How do supply shocks to inflation generalize? Evidence from the pandemic era in Europe*

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Abstract

We document how the interaction of supply chain pressures, heightened household inflation expectations, and firm pricing power contributed to the pandemic-era surge in consumer price inflation in the euro area. Initially, supply chain pressures increased inflation, especially in manufacturing sectors, through a cost-push channel and raised inflation expectations. Subsequently, the cost-push channel intensified as firms with high pricing power increased product markups in sectors witnessing high demand, including in services sectors that were initially not exposed to supply chain constraints. Eventually, even though supply chain pressures eased, these firms were able to further increase markups due to the stickiness of inflation expectations. The resulting persistent impact on inflation suggests supply-side impulses can generalize into broad-based inflation via an interaction of household expectations and firm pricing power.

JEL: E31, E58, D84, L11.

Keywords: inflation expectations, euro area, firm markups, market power, supply chain, generalized markup shocks.

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1 Introduction

In response to the outbreak of the COVID-19 pandemic in March 2020, governments and central banks implemented substantial stimulus measures to avert a deep recession. The global economy and aggregate demand rebounded rapidly, leading to a rise in inflation.[1] Throughout 2021 and 2022, additional supply-side shocks intensified inflationary pressures. Notably, new pandemic waves and the resultant restrictions on economic activity put severe strain on global value chains, resulting in shortages across various sectors. Moreover, energy prices began to climb in 2021 and surged dramatically in early 2022, following the Russian invasion of Ukraine, causing inflation rates to reach their highest levels in four decades in many countries across the globe, and in particular in the euro area. Since 2023, however, in spite of the abatement in these initial catalysts, consumer price inflation has remained entrenched and even generalized across goods and sectors.

In this paper, we show how supply chain pressures, household inflation expectations, and firm pricing power interacted, fueling the pandemic-era surge, then persistence, and eventually generalization, in consumer price inflation in the euro area. We start by documenting (i) the contemporaneous increase in production constraints and localized inflation (i.e., inflation in sectors affected by these constraints) starting in late 2020/early 2021, (ii) the rise in household inflation expectations starting in 2020, and (iii) the increase in broad-based inflation (i.e., inflation in sectors not directly affected by production constraints) beginning in the second half of 2021.

Using several cross-sectional and time-series tests, we then link these observations through a coherent narrative, illustrated in Figure 1. First, we present evidence of a localized pass-through of supply chain constraints to prices, consistent with a *cost-push channel*. Second, we

[1] See Reis (2022a) for an in-depth description of this inflationary period.

show that localized supply chain constraints also led to an increase in *inflation expectations*. In response to witnessing higher consumer prices in their consumption basket (*experience channel*), and upon exposure to news regarding supply-side shocks signaling rising costs like delays in cargo ship deliveries (*news channel*), households revised their inflation expectations, anticipating a rise in *aggregate prices*. Consequently, *generalized* inflation took hold, i.e., there wass a pass-through of inflation to sectors hitherto unaffected by cost increases and particularly pronounced in sectors where firms have high pricing power. These firms (i) were more likely to maintain, or even increase, their markups when facing supply chain constraints and high demand, and (ii) were more likely to sustain relatively higher markups when inflation expectations became elevated and sticky, even after supply chain pressures eventually eased.[2]

To conduct our tests, we combine several data sets at various units of observations. At the industry-country-time level, we observe (i) firms' production constraints, price expectations, and their order book from the Joint Harmonised EU Programme of Business and Consumer Surveys (BCS) conducted by the European Commission's Directorate General for Economic and Financial Affairs, and (ii) energy consumption and Producer Price Index (PPI) data from Eurostat. At the country-time and at the household-time level, we observe inflation expectations from the BCS and the European Central Bank (ECB) Consumer Expectations Survey (CES), respectively. At the product-country-time level, we observe Consumer Price Index (CPI) data from Eurostat. Finally, at the firm-time level, we observe financial data

[2]In an environment characterized by heightened inflation expectations and aggregate cost and price uncertainty households can become less informed about the *distribution of prices across firms and products*, lowering the price elasticity of demand—a phenomenon highlighted in theoretical research on the impact of cost shocks and inflation in imperfectly competitive search markets (e.g., Benabou and Gertner, 1993; Tommasi, 1994). Less precise household price information across firms can result in higher acceptance prices and, in turn, an upward shift in the demand curve faced by individual producers. Consequently, producers can sustain, or even increase, their markups without risking a significant sales decline.

