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Price Stickiness in the Euro Area

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ABSTRACT

This chapter reviews the empirical evidence on price stickiness in the euro area. We provide an overview of the different sources of granular consumer and producer price data now available in the euro area. We document new stylized facts on price adjustment in the euro area over the last 20 years. We first present results on the frequency and size of price adjustment in the cross-section dimension. Then we describe some results on the evolution of price stickiness over time. We also derive some implications for the micro-foundations of macro models, discussing the consistency of available evidence with predictions of state- and time-dependent models.

Keywords: Nominal Rigidities, Inflation, Micro Data, Euro Area

JEL classification: D40, E31

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NON-TECHNICAL SUMMARY

Infrequent price adjustment is a crucial assumption in standard macro models used for the analysis of monetary policy. In these models, the frequency of price changes shapes the speed at which aggregate shocks impact inflation. In particular, a low frequency implies that a monetary shock will take longer to be transmitted to inflation and will have real effects in the short run. In addition to this nominal rigidity, the size of the adjustment also matters for inflation dynamics. Even with infrequent price changes, money can still be neutral if the price changes which occur are large. Specifically, a key factor is whether price setting is state-dependent, i.e., whether the prices that change are those that need to adjust the most, because they are most misaligned from their target value. In the presence of this selection effect large price changes can be associated with small aggregate shocks, accelerating the reaction of aggregate inflation. Instead, in the main alternative model of price setting (known as 'time-dependent'), widely used in New Keynesian macro models, selection is absent: the probability of changing prices is exogenous and independent of price misalignment. This difference suggests that characterizing price stickiness requires information not only on the frequency of price changes, but also on the moments of their size distribution.

The calibration of price stickiness in macro models can only rely on the analysis of the most granular price data. However, until the early 2000's, there was hardly any micro evidence on price adjustment, especially for the euro area. This paper provides an overview of available empirical evidence on price stickiness in the euro area, focusing on the period 2005-2019 but also including an update on the post-Covid surge in inflation.

We first describe the euro area price data sets that have been made available to researchers since the early 2000s. The initiatives behind these data sets have had to face the challenge of assembling and making comparable data from several different countries. The Eurosystem's Inflation Persistence Network (IPN) pioneered studies of micro prices in the euro area. More recently, the European System of Central Banks (ESCB) Price-Setting Microdata Analysis Network (PRISMA) has embarked on a project to harmonize micro price data into a single dataset that provides comparable statistics on patterns of price adjustment, at the product level across euro area countries.

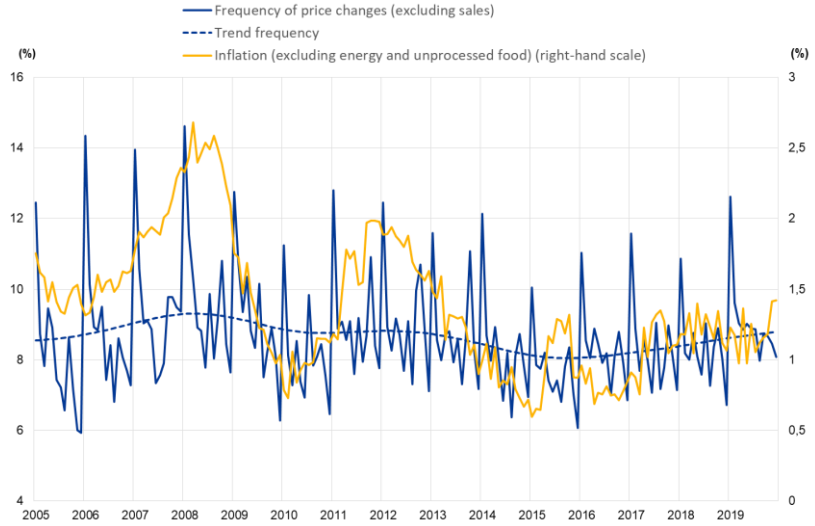
The main findings of the empirical literature on the euro-area price stickiness are the following. First, in a low inflation environment, consumer prices change on average once a year. Within the euro area, we find small differences in the frequency of price changes across countries. The frequency of price adjustments varies much more across sectors. Second, price changes in the euro area are large on average. Another important feature of the price change distribution is that non-zero price changes are highly dispersed, with many changes smaller than average inflation but with a significant number of large increases and decreases.

Price changes are more frequent in the US than in the euro area but the difference is primarily due to sales and, once price changes due to sales are excluded, prices changes are as frequent in the US than in the euro area. When we compare the frequency of producer price changes and the frequency of consumer price changes for similar products in the euro area, they are highly correlated, but for a majority of products the frequency of producer price changes is larger than that of consumer prices. Similarly, the average size of producer price changes is smaller than the one of consumer prices.

When looking at how price stickiness varies over time, the frequency of price changes remained broadly stable over the period 2005-19 and is not correlated to aggregate inflation (Figure 1). Price changes are much more frequent in January than in other months (even after removing price changes

due to sales). This January effect is much stronger than any cyclical variation we can detect over the period 2005-2019 in the frequency of price changes.

Figure 1. Inflation and frequency of price changes over time in the euro area



Note: the frequency of price changes is the share of consumer prices adjusted in a given month. The trend is computed using the standard Hodrick-Prescott filter for monthly data. The inflation rate is a year-on-year change of the HICP index (excl. energy and unprocessed food) 2005-2019.

Another crucial finding is that state dependence is a relevant feature of price setting in the euro area. In the recent inflation surge, characterized by large inflationary shocks, the frequency of price changes has increased, consistently with the nonlinear effects of shocks that state dependence predicts. This increase in the frequency of price changes entails faster inflation dynamics: for a given degree of persistence of the underlying cost shocks, inflation will rise more quickly than if the frequency of price changes had remained unaffected.

La rigidité des prix dans la zone euro

RÉSUMÉ

Ce chapitre passe en revue les résultats empiriques sur la rigidité des prix dans la zone euro. Nous proposons un aperçu des différentes sources de données individuelles sur les prix à la consommation et à la production désormais disponibles dans la zone euro. Nous documentons de nouveaux faits stylisés sur l'ajustement des prix dans la zone euro au cours des vingt dernières années. Nous présentons d'abord les fréquence et ampleur moyennes de changement de prix. Nous décrivons ensuite quelques résultats sur l'évolution de la rigidité des prix dans le temps. Nous en déduisons également quelques implications pour les fondements microéconomiques des modèles macroéconomiques, en discutant de la cohérence des faits stylisés disponibles avec les prédictions des modèles dépendants de l'état et du temps.

Mots-clés : rigidités nominales, inflation, données microéconomiques, zone euro.

1 Introduction

Infrequent price adjustment is a crucial assumption in standard macro models used for the analysis of monetary policy. A central question in the sticky price literature is whether monetary variables affect the real economy, or whether money is "neutral". How sticky are prices and which model best captures price adjustment patterns? These questions are crucial for these macro models and answering them requires analysing price adjustment patterns at the most granular level. However, until the early 2000's, there was hardly any micro evidence on price adjustment, especially for the euro area.

Inflation is the sum of heterogeneous individual price setting decisions, whose analysis requires micro data. Price adjustment is "lumpy": prices change infrequently, and both price increases and decreases can be large. The frequency of price changes shapes the speed at which aggregate shocks impact inflation. Furthermore, according to workhorse models used by many central banks, the link between inflation and economic "slack" depends on the frequency of price adjustments: other things equal, a low frequency implies a flat Phillips curve, conditional on inflation expectations; hence, a monetary shock will take longer to be transmitted to inflation. Micro data sets are necessary for measuring the frequency of price changes, addressing the empirical challenge of calibrating this crucial parameter in macro models.

In addition to this nominal rigidity, the size of the adjustment, i.e., by how much *reset prices* differ from their prior values before the adjustment, also matters for inflation dynamics.[1] Indeed, the literature has shown that even with infrequent price changes, money can still be neutral if the price changes which occur are large (see e.g. Caplin and Spulber (1987)). Specifically, a key factor is whether price setting is *state-dependent*, i.e., whether the prices that change are those that need to adjust the most, because they are most misaligned from their target value. In the presence of this *selection effect* large price changes can be associated with small aggregate shocks, amplifying the reaction of aggregate inflation even if the frequency of price changes is relatively low. Instead, in the main alternative model of price setting (known as *'time-dependent'*), widely used in New Keynesian macro models, selection is absent: the probability of changing prices is exogenous and independent of their misalignment.[2] This difference suggests that frequency might not be the only statistic to look at when we want to characterize price stickiness. Alvarez et al. (2016) and Alvarez et al. (2022) show theoretically that the cumulative real effects of monetary policy shocks are related to both the frequency of price changes and the kurtosis of the non-zero price change distribution. In other words, characterizing price stickiness in general requires information not only on the frequency of price changes, but also on higher moments of their size distribution.

Theoretical work has shown that in an environment of low and stable inflation with small aggregate shocks, time- and state-dependent models generate similar price adjustment characteristics and similar aggregate responses of prices and output to a monetary policy shock (see, among others, Alvarez et al. 2016 and Auclert et al. 2024). This is not the case when inflation is high and volatile. With large demand or cost shocks, state-dependent models predict a quicker reaction of prices, as they would be more misaligned with their reset values. This increases the probability of price changes. By contrast, time-dependent models predict that the frequency of price changes would remain the same independently of the size of shocks and the level of (trend) inflation. That is why looking at price adjustment patterns in a higher inflation context provides more insights on the degree of state-

[1] The reset price refers to the new price after a price change.

