and the bars represent 95% confidence intervals. The dependent variables are the frequency and absolute size of price changes (including sales) as well as the share of sales. A negative value indicates a decline in the frequency/magnitude of price changes/share of sales in 2020 compared with 2019. Only products which were available during the 2015-20 sample for a chosen country and corresponding month are selected. No observations for Slovakia for April-June 2020.

A2 Appendix to: Online price setting during the pandemic

Chart A4

Price dynamics of food and hygiene products

(percentages, w/w)

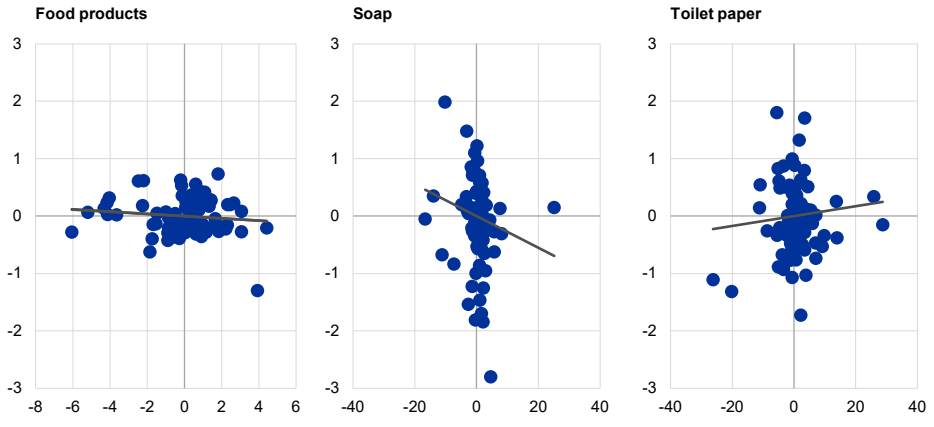


Source: Narodowy Bank Polski.
Notes: The charts show weekly price dynamics. Data starting in third week of February 2020. The most recent observation is the last week of July 2021.

Chart A5

Relation between changes in availability of food products, soap and toilet paper and their price dynamics

(percentages, w/w)

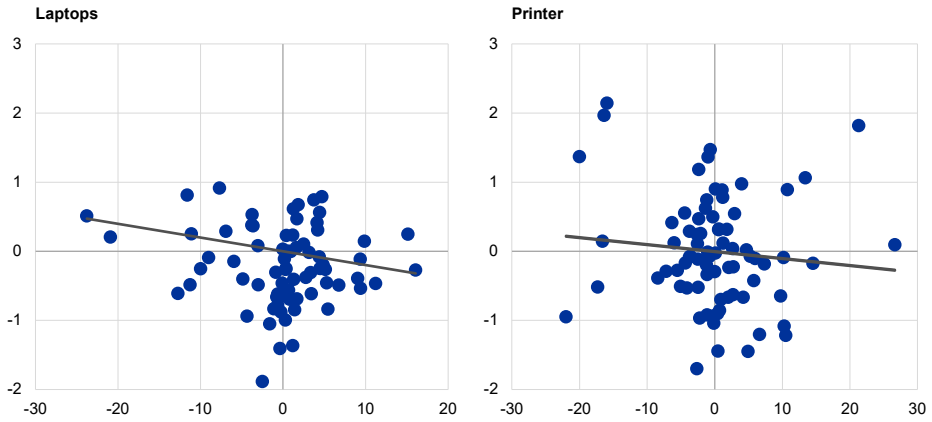


Source: Narodowy Bank Polski.
Notes: The charts show the relation between weekly changes in product numbers and their price dynamics. Data starting in third week of February 2020. The most recent observation is the last week of July 2021.

Chart A6

Relation between changes in availability of electronic products and their price dynamics

(percentages, w/w)



Source: Narodowy Bank Polski.
Notes: The charts show the relation between weekly changes in the number of products and their price dynamics. Data starting in third week of February 2020. The most recent observation is the last week of July 2021.

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