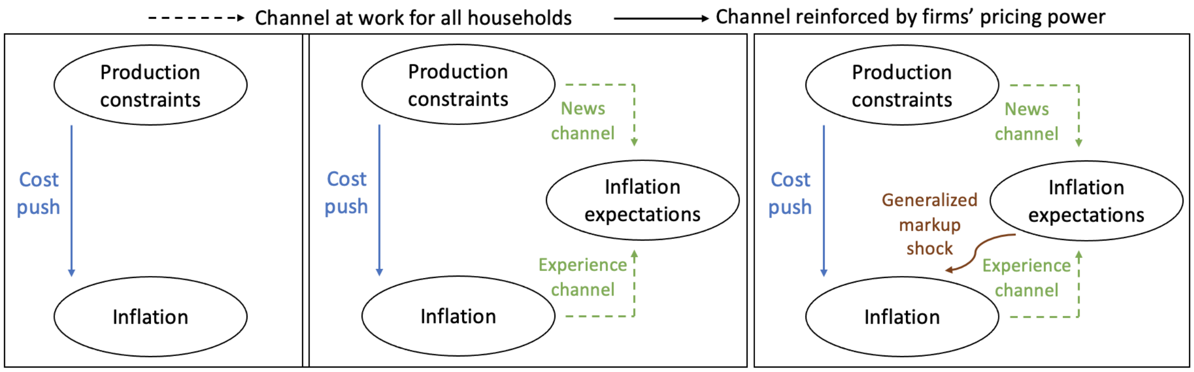

Figure 1: From supply chain constraints and localized inflation to high inflation expectations and generalized inflation. This figure shows the main channels at the core of our analysis. The left panel shows how production constraints might affect inflation through a cost-push channel. The middle panel shows how production constraints and inflation might increase inflation expectations. The right panel shows how inflation expectations might contribute to the rise in generalized inflation.

from Compustat Global, which we use to estimate firm markups.

The analysis is structured in six parts. First, we document the pass-through of supply chain constraints to price levels, consistent with a cost-push channel. For consumer prices, we show that product-country pairs characterized by increasing supply constraints are positively associated with CPI growth in the post-pandemic period. An instrumental variable (IV) estimation supports a causal interpretation of this finding. Specifically, we instrument a market's degree of supply chain disruptions with its firms' pre-COVID reliance on imports from China paired with Chinese province-time-level data on lockdown stringency.[3] We employ granular energy consumption and price data to isolate—and confirm robustness of—the impact of supply chain frictions on inflation from the impact of the contemporaneous surge in energy costs.

Second, we show that supply chain constraints generalize into broad-based inflation ex-

[3]Specifically, we use data for the top-5 Chinese exporting provinces from the Oxford COVID-19 Government Response Tracker project and track the time-series evolution of nine types of COVID responses, including workplace closures and travel banks. See Figure C.1 for the evolution of this aggregate stringency index.

pectations. Specifically, we find a positive association between the prevalence of supply chain constraints in a country with both (i) the share of households with heightened inflation expectations in that country as well as (ii) individual short-term and long-term household inflation expectations. We further substantiate the causal link between supply chain disruptions and rising household inflation expectations by employing again the IV estimation approach that capitalizes on the trade shock induced by China's lockdowns. The household-time-level estimation also shows that households that more accurately assess realized past inflation expect CPI growth to increase more when reported supply chain constraints tighten and that this relationship is stronger in countries with more Google searches about supply chain issues. These findings lend support for both the experience and the news channel of household expectation formations.

Third, we find evidence consistent with a generalization of inflation for markets that were initially not exposed to supply chain constraints, notably in service sectors. In particular, we document that in countries with elevated household inflation expectations, products with a high contribution from service sectors—thus less impacted by supply constraints—exhibit higher relative CPI growth in 2022 compared to similar products in countries where inflation expectations were less pronounced.

To ensure this effect is not driven by demand factors, we employ several controls: (i) we account for potential pent-up demand by controlling for country-level energy costs and the intensity of lockdown measures during the COVID-19 pandemic; (ii) we include product-country-time fixed effects at the 1-digit COICOP level to absorb the impact of broader demand shocks on product categories; and (iii) we control for demand shifts across different product categories using data on final consumption expenditure of households at the product-country-time level, sourced from Eurostat at the 2-digit COICOP level.

Moreover, we show that the generalization of inflation (i) is driven by industry-country pairs where firms possess significant market power and (ii) is present in both countries with a high and low share of employees covered by a collective bargaining agreement. The latter finding suggests that the generalization into broad-based inflation is not driven by firms anticipating a rise in labor costs. Finally, the generalization effect is robust to controlling for a potential delay in supply shock transmission along the supply chain, i.e., allowing for the supply chain constraint affecting, for each product, upstream firms.

Fourth, we document an important role played by firms' pricing power. Firms with higher pricing power in industry-country pairs that experienced large supply chain pressures were able to raise their markups more than firms with ex-ante lower pricing power—a result driven by markets with sufficiently high demand. Conversely, firms with higher pricing power in industry-country pairs that did not experience large supply chain pressures were less able to maintain their markups compared to firms with lower pricing power.