[2] The most prominent example is the Calvo (1983) model: only some firms can adjust their prices, and the probability to do so is exogenous and constant (see also Costain and Nakov 2024 for more details). This assumption implies that the proportion of firms that change their prices in any given period is constant, which will deliver a constant frequency of price changes when estimated using micro data.

dependence. Gagnon (2009), Wulfsberg (2016), Nakamura et al. (2018) and Alvarez et al. (2019) have documented some evidence in times or countries where inflation was much higher than 2%, but no evidence has been made available for the euro area.

In this chapter, we provide an overview of existing evidence on price stickiness in the euro area based on micro price data sets.

First, we describe the euro area data sets that have been made available to researchers since the early 2000s. The initiatives behind these data sets have had to face the challenge of assembling and making comparable data from several different countries. The Eurosystem's Inflation Persistence Network (IPN) pioneered studies of micro prices in the euro area. More recently, the European System of Central Banks (ESCB) Price-Setting Microdata Analysis Network (PRISMA), has embarked on a project to harmonize micro price data into a single dataset that provides comparable statistics on patterns of price adjustment, at the product level across euro area countries (see Gautier et al. 2024b replication package). In addition, the coverage of products and the period were extended.

This chapter will mainly focus on results obtained with micro data on prices collected for the construction of the CPI, but empirical results obtained with PPI data and online prices will also be documented. The second section describes the main sources of micro price data, while the third section discusses the key cross-sectional features of consumer and producer price adjustment in the euro area across sectors and countries as well as a detailed comparison with US evidence. For that, we rely on Gautier et al. (2023) and Gautier et al. (2024a), which have documented the most recent results on consumer price stickiness from the PRISMA network research. In this section, we also provide a detailed comparison with earlier evidence documented by Dhyne et al (2006), the first study covering the euro area. We also report the results of Gautier et al. (2024a) comparing in detail US and euro area CPI results. Finally, we document some findings on producer price stickiness in the euro area and how it compares with CPI price stickiness.

In the fourth section, we investigate whether the frequency of price changes varies over time with the level of inflation. One of the key predictions of time-dependent models and the Calvo model, is that the frequency of price changes does not depend on inflation variation over time, since firms or retailers can react to shocks by adjusting the size of price changes but not the timing at which they revise their prices. Time series analysis can help to test this prediction. Specifically, we provide some preliminary evidence on how the frequency of price changes has responded to the higher inflation in the euro area.

2 Micro price data sets

Micro data on individual prices are necessary to document how frequently firms adjust their prices and by how much they change them when they do. Price indices (even at a very disaggregate level) might seem perfectly flexible, but only because they average the evolution of many different prices, each adjusting infrequently. Therefore, aggregate inflation measures cannot inform us about the frequency and the size of price adjustment. Since the early 2000s, several new data sets containing micro price quotes have been made available to researchers.

These micro data sets can be grouped in four categories. The first category consists of data sets containing price quotes collected by National Statistical Institutes (NSI) and underlying the official Consumer Price Indexes (CPI) or the official Producer Price Indices (PPI). These data sets cover a very large share of the consumer and producer price indices; they are highly reliable and collected following a harmonized methodology within the euro area. In some of the larger countries of the euro area like Austria and France, these data are available for a very long time period (starting in the 1990s in France for instance), which helps to investigate time series evidence on price setting, including on the impact

of monetary policy shocks. The second category consists of supermarket scanner data. They cover a more limited range of products (typically grocery items) than CPI micro data and are generally available for shorter time periods (2013-2017 in the case of the data used by Karadi et al. (2023)), but they usually contain the prices of a much larger number of products within each product category than typical CPI data and provide more detailed information on the characteristics of each product. Scanner data sets also contain the quantities purchased, which can inform us on the sources of price variation and potentially on some additional parameters like the demand elasticity.[3] The third category consists of web-scraped online price data: these price quotes are collected on the web sites of online shops such as supermarkets, clothing and electronics shops, and are very useful to compare the degree of price rigidity for offline and online purchases or to investigate high frequency price adjustment (see for instance Cavallo (2017) and Strasser et al. (2022)). The last data source on price adjustment is firm business surveys: these surveys usually collect qualitative (and less frequently quantitative) information on the evolution of firms' prices (see Bachmann et al. 2019 for an example using German data or Loupias and Sevestre (2013) using Banque de France survey data).

This chapter mainly focuses on results obtained from price data sets collected by National Statistics Institutes (NSIs) to compute official CPI and PPI indices. Models often represent the behaviour of producers selling their goods to other firms or to retailers. This would indicate PPI micro data as the most suited to document price stickiness and investigate price setting.[4] However, most central banks target CPI inflation, which makes it just as important to understand consumer price adjustment.

2.1 Consumer price data

The Eurosystem Inflation Persistence Network (IPN) pioneered studies of micro prices in the euro area in the early 2000s. In the context of that research network, several central banks had access, at the national level, to confidential price micro data sets collected by NSIs to calculate Consumer Price Indices (CPIs) and Harmonised Indices of Consumer Prices (HICPs). Depending on the country, these confidential data included all price quotes collected in outlets (like in France or Germany) or a selection of products (like in Italy). These data sets typically contained sequences of prices for a specific good or service sold by a given retailer/outlet. Variables included the individual price in national currencies, a product identifier (including a COICOP classification identifier and the identifier of the retailer) and some metadata information on whether the good was on sale or not and on whether the product had been substituted or replaced.[5] Price collection is harmonized by general regulations and recommendations defined at the European Union level by Eurostat. This ensures the data's comparability across countries and reliability, as NSIs meticulously sample products based on national household consumption patterns. However, the data sets made available by euro area NSIs can differ across countries on the coverage of products as well as on the characteristics provided with prices, products and outlets. Within the IPN, several country-specific studies were released using these country-level data sets: Álvarez and Hernando (2006) for Spain, Aucremanne and Dhyne (2004) for Belgium, Baudry et al. (2007) for France, Costa-Dias et al. (2008) for Portugal, Fabiani et al. (2005) for Italy, Hoffmann and Kurz-Kim (2006) for Germany, and Rumler et al. (2011) for Austria among others. At the euro area level, Dhyne et al. (2006) used a harmonised sample of 50 individual products for 10 EA countries, which together accounted for more than 97% of the EA GDP (including Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Portugal, and Spain). The sample period was also similar, starting in 1996 and ending in 2001, just before the euro cash changeover. The

[3] See Dubois et al (2022) for an overview of the use of scanner data for economic research.

[4] PPI price data are also more informative when we want to link prices to the evolution of marginal costs which are more easily identified for productive firms than for retailers. This helps in particular to document the delays in the transmission of marginal cost shocks (see for instance Dedola et al (2021), Carlsson (2017), Carlsson and Nordström Skans (2012))

[5] COICOP refers to the Classification of Individual Consumption by Purpose.

harmonized sample of 50 products was chosen to cover each of the five different broad categories of goods and services in the HICP: unprocessed food, processed food, energy, non-energy industrial goods (NEIG) and services.

Some years after the IPN research network, country-specific studies were revisited using updated versions of the same national CPI data sets. Data were updated in France (Berardi et al., 2015), in Italy (Fabiani and Porqueddu, 2017) in Belgium (Blanas and Zimmer, 2020).

More recently, the new ESCB-wide research initiative called Price-Setting Microdata Analysis Network (PRISMA) has updated and extended the micro price data sets for the euro area (see Gautier et al., 2024a for details).[6] First, the national micro CPI data sets were extended to the end of 2019 for most countries. Second, the country coverage was slightly different: the PRISMA study includes 11 countries covering more than 90% of the euro area HICP country coverage, based on expenditure weights. Seven countries are covered by both IPN and PRISMA studies (Germany, France, Italy, Spain, Belgium, Austria, and Luxembourg), four countries are only included in the PRISMA study (Greece, Latvia, Lithuania and Slovakia) and three countries are only included in the IPN study (the Netherlands, Portugal and Finland).[7] Together all national datasets account for 135 million price quotes over the period from the late 1990s or early 2000s to 2019 (see Table 1 summarizing data sets available in Dhyne et al. (2006) and Gautier et al. (2024a)).

One main difference between IPN and PRISMA is the product coverage. Gautier et al. (2024a) constructed a common sample of 166 products defined at level 5 of the European Classification of Individual Consumption by Purpose (ECOICOP), which is the most detailed level of the HICP, e.g., "01.1.1.1 - Rice, incl. rice preparation". A COICOP-5 category is included when it is available for at least three of the four largest euro area countries (Germany, France, Italy and Spain). Overall, this sample of common products covers 59% of the euro area HICP and 65% of the euro area HICP excluding energy. By comparison, the harmonised sample of 50 individual products in Dhyne et al. (2006) covered about 10% to 14% of the CPI baskets of the respective member countries. However, the PRISMA sample excludes energy products and approximately half of all services that are included in the HICP. It excludes services such as rents, communication services, and certain travel-related items, like package holidays. Usually NSI data sets do not contain most of centrally collected prices of manufactured goods, such as new and used cars, pharmaceutical products, ICT products, and some regulated food products like tobacco or alcohol.[8]

Looking at consumer price adjustment, it is crucial to account for price changes that are due to sales and promotions, as these usually imply large but temporary or highly seasonal price changes (see Nakamura and Steinsson, 2008). However, sales are not systematically reported in all country-specific CPI micro data. In several countries (Germany, France, Italy and Austria), temporary promotions are identified by a sales flag reported by the NSI, but in other countries sales flags are not available (in Spain for instance). Besides, the definition of sales and promotions might depend on national practices. Therefore, Gautier et al. (2024a) also use a sales filter based on Nakamura and Steinsson (2008) to detect temporary price decreases.

[6] https://www.ecb.europa.eu/pub/research-networks/html/researcher_prisma.en.html

[7] The product coverage and sample period vary across countries. The highest product coverage amounts to 97% of the HICP (Luxembourg) while the lowest is around 43% (Belgium). The longest time periods span two decades or more of micro price observations (Austria (2000-2017), France (1994-2019), Greece (2002-2019)) and the shortest three years (Latvia, 2017-2019).

[8] Centrally collected, administered or regulated prices typically raise serious measurement issues for price dynamics statistics (e.g. unit values, average price, quality adjustment) biasing the size and frequency of price adjustment (see Eichenbaum et al. (2014) for a discussion).

Table 1: Country CPI Micro Data sets considered in Dhyne et al. (2006) and Gautier et al. (2023)

	PRISMA - Gautier et al. (2024a)		*IPN - Dhyne et al. (2006)*	
Country	Sample period (months indicated when whole year unavailable)	Total observations in millions	Sample period	CPI coverage of the national data set
Countries covered in both studies				
Austria	2000-2017	8.3	1996-2003	80%
Belgium	2007-2015	8.5	1989-2001	68%
France	2003(M4)-2019(M9)	25.0	1994(M7)-2003(M2)	65%
Germany	2010-2019	46.8	1998-2004(M1)	52 product categories
Italy	2011-2018	22.7	1996-2003	50 product categories
Luxembourg	2005-2017	1.2	1999-2004	100%
Spain	2008-2018(M2)	1.4	1993-2001	70%
Countries only in Gautier et al. 2024a				
Greece	2002-2019	7.7	-	
Latvia	2017-2019	0.7	-	-
Lithuania	2010-2018	5.4	-	-
Slovakia	2011-2019	8.3	-	-
Countries only in Dhyne et al. (2006)				
Finland			1997-2003	100%
The Netherlands			1998(M11)-2003(M4)	49 product categories
Portugal			1992-2001(M1)	95%

Sources: Dhyne et al. (2006) and Gautier et al. (2024a); "Total observations" refers to the total number of price observations pooled across time periods and products.

Another potentially major concern in constructing measures of price stickiness relates to product replacements or substitutions. Typically, when a product is unavailable or discontinued temporarily or permanently, the price of a close substitute is used for the CPI compilation. For most countries in the sample, a flag for such product replacements is available; in some national data sets, we are able to identify the new product replacing the one that has disappeared. However, as the definition of product replacements varies across countries due to differences in national statistical practices and product identifiers (e.g., link between old and new product identifiers, qualitative information on the type of replacement, i.e., whether it is a fully new product, very similar, or different product), price changes due to replacements and substitutions are excluded from the baseline statistics.

Finally, aggregate statistics of price rigidity are obtained using euro area HICP weights at the ECOICOP-5 product level so that differences in price adjustment between countries are not influenced by variations in national consumption structures. Gautier et al. (2024a) also use HICP country weights to derive aggregate euro area statistics.

2.2 Producer price data

Producer prices correspond to prices set by productive firms when they sell their products to another firm, at the factory gate. In principle, the price also refers to an actual transaction price, not a list price. This means that the data collection is different from that of consumer prices: individual producer prices cannot be directly observed in outlets like consumer prices, but they are generally collected through firm surveys. These surveys are conducted by National Statistical Institutes (NSI) to collect prices and calculate the PPI indices. The data collection follows EU legislation and Eurostat recommendations. For a given product, the NSI builds a representative sample of firms that produce that product using annual firms' surveys. Then, for every sampled firm, the most representative transactions are selected and the price for a specific product to a specific customer is collected every month. Prices refer to ex-factory basic prices, which include all duties and taxes including subsidies on products received, but exclude VAT, other similar deductible taxes directly linked to turnover and subsidies on products received, as well as transport costs. In theory, individual price quotes underlying the PPI are specific, not only to a product and a firm (as for consumer prices), but also to a customer.

In practice, the collection of individual producer prices raises many measurement issues, and some firms may average prices over different customers, over several transactions or sometimes even report unit values (i.e. values of sales divided by quantities). This could lead to positive bias when measuring the frequency of price changes (see Gautier (2008) for a discussion in the French case). Some country evidence also suggests that the method of price collection (phone vs web questionnaire) could generate structural changes in the frequency of price changes (see Gautier et al. (2023) for an example in Belgium). Besides, like for consumer goods, product replacement could be an important empirical challenge and usually it is very difficult to track how products are replaced over time. Finally, contrary to consumer prices, there is no sales flag. However, this issue might be much less relevant for the PPI than for the CPI (see Nakamura and Steinsson (2008) or Vermeulen et al. (2012) for a discussion).

In the euro area, both IPN and PRISMA research networks have used micro price data underlying the construction of producer price indices (for products sold on the domestic market) in the manufacturing sector.[9] Vermeulen et al. (2012) summarize euro area evidence obtained using several millions of prices collected in six euro area countries (Belgium, France, Germany, Italy, Portugal and Spain) between early 1990s and the mid-2000s.[10] Gautier et al. (2023) provide results on PPI price rigidity for the recent period (between the beginning of 2000s and the end of the 2010s) using microdata underlying official PPIs in Belgium, France, Greece, Lithuania, the Netherlands and Portugal; the euro area coverage is more limited in Gautier et al. (2023) since data from large euro area countries like Germany, Italy or Spain are missing. In both euro area studies, it was not possible to harmonize the sample of products across the different countries; in particular, the product coverage depends a lot on the country-specific domestic production structure. Contrary to consumption structure, which is similar across euro area countries, the production structure might differ a lot from a country to another, especially for smaller countries. These differences might also imply large differences of weights across countries for similar products.[11] Overall, country comparisons should be made with caution. Vermeulen et al. (2012) document detailed product results by country in order to make more precise comparisons.

[9] For evidence on business services, Gautier (2008) provides some price rigidity statistics in France using quarterly data.

[10] Detailed country data sets are described in Cornille and Dossche (2008), Gautier (2008), Stahl (2006), Sabbatini et al. (2005), Dias et al. (2004) and Alvarez et al. (2010).

[11] In Gautier et al. (2023), since for the euro area as a whole, the annual weights are not publicly available on national statistical websites or on Eurostat, they use French PPI weights to provide euro area weighted statistics.

Importantly, CPI and PPI micro data could help to understand how price rigidity evolves along the production chain since PPI data measure out-of-the-factory price data while CPI data are collected at the retail level. Two important empirical issues should be mentioned. First, there are coverage differences. Usually PPI data cover only domestically produced goods, whereas CPI data also cover imported goods; PPI data do not cover services and cover products at different stages of production (intermediate goods, finished goods…). In Vermeulen et al. (2007, 2012), a comparison is performed using only comparable products in both CPI and PPI baskets (which by construction uses mainly results of PPI of consumer goods). A second difference between PPI and CPI is that producer prices are collected net of indirect taxes whereas CPI prices include all taxes.

Table 2: Country PPI Micro Data sets considered in Dhyne et al. (2006) and Gautier et al. (2023)

	PRISMA - Gautier et al. (2023)		*IPN – Vermeulen et al. (2012)*	
Country	Sample period	Total observations in thousands	Sample period	PPI coverage of the national data set
Countries covered in both studies				
Belgium	2001-2014	150	2001-2005	83%
France	2013-2019	750	1994-2005	92%
Portugal	2010-2020	900	1992-2001	95%
Countries covered in Gautier et al (2023) only				
Greece	2008-2020	420	-	
Lithuania	2010-2018	130	-	-
The Netherlands	2000-2019	1,600		
Countries covered in Vermeulen et al. (2012) only				
Germany			1997-2003	100%
Italy			1997-2002	44%
Luxembourg			1999-2004	100%
Portugal			1995-2000	100%
Spain			1991-1999	99%

Sources: Vermeulen et al. (2012) and Gautier et al. (2023); "total observations » refers to the total number of price observations pooled across time periods and products.

3 Cross sectional evidence on price stickiness in the euro area

In this section, we document cross-sectional features of consumer price stickiness in the euro area. We provide results on the frequency of price changes and on the distribution of non-zero price changes, that are useful to inform models of price setting. First, the frequency of price changes is a key statistic for the calibration of both time-dependent and state-dependent models. Second, the distribution of price changes is a crucial object to replicate for state-dependent models with firms subject to idiosyncratic shocks. Here, we rely mainly on the results in Gautier et al. (2024a) for

consumer prices over the period 2010-2019, while also providing some comparison with producer prices drawing from Gautier et al. (2023) and Vermeulen et al. (2012).[12]

3.1 Frequency of price changes

Consumer prices in the euro area are sticky, they adjust infrequently. Gautier et al. (2024a) find that on average 12.3% of consumer prices (ex-energy) change each month when price changes related to sales are included. Sales are a key feature of retail price behaviour, and a typical price adjustment related to sales is first a large drop in prices, followed by the price coming back close to its previous level. At the macroeconomic level, there is a discussion on whether these "temporary" large price adjustments contribute or not to the transmission of aggregate shocks.[13] Macroeconomic models often remove these price changes from standard measures of price stickiness. In euro-area consumer prices, the proportion of price changes due to sales is limited and represents about 4.4% of all non-zero changes. When we remove price changes due to sales, the frequency of price changes falls to 8.5% (Table 1). Thus, the typical non-sale retail price adjusts only every 12 months, entailing a slow transmission of nominal impulses, other things equal.[14]

Besides the average, also the median frequency of price changes can be an important statistic to look at. As argued in some papers, a one-sector model calibrated using the median frequency can approximate well the degree of monetary non-neutrality of richer multisector models (Nakamura and Steinsson (2010) or Gautier and Le Bihan (2022)). In the euro area, the median frequency is 9.6% when including price changes due to sales and 5.7% when excluding them. These median frequencies are lower than the average frequency: the gap is a little less than 3 pp, not as large as in Nakamura and Steinsson (2010) for US data or Gautier and Le Bihan (2022) for French data, where the difference exceeds 6 pp. The reason is that Gautier et al. (2024a) do not include energy products. Available euro-area country studies suggest that the frequency of price changes is much larger for this type of product than for other consumer products, in particular because gasoline prices change very frequently (see Gautier, Marx and Vertier (2023)). For instance, Berardi et al. (2015) find that about 80% of energy prices are updated each month in France. As energy products represent about 10% of the euro area HICP basket of products, this higher frequency of price changes would contribute to increase the overall frequency of price changes by about 8pp and to widen the gap between the median frequency and the average frequency.

Looking at sectoral heterogeneity, even when excluding energy, the frequency of price adjustments varies across sectors. The highest frequency is observed for unprocessed food at 31.4%, while it is 15.4% for processed food and 12.9% for NEIG. The lowest frequency is found in the services sector (6.0%). Excluding price changes due to sales significantly reduces the sectoral heterogeneity. In product categories like unprocessed food and NEIG, the share of sales is larger than the average (about 8%) and the frequency is reduced by about 7 percentage points, the effect of sales is a little bit smaller for processed food (-5pp) but removing sales has only a limited impact on services, where the share of sales and promotions is only 0.5%.

There are differences in the frequency of price adjustments between broad sectors, but also within these broad product categories. The differences in the frequency of price changes across products can

[12] For details on the coverage of the CPI country-specific samples see Gautier et al (2024a), Table 1. The replication package of Gautier et al. (2024a) makes a detailed data set available, which contains different moments of the CPI price change distribution calculated at country- and product-level.

[13] For instance, Anderson et al (2017) or Berardi et al. (2015) find little covariance between sales price changes and aggregate shocks whereas Kryvtsov and Vincent (2021) find a positive correlation.

[14] This result is robust to using the sales filter instead of the NSI flag to exclude price changes due to sales, see Gautier et al (2024a). For calibration of macro models Gautier et al (2024a) also provide quarterly figures for the frequency of price changes.

be traced back to the products' cost structure. Specifically, Gautier et al. (2024a) find that an increase in the share of labour costs tends to decrease the frequency of price changes, while an increase in the share of energy and raw material inputs tends to increase it. A 10-percentage point increase in the share of labour costs reduces the frequency of price adjustment by about 2 percentage points. Conversely, a 10-percentage point increase in the share of imported energy and raw material inputs, keeping the share of all imported inputs constant, increases the frequency of price adjustment by about 8 percentage points.

A further important source of sectoral heterogeneity is due to the rise of online retailing, a force that could impinge on price setting, including price flexibility. Comprehensive data are still lacking to thoroughly analyse the consequences of this phenomenon on inflation dynamics in the euro area. While the COVID-19 pandemic accelerated the already existing trends everywhere, especially in the retail sector, the diffusion of e-commerce has been very heterogeneous across not only sectors but also countries in Europe. PRISMA work spotlights important parts of e-commerce in the euro area, providing indicative evidence for a rapidly evolving market, rather than definitive conclusions (see Strasser et al (2023)). It draws from diverse and complementary data sources allowing to directly compare online and offline prices mostly of (non-energy) goods: i) CPI microdata for Germany, which include price quotes from internet trade (represented on the basis of 2015 weights); ii) web-scraped data for Poland matched with the Polish CPI microdata; iii) household-level scanner data for online and offline supermarket (FMCG) purchases in France, Spain and the UK.

Online prices of most goods change more frequently than in brick-and-mortar stores, while the respective sizes of both price cuts and hikes are not consistently different. The frequency of price changes of non-energy goods is higher online than offline in both Poland and Germany (standing at 16.7% and 11.1%, respectively). Conversely, for these countries, there is little difference in the frequency in the processed food sector. Interestingly, among the few services available, price changes in online food services in Poland are as frequent as in brick-and-mortar restaurants. Overall, these findings are consistent with lower price setting frictions online, at least for goods. They confirm previous evidence supporting the conclusion that as online trade gains market share in more and more sectors, aggregate price flexibility might increase.

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

While sectoral heterogeneity in CPI price stickiness among broad product categories is substantial, differences across euro area countries are relatively small. On aggregate, including sales, the frequency of CPI price changes ranges from 10.3% in Italy to 18.6% in Latvia, while for most countries it lies between 11% and 14%. This cross-country variation narrows further when we exclude sales: in this case, the frequency varies between 4.8% in Italy and 13.3% in Belgium, standing between 7% and 10% for the others.

Table 3: CPI: Euro Area Price Changes: Frequency

(in %)

	Including sales		Excluding sales		% of sales
	Frequency of price changes	% of price increases	Frequency of price changes	% of price increases	
EURO AREA	**12.3**	**64.0**	**8.5**	**68.8**	**4.4**
By sector:					
Unprocessed Food	31.4	54.5	24.0	57.6	7.4
Processed Food	15.4	57.0	10.4	61.8	4.3
NEIG	12.9	48.2	6.4	59.8	8.6
Services	6.0	82.5	5.7	82.4	0.5

Source: Gautier et al (2023)
Notes: Statistics are based on products that are available for at least three of the four largest countries (France, Germany, Italy and Spain). Price changes due to product replacements are excluded beforehand. See Gautier et al (2024a) for details on how sales are computed.

A last finding on the frequency of CPI price changes is that price increases represent about two thirds of all price changes, but this share is slightly higher when we exclude sales. There is sectoral heterogeneity also in the proportion of price changes that are increases or decreases: NEIG prices are affected by the more frequent sales that occur in this category, so that there are more price decreases than increases. The opposite is true for food prices, both processed and unprocessed. Again, service prices stand out: due to the very rare occurrence of sales, 80% of price changes are increases.

3.2 Distribution of non-zero price changes

The distribution of non-zero price changes is also informative on price adjustment. In particular, this distribution will reflect how prices respond to underlying shocks and will inform us on the distribution and possibly the type (aggregate vs idiosyncratic) of these shocks (see for instance Midrigan (2011)). It can also be informative on the degree of state dependence. In particular, Alvarez et al. (2022) show that the kurtosis of price changes can capture the degree of state dependence.

When looking at the size of consumer price changes, the first observation is that typical price changes are quite large in comparison to aggregate inflation. Table 4 shows the median of price increases and decreases, both including and excluding sales. When price changes due to sales are considered, the median price increase is 9.6% while the median price decrease is larger in absolute terms, at 13%. When sales are excluded both the median price increase and the median price decrease are smaller: the median increase is 6.7% and the median (absolute) decrease is 8.7%. Therefore, even when sales (which tend to be the largest price changes) are excluded, the typical price increase and decrease are considerably larger compared to the average inflation in the euro area over the sample period, which is closer to 1.5%. This suggests that firm-specific shocks have a more significant impact on the size of price changes than aggregate shocks.

Similarly to the frequency, sectoral differences in the size of price changes are quite significant, especially when sales prices are included (see Table 4). Both NEIG and unprocessed food have relatively large median price increases at 13.9% and 12.6% respectively, while the median price decreases stand at 19.2% and 15.0%. These figures contrast with the services sector, where the median increase is 5.6% and the median decrease is 8.2%. Excluding price changes due to sales reduces the sectoral variation because it lowers the median increase and decrease for NEIG as well as for processed and unprocessed food, where most sales are concentrated.

Table 4: Euro Area Consumer Price Changes: Absolute Sizes

(in %)

	Including sales		Excluding sales	
	Median price increase	Median price decrease	Median price increase	Median price decrease
EURO AREA	9.6	13.0	6.7	8.7
By sector				
Unprocessed Food	12.6	15.0	10.1	11.0
Processed Food	9.2	12.0	5.8	6.5
NEIG	13.9	19.2	7.9	10.7
Services	5.6	8.2	5.5	7.9

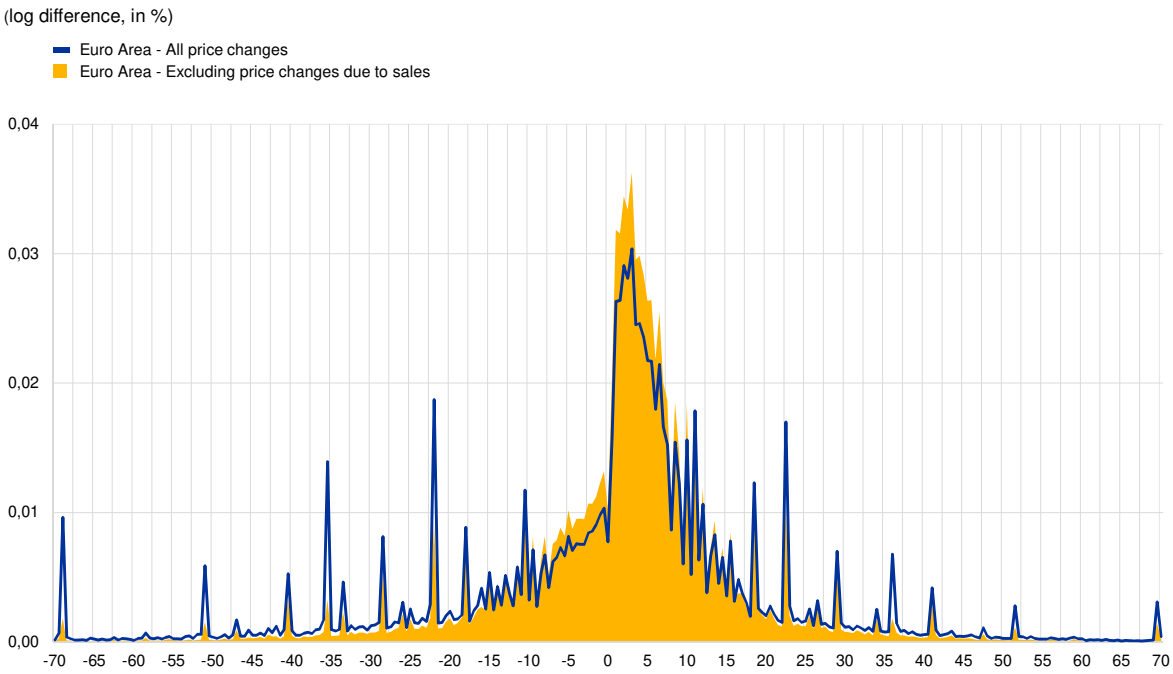
Notes: Statistics are based on the country-specific period and on products that are available for at least three of the four largest countries (France, Germany, Italy and Spain). Price changes due to product replacements are excluded beforehand (except for Greece and Slovakia). Results excluding sales are based on the NSI sales flag, except for Greece, Luxembourg, Slovakia and Spain for which no such flag is available and for which sales are excluded by the sales filter. Seasonal sales are excluded in the Belgian dataset, but temporary promotions are included.

Variations across countries are relatively limited, but larger than the differences seen for frequencies. In countries like France, Italy, Belgium, Luxembourg, and Spain, the median price increase ranges between 7.5% and 9.1%, while in Austria, Germany, Latvia, Lithuania, and Slovakia, the median price increase exceeds 10%. A similar pattern is observed for price decreases: in the first group of countries, the median decrease ranges between 11% and 12%, whereas in the second group the median is closer to 15%. These differences persist even when excluding price changes due to sales, and the country rankings remain similar.

A second important feature of the price change distribution is that non-zero price changes are highly dispersed, with many changes smaller than average inflation but with a significant number of large increases and decreases. Chart 1 plots the full distribution including price changes due to sales (blue line) and excluding price changes due to sales (yellow histogram). When considering all price changes, their distribution is asymmetric with more small positive price changes than negative ones, showing a modal range of values between +1% and +3%. There are also several peaks at large values corresponding to price changes due to sales. When price changes due to sales are removed, the peaks at large values are smaller but still significant and the asymmetry around 0 is more pronounced. When we exclude sales, the average non-zero price change is positive (reflecting the aggregate positive inflation rate and that price increases are more frequent) and equal to 2.4% (see Table 5).[15]

[15] In computing the moments of the distribution, we use the data provided by Gautier et al. (2024b – replication package).

Chart 1: Distribution of the Size of Price Changes in the euro area (in %)



Source: Gautier et al. (2023)
Notes: The chart plots the distribution of price changes (in log difference, in %) calculated first at the product/country level for the common sample of products (bins of 0.5 pp), then aggregated at the country level using euro area product weights and then aggregated at the euro area level using HICP country weights. The grey histogram corresponds to the distribution of price changes excluding price changes due to sales whereas the black line corresponds to the distribution of price changes including price changes due to sales. Results excluding sales are based on the NSI sales flag if available and the sales filter otherwise.

The standard deviation of price changes is quite large (Table 5), reflecting both large price increases and decreases. However, the standard deviation is smaller in services, which might reflect that aggregate shocks play a greater role there than in other sectors where idiosyncratic shocks play a bigger role. The skewness is small, as the distribution of price changes is rather symmetric around its mean.[16]

Alvarez et al. (2022) show that the ratio of kurtosis of non-zero price changes to the frequency can summarize the real effects of small monetary policy shocks. In particular, kurtosis should capture the degree of state dependence in a given economy or sector: it ranges from 1 in a pure state-dependent model to 6 in a Calvo model.[17] However, the estimation of kurtosis is challenging because it is very sensitive to measurement issues, such as unobserved heterogeneity or outliers (see Alvarez et al. (2022 and 2023) for a discussion). The presence of outliers or heterogeneity results in an upward bias in kurtosis measures. For euro-area consumer prices, we find that the kurtosis is equal to 5.4, which is quite high and suggests, at face value, a small degree of state dependence.[18] Comparison across products is also revealing: the kurtosis is smaller for unprocessed food than services, again suggesting a lower degree of state dependence in services than in other sectors.

[16] Alvarez et al. (2023), focusing on French CPI and PPI data and using exact moments of the price distribution, report similar numbers for CPI and for PPI (even if for PPI price changes, the distribution of price changes is less dispersed).

[17] See Alvarez et al. (2023) and Gautier, Marx and Vertier (2023) testing the sufficient statistic prediction respectively on CPI data and on French gasoline price detailed data.

[18] When we define outliers more broadly, excluding price changes below the 2nd percentile and above the 98th percentile, the average kurtosis is 4.6, when we put thresholds at 2.5% and 97.5% it is equal to 4.3. On the contrary, considering thresholds at 0.5% and 99.5% gives an average kurtosis of 6.1. Alvarez et al. (2023) report a similar result for French CPI products (average of about 5), when product heterogeneity is taken into account the average kurtosis is smaller (a little above 3).

Table 5: Higher moments derived from the product-level distribution of price changes (excluding sales)

	Average	Standard deviation	Skewness	Kurtosis
Euro area	2.5	11.9	-0.1	5.4
By sector				
Unprocessed Food	2.2	17.1	-0.1	3.4
Processed Food	2.5	10.7	-0.1	4.7
NEIG	0.6	15.2	-0.1	4.8
Services	4.1	8.9	-0.1	6.7

Source: Gautier et al 2024b (replication package) and authors' calculations
Notes: for each product in a given country, we calculate moments of the price change distribution (excluding sales) from the distribution of price changes provided in the replication package of Gautier et al. (2024a) (for each product, we exclude price changes below the 1st percentile and above the 99th percentile of price changes). All the calculated moments from the product level distribution are then aggregated using the same weighting scheme as the one used in Gautier et al. (2024a).

The distribution of price changes varies between sectors. The distributions for food and NEIG share similar patterns: a small degree of asymmetry, large peaks corresponding to sales, and a quite dispersed distribution of price changes. For services, the distribution is much more asymmetric (i.e., many more positive small price changes than negative small price changes) but also much less dispersed (more than 25% of price changes are between 0 and 3%). This finding for services might again reflect the relatively higher relevance of aggregate nominal shocks compared to firm-specific shocks as a motive for price changes. For instance, wages are an important component of the production cost for services, and they tend to move similarly across firms in the euro area due to collective bargaining. It is also consistent with the lower frequency of price changes being driven by less volatile idiosyncratic shocks.

3.3 A comparison with earlier evidence on price changes in the euro area

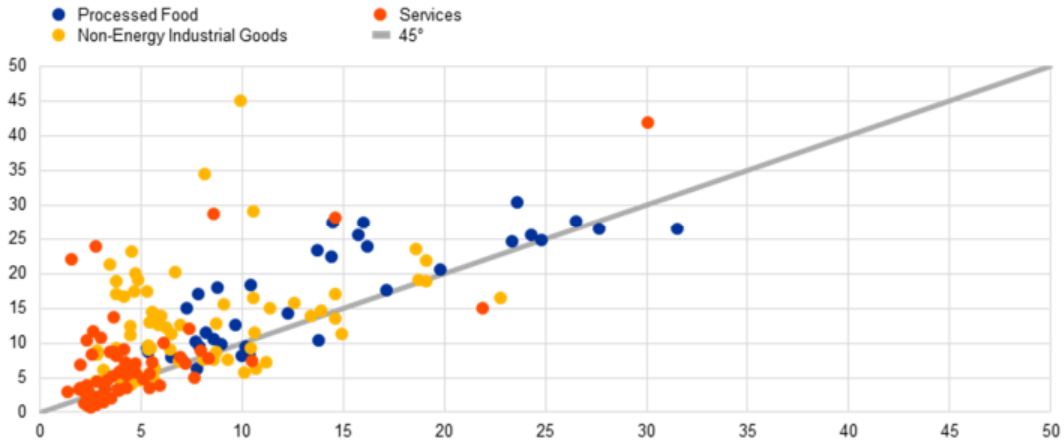
The Inflation Persistence Network (IPN) collected the first evidence on euro area price rigidity based on micro-level consumer price data harmonized across countries; the results are presented in Dhyne et al. (2006). The sources of the IPN price data were the same as for the PRISMA CPI data: the National Statistical Institutes of euro area countries.

Their findings were derived for the period 1996-2001 from 10 countries and a harmonised sample of 50 product categories chosen to be broadly representative of the consumption basket. To make a consistent comparison on how price rigidity evolved from the nineties, in addition to using a similar methodology it is necessary to focus only on the products studied in Dhyne et al. (2006); this was possible for five countries in the sample (Austria, Belgium, France, Germany and Italy), and for 43 of the original 50 product categories.

The main result is that the prices of the products sampled by the IPN became more flexible in the PRISMA period across all five countries (although most noticeably in Austria, Germany and Belgium). Looking at the individual sectors, the increase was most pronounced for NEIG and somewhat smaller for food and services. Chart 2 plots more granular results; it displays the frequency of price changes in the PRISMA period against the frequency in the IPN period for all product/country combinations. It shows that a majority of products (about 70%) has a higher frequency in the PRISMA period, even if for most products the frequency has not changed dramatically. There is also a non-negligible number of products with a slightly lower frequency in the more recent period. This demonstrates that, as a few rather extreme changes over time could drive the results, the limited number of products, representing only a fraction of the HICP basket, makes it hard to generalize this result to the whole basket.

Chart 2: Frequency of price changes: comparison of results of IPN (1996-2001, x-axis) and PRISMA (2011-2017, y-axis)

Each dot corresponds to a product-country combination



Source: Gautier et al. 2023

3.4 How do price changes statistics in the euro area compare with their US counterparts?

Comparing United States and euro area results, Dhyne et al. (2006) concluded that on average and at the aggregate level, prices seem to be more flexible in the United States than in the euro area. More recently, Berardi et al. (2015) for France and Gautier et al. (2024a) for the euro area have conducted a more detailed analysis comparing, for the same product categories, their findings to the ones documented by Nakamura and Steinsson (2008) for the United States. This comparison is limited to equivalent products to account for potential differences in the composition of consumption baskets. To control for differences in product weights, euro area HICP weights are used to derive aggregate statistics for both economic areas.

When all price changes are considered, prices are updated more frequently in the United States than in the euro area on average. The frequency of price changes is 19.3% in the United States, which is 7 percentage points higher than in the euro area (Table 6). When price changes due to sales are excluded, however, the frequency of price changes drops to 10.0% in the United States and 8.5% in the euro area. Therefore, the difference between the United States and the euro area is primarily due to sales. The proportion of price increases is similar in both economic areas. The share of sales is higher in the United States (Nakamura and Steinsson (2008) report 7.4%, while it is 4.4% in the euro area).

The average price change is greater in the United States than in the euro area, but this difference is largely attributed to sales. Similar to frequency, we compare the magnitude of price changes in the euro area to findings for the United States (Nakamura and Steinsson, 2008). When sales are included, price changes are about 5.5 percentage points larger in the United States than in the euro area. However, when excluding price changes due to sales, the difference becomes much smaller: the average price increase is 10.6% in the United States versus 8.9% in the euro area, and a similar difference exists for price decreases (Table 6). Regarding the proportion of small price changes, Eichenbaum et al. (2014) find that for the United States, the percentage of price changes below 2.5% in absolute terms is 10.5% including sales and 13.8% excluding sales. Therefore, the proportion of small price changes is larger in the euro area than in the United States, but the difference is relatively minor.

Table 6: Euro Area vs US Price Changes: Frequency and Size

(in %)

	Euro area		United States	
	Including sales	Excluding sales	Including sales	Excluding sales
Average frequency of price changes	12.3	8.5	19.3	10.0
% of price increases	64.0	68.8	62.0	71.1
Average size				
Price increases	12.3	8.9	17.8	10.6
Price decreases	16.2	11.6	21.6	13.4
Absolute price changes				
25th percentile	*6.0*	*3.9*	*7.2*	*5.2*
50th percentile	*10.9*	*7.1*	*14.2*	*10.7*
75th percentile	*18.9*	*12.5*	*25.4*	*20.1*

Notes: The US results are based on the detailed product-level results of Nakamura and Steinsson (2008). To make the results for the two economic areas as comparable as possible, the average statistics have been calculated using the same products for both economic areas and euro area product weights.

3.5 Comparing price setting statistics in consumer prices with producer prices

Micro data on producer prices are much harder to come by in the euro area than data on consumer prices and the country coverage of producer prices in Gautier et al (2023) is more restricted than that on consumer prices. Furthermore, calculations on PPI price flexibility may be biased by the difficulty of keeping track of product varieties, given the survey collection method discussed in Section 1.

These limitations notwithstanding, there is clear evidence that prices change much more often at the producer level than at the consumer level. Data for the euro area as a whole are harder to compute than for CPI because the country coverage is much smaller and the structure of production is very different across countries. Hence, we focus on country-level data, which show that the frequency of producer price changes in Belgium, France, Greece and Lithuania ranged between 20.1% and 40.6%, while for CPI the range was lower and narrower, from 11.3% to 14.5%.

Previously, within the IPN research network, Vermeulen et al. (2012) have summarized evidence for four of the largest euro area countries plus Belgium and Portugal, covering a larger share of the euro area production, over a period starting in the mid-1990s and ending in the early 2000s. They find that the frequency of producer price adjustment in the euro area was about 20.8%. Like for consumer prices, they find that the sectoral heterogeneity in price stickiness increases along the production chain. Vermeulen et al. (2012) also document that the cost structure of sectors, in particular the share of labour costs and energy inputs play a significant role in explaining cross-sectoral differences in the frequency of price adjustments. They also find that competition has a positive and significant effect on the frequency of price changes. For business-to-business services, Gautier (2008) documents results for France and finds that the monthly frequency of price changes is about 7% (which is quite close to the frequency of price changes observed for CPI services).

In order to assess more precisely to which extent producer prices are more flexible than consumer prices, we need to compare similar products at the producer and consumer level because PPI and CPI

baskets are not the same. Vermeulen et al. (2012) have matched 240 pairs of products at a rather disaggregate level of product classification to perform this comparison for the euro area. Most of these products are consumer goods, in particular processed food and non-durable consumption goods. They find that the frequency of PPI price changes and the frequency of CPI price changes are highly correlated, but for a majority of products the frequency of producer price changes is larger than that of consumer prices.

While changing more frequently than consumer prices, producer prices tend to change by less: across the countries analysed in Gautier et al. (2023), the range of the median price increases is 1.5%to 5.3% while for decreases it is between 2.5% and 9%. Vermeulen et al. (2012) reported a median size of price changes between 2 and 3% for the euro area as a whole. By comparison, the median size of CPI price changes is closer to 10% when we remove services and price changes due to sales.

4 Time series evidence on price stickiness in the euro area

In this section, we document the main findings on the time variation of the frequency and size of consumer price adjustments. How the frequency of price changes evolves over time is a crucial element to assess the degree of time and state dependence. In a Calvo model, the frequency of price changes is exogenous by assumption, which implies that it does not correlate with aggregate shocks. By contrast, in a standard menu-cost model, firms will adjust the timing of their price changes depending on the shocks hitting them, and the frequency of price changes will be sensitive to large aggregate shocks in particular.

4.1 Price stickiness in a low and stable inflation environment

In the euro area, over the period 2005-19, the aggregate frequency of price changes does not show any strong correlation with the inflation rate. Chart 3 plots the time trend of the frequency of price changes (estimated using a standard HP filter). The frequency of price changes was somewhat higher during the global financial crisis, when euro area inflation (net of unprocessed food and energy prices) reached a maximum of around 2.5% in 2008. It also decreased somewhat after 2013, when the average inflation rate was rather low. However, the range of these variations is on average rather small and overall, the frequency did not change much. This pattern is the same across broad sectors. This flatness in the frequency of price changes is also observed for producer prices (see Gautier et al. (2023) and Vermeulen et al (2012)).

It is important to remark that there is an empirical issue of observational equivalence between time- and state-dependent models when aggregate shocks are small, and inflation is stable. In a low and stable inflation period, an invariant frequency of price changes is consistent with a standard Calvo model but also with a menu cost model where aggregate shocks are small relative to idiosyncratic shocks. In such an environment, it is hard to discriminate between time- and state-dependent models just looking at the time variation of the frequency of price changes.

Chart 3

Inflation and frequency of price changes over time

(lhs: frequency of price changes (%), rhs: HICP inflation rate (yoy, %))

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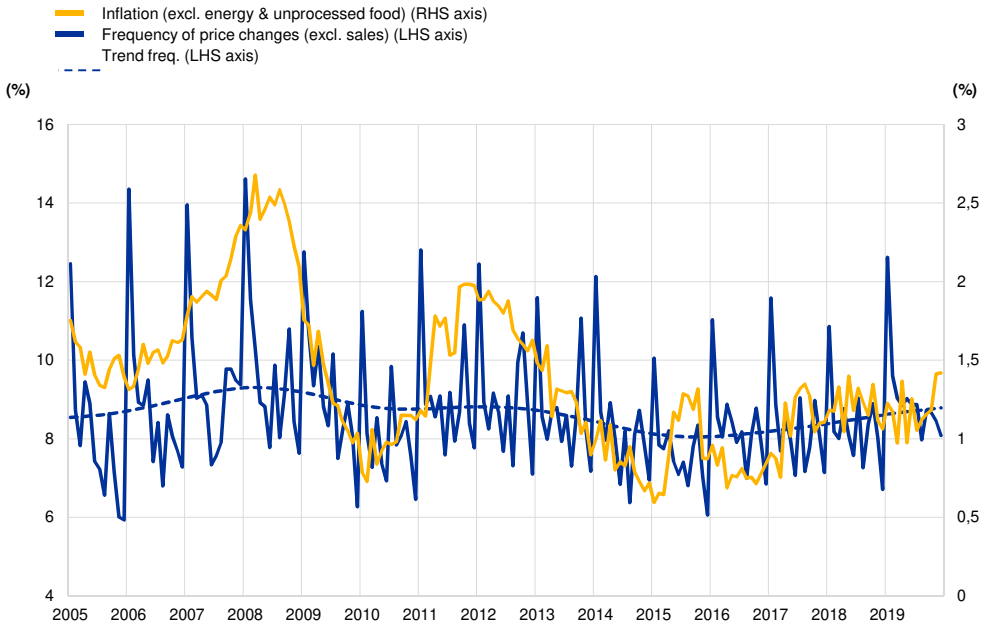


Source: Dedola et al. (2024).
Notes: The trend is computed using the standard Hodrick-Prescott filter for monthly data.

While the frequency of price changes does not correlate with aggregate shocks and is flat on average, it still shows large seasonal effects. In particular, price changes are much more frequent in January than in other months. Gautier et al. (2024a) show that in January the frequency of price changes is larger by 8.2 percentage points on average. Part of this seasonality reflects the seasonality of sales, but when we exclude price changes due to sales, this January effect persists and remains rather strong: +6.0 pp on the frequency of price changes and +4.8 pp on the frequency of price increases. Most of this effect comes from services, where the frequency is larger by 11pp while the average frequency is about 6%. This effect is stronger in Austria, Luxembourg, France, Germany and Spain.

This type of January effect is also observed with producer price adjustment. Vermeulen et al. (2012) document that the frequency of producer price changes is about 30% in January versus 20% during the other months of the year. This January effect is stronger in Belgium, France, Portugal and Spain. Across sectors, the January effects are stronger for consumer goods other than food and for capital goods, where the frequency of price changes is almost doubled in January compared to other months. Gautier (2008) is one of the rare studies looking at business services and finds a similar pattern, with a monthly frequency of price changes of 11.2% in the first quarter of the year and between 5 and 6% in the other quarters.

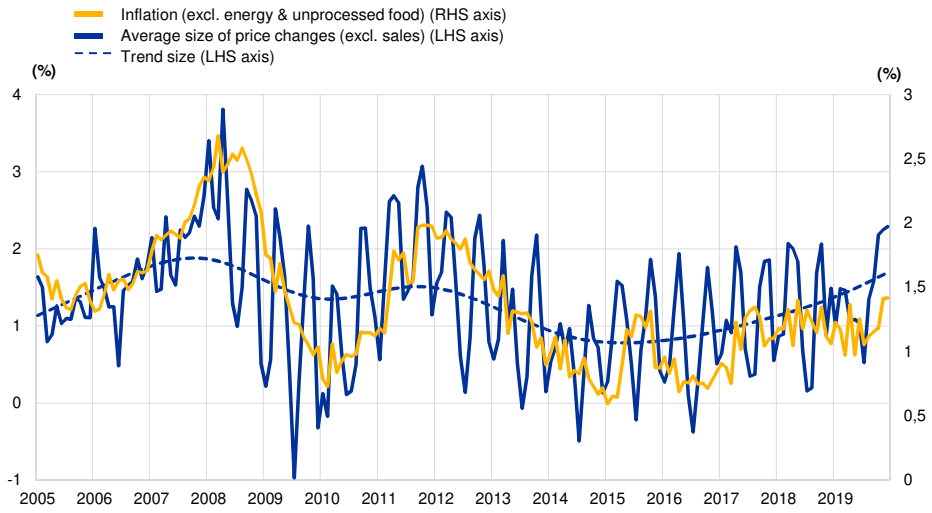
Overall, this January effect is much stronger than any cyclical variation we can detect over the period 2005-2019 in the frequency of price changes. This pattern would be quite consistent with the presence of annual contracts à la Taylor (1980) with limited staggering, as most price changes are observed in January.

Since the frequency of price changes is on average constant outside large seasonal movements, inflation varies mainly with the size of price changes. Specifically, Gautier et al. (2023) document that the average size correlates strongly with aggregate inflation and the share of price increases plays an important role in this correlation (Chart 4). Again, this evidence would be in line with a time-dependent model with large idiosyncratic shocks or a menu cost model where aggregate shocks are much smaller than idiosyncratic shocks, which would explain why the frequency of price changes does not show strong cyclical movements.

Chart 4

Inflation and average size of (reset) price changes

(lhs: average size of price changes (%), rhs: HICP inflation rate (yoy, %))



Source: Dedola et al. (2024)
Notes: The trend is computed using the standard Hodrick-Prescott filter for monthly data.

To assess the presence of state-dependence, several empirical studies have estimated adjustment hazard functions that link the probability of price changes to the price gap (i.e. the difference between the actual price and the reset price). In a pure time-dependent model, this probability of price adjustment is the same irrespective of the value of the price gap. In a random menu cost model, the probability of a positive price adjustment is expected to decrease monotonically with the price gap, while the probability of a negative price adjustment is expected to increase monotonically (Caballero and Engel, 1999, 2007). For many products, the price gap is often hard to measure since it requires to observe the counterfactual reset price. Among studies using price data for the euro area, Karadi et al. (2023) use the average price of competitors as a proxy for this counterfactual reset price whereas Gautier, Marx and Vertier (2023) also use a precise measure of marginal costs for gasoline prices in France. More recently, Gutierrez-Chacón and Roldan-Blanco (2024) have estimated hazard rates for the Spanish CPI also using other prices for a product category as proxy for the counterfactual reset price. The main conclusions of these recent studies are the following: price changes are more likely when the price gap is large, suggesting the presence of state dependence; adjustment hazard rates are asymmetric, suggesting that for a given absolute shock size, price adjustment is less likely if a large shock is negative than if it is positive. These patterns of the adjustment hazard rates are often in line with predictions of a random menu cost model (Alvarez et al. 2022).

Finally, Gautier et al. (2024a) look at how identified aggregate shocks like monetary shocks are transmitted to consumer prices by estimating local projections regressions on micro price data. They

show that an aggregate shock takes about 24 months to be fully passed through to prices, which is consistent with nominal price rigidity. They also show that products that display a higher frequency of price changes transmit aggregate shocks more quickly to prices. Finally, they find that shocks are mostly transmitted via the average size of non-zero price changes: in response to both (oil) supply and demand shocks (monetary policy and global activity), firms adjust the average size of their price changes but not the frequency at which they change their prices. [19] These facts are consistent with the unconditional results discussed above.

4.2 Price stickiness during the COVID-19 pandemic

The coronavirus pandemic caused a major economic shock in the euro area in 2020 and 2021, characterized by a deep recession and a decline in inflation. Henkel et al. (2023) document how the COVID-19 pandemic affected the price setting behaviour of retailers. This paper also discusses the major price measurement issues that arose in those years, as several CPI goods and services were not available to consumers.

The analysis in Henkel et al. (2023) is based on three micro data sources: micro price data underlying the official CPI in Germany, Italy, Latvia and Slovakia; scanner data from German and Italian supermarkets, online web scraped prices for Poland. The pandemic impacted consumer products quite differently: it led to a positive demand shock for supermarket goods and goods sold online, while contact-intensive services became unavailable (restaurants, hairdressers…). Moreover, policy responses differed across countries. For example, Germany implemented a temporary cut in the value added tax (VAT), modulated differently across sectors and goods. Overall, this shock was expected to amplify product-level heterogeneity in price-setting behaviour.

National CPI microdata show that the price-setting effects of the pandemic in 2020 were largest in Italy, where the first wave of the pandemic was more severe: the change in the frequency of price changes in 2020 was at least as large as the change observed during the Global Financial Crisis in the euro area in 2008-09. In Germany it was the VAT change that most affected price setting in the summer of 2020. This evidence suggests that nonlinearities resulting in faster inflation dynamics may become more relevant not only in a more volatile environment with larger shocks, as would be predicted by state dependence in price setting, but also in the aftermath of especially salient shocks, like the German VAT change.

The changes in pricing behaviour during 2020 and 2021 were heterogeneous across product categories, types of data sources, countries, and even across waves of lockdowns in the same country. This heterogeneity, documented in detail in Henkel et al (2023), makes it hard to discern general patterns of change in price-setting in response to the pandemic shock.

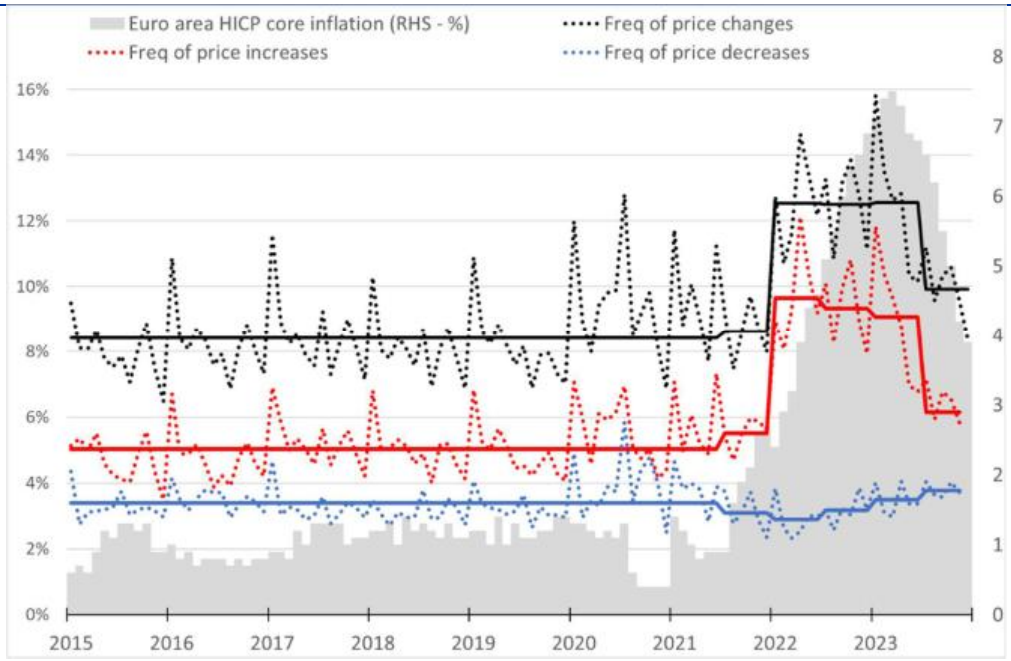
4.3 Price stickiness in a volatile inflation environment

When inflation is stable and aggregate shocks are small, it is not straightforward to identify the degree of state-dependence in the price behaviour of retailers. However, in late 2021, inflation started to steadily increase, driven to a large extent by shocks to firms' costs, raising the question of whether this outcome was associated to a change in the pattern of consumer price adjustment. Following the very large shocks experienced since 2021, state-dependent models would predict that more firms experience widely misaligned prices and decide to change them, driving up the aggregate frequency of price adjustment.

[19] Oil supply and global activity shocks are those obtained by Baumeister and Hamilton (2019); monetary policy shocks are taken from Jarocinski and Karadi (2020). See Gautier et al. (2024a) for details.

Chart 5

Frequency of consumer price changes over time



Source: Consumer price micro-datasets from the national statistics institutes of Germany, Estonia, Spain, France, Italy, Latvia and Lithuania, see Gautier et al (2024c) for details.
Notes: The chart shows the weighted average frequencies of price changes (excluding sales). VAT changes in Germany (2020-21) and Spain (2020-23) have been excluded. The solid lines plot the average over the period 2015-21 and half-year averages over the period 2021-23. The latest observations are for December 2023.

An update of the PRISMA microdata has been made available covering the most recent period (2021-2023) for seven countries accounting for about 80% of the euro area HICP (Estonia, France, Germany, Italy, Latvia, Lithuania, and Spain). Gautier et al. (2024c) document the main results obtained with this update, which covers mainly core inflation products not directly affected by the input cost shock. First, over 2022 the frequency of price changes excluding sales increased to 12.5% on average, compared to 8.5% over the period 2010-2019 (Chart 5). In response to the large inflationary shock, prices appear to be more flexible than in the period of lower and less volatile inflation. Afterwards, the frequency of price changes has declined somewhat in the course of 2023. This implies that a positive correlation between inflation and the frequency of price changes and inflation emerged, while no such correlation was visible for the low inflation period (Chart 6).

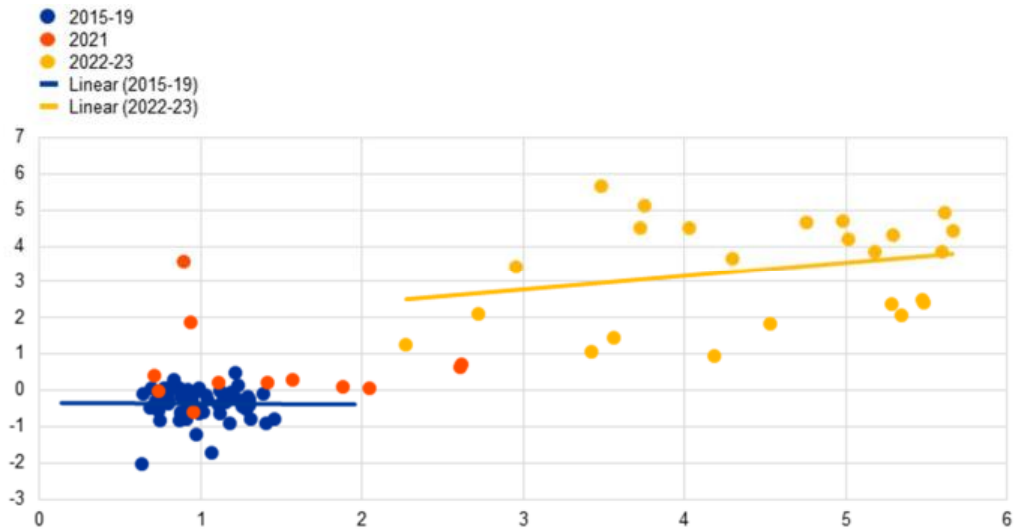
This sharp rise in the frequency of price increases was common to all broad product categories underlying the HICP. The rise in the frequency of price increases has been sharper for food products than NEIG or services. In the food sector, the frequency of price increases shifted from around 8% on average before 2020 to close to 15% in 2022, whereas price decreases were a little less frequent than usual. For NEIG and services, the rise of the frequency of price increases has also been significant, but much smaller than the one observed for food (an increase of around 3 percentage points for NEIG and for services) whereas the frequency of price decreases has remained mostly stable. Finally, in all three sectors, the frequency of price increases fell during the second half of 2023.

Similar evidence has been documented in Spain (Gutierrez-Chacon and Roldan-Blanco, 2024), in Lithuania (Jouvanceau, 2024), in the UK (Dedola et al., 2023) for consumer prices but also in France using producer prices from monthly business survey data (Gautier-Le Bihan-Lippi, 2023).

Chart 6

Inflation and frequency of price adjustment

(x-axis: euro area HICP inflation excluding energy and food (year-on-year percentage change); y-axis: seasonally adjusted frequency of price adjustment (month on month))



Source: Calculations by Banque de France and ECB staff based on consumer price micro data sets (national NSIs) (Estonia, France, Germany, Italy, Latvia, Lithuania, Spain), see Gautier et al (2024c) for details.
Note: Each dot corresponds to the frequency of price adjustment in a month, minus the average frequency of price adjustment in that calendar month over the period 2011-2019. 2020 is excluded as it is heavily impacted by the COVID-19 pandemic, for more details on price setting during the COVID-19 pandemic, see Henkel et al (2023).

This evidence is consistent with some degree of state dependence in price setting, which implies a non-linear relation between the frequency of price changes and inflation. One remaining empirical issue is to quantify how much this increase in the frequency of price changes affects the slope of the Phillips curve and may increase the transmission of monetary policy shocks. Another potential question is whether the non-linearities observed are asymmetric and whether in response to a large negative shock the frequency of price changes would have risen as much.

5 Conclusions

Since the early 2000s, several comprehensive micro data sets of prices in the euro area have been made available to researchers, in particular data sets containing price quotes collected by euro area NSIs to construct CPI and PPI official indices. Two research networks (IPN and PRISMA), gathering researchers from the euro area national central banks and the ECB, contributed to assembling comparable data from the different countries. They also made considerable progress in documenting key empirical facts on nominal rigidities in the euro area based on microdata, providing crucial evidence for price setting models calibrated to the euro area.

In particular, the evidence shows that in a low inflation environment, consumer prices change on average once a year, but price changes are large on average. Moreover, the frequency of price changes remained broadly stable over the period 2005-19 with only “seasonal” peaks in the month of January.

Another crucial finding is that state dependence is a relevant feature of price setting in the euro area. Even in a period of low and stable inflation, with a broadly stable frequency of price changes, estimates of the adjustment hazard function point towards the presence of state dependence. In the recent inflation surge, characterized by large inflationary shocks, the frequency of price changes has increased, consistently with the nonlinear effects of shocks that state dependence predicts.

This increase in the frequency of price changes entails faster inflation dynamics: for a given degree of persistence of the underlying cost shocks, inflation will rise more quickly than if the frequency of price

changes had remained unaffected. At the same time, the pass-through of the shocks to the price level will be faster and, absent further shocks, inflation will return to the central bank's target more quickly.

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