Fifth, we show that subsequently firms with pricing power were more likely to maintain, or even increase, their markups in an environment with elevated inflation expectations, irrespective of whether they were affected by supply-side constraints (e.g., in services sector) and even after these constraints eventually subsided (in manufacturing sector). This result is driven by industries with an above median share of final goods produced, suggesting that firms with higher pricing power are better able to support their markups in an environment with elevated inflation expectations when they operate in more household-facing industries., lending further credibility to an interaction mechanism between firm pricing power and household inflation expectations.

Finally, we test directly and confirm that firms with substantial market power were more capable of increasing their markups in response to rising inflation expectations among households, particularly in markets experiencing increased price variability. This evidence aligns with the theoretical predictions of Tommasi (1994), which suggests that higher price variability can diminish the perceived benefit for households of seeking additional price information.

Overall, the combination of households anticipating a rise in aggregate price levels, coupled with less precise information about the distribution of price across firms and products, can lead to supply-side shocks generalizing into broad-based inflation via an interaction of household expectations and firm pricing power. Our results therefore highlight the importance of a nuanced understanding and approach in policy formulation to mitigate the risk of supply-side inflation impulses becoming broad-based. As inflation began to rise in 2021, central banks initially tolerated the elevated inflation levels under the assumption that the supply shocks were transitory in nature. The conventional monetary policy response to a transitory supply shock involves permitting inflation to surpass target levels, ensuring that actual output remains near the efficient level of output, even if it exceeds potential output.

However, this "see through the shock" policy is only effective if inflation expectations remain anchored. In this case, they help pull inflation back towards target levels, making most inflation shocks short-lived. Instead, if the supply-side shocks result in an unachoring of inflation expectations, they can lead to a disproportionate, widespread, and persistent surge in actual inflation rates. Such generalization can be further exacerbated by its interaction with firm pricing power, necessitating a proactive monetary policy response to supply-side shocks.

Related Literature. The literature on supply-side factors and their connection to inflation and inflation expectations covers several interconnected areas of research, including (i) the effect of supply shocks on prices, (ii) the formation of inflation expectations, as well as (iii) the relationship between inflation and inflation expectations.

A variety of studies has investigated the impact of supply-side frictions on prices and price expectations. In the theoretical literature, Alessandria et al. (2022) and Kalemli-Ozcan et al. (2022) model the aggregate effects of supply chain shocks during the COVID-19 pandemic. Bilbiie and Känzig (2023) investigates the interplay of corporate profits and income distribution in shaping inflation and aggregate demand. In the empirical literature, Carriere-Swallow et al. (2022) and Jiménez-Rodríguez and Morales-Zumaquero (2022) examine the effects of global shipping costs and commodity prices, respectively, on domestic prices and inflation expectations. Benigno et al. (2022) proposes a new index to capture global supply chain pressures and their impact on inflation. There is also a growing body of country-specific research on the effects of supply-side factors on inflation (Isaacson and Rubinton, 2022; Amiti et al., 2022; Ball et al., 2022; Bernanke and Blanchard, 2023; Comin et al., 2023; Finck and Tillmann, 2022; Kuehl et al., 2022; Celasun et al., 2022; Binici et al., 2022).

More closely related to our paper, Franzoni et al. (2023) focuses on the role of market power in the propagation of the initial cost-push shock. Specifically, the authors provide evidence that supply chain constraints can help explain about 19% of the U.S. inflation in industries with more asymmetric firm size distribution, where supply chain shortages are more likely to benefit large firms at the expense of smaller firms. Similarly, Bräuning et al. (2022) investigates the effect of market concentration on the pass-through of "cost shocks" into prices in the U.S., suggesting that increased industry concentration may amplify inflationary pressures. Our paper provides further evidence of a pass-through of the supply-side shocks during the pandemic and its aftermath into higher inflation in Europe. Our main contribution to this literature is showing that supply-side shocks can *interact* with household inflation expectations and firm pricing power, leading to broad-based inflation.

More generally, our paper is also related to the literature on the formation of inflation expectations and their link to household behavior, firm behavior, and inflation. Candia et al. (forthcoming) and Weber et al. (2022) review the literature on firms' inflation expectations, highlighting systematic upward bias, large disagreements, high forecast uncertainty, deviations from professional forecasters, joint short-long term adjustments (suggesting potential "unanchoring"), inattention in stable economies, and varied expectations across countries.

With respect to how inflation expectations affect firms' decisions, empirical evidence is significantly more limited. Coibion et al. (2018) surveys firms in New Zealand, revealing managers consistently overestimate inflation, perceptions and forecasts are correlated, informed firms forecast closer to true values, and firms' attentiveness is tied to competition and their price-change intent. Coibion et al. (2020) and Savignac et al. (2021) find that Italian and French firms, respectively, with higher inflation expectations raise their prices relative to firms with lower inflation expectations. Coibion et al. (2021) finds that French firms have less biased inflation expectations than households and see only a weak link between price and wage inflation. Finally Anayi et al. (2022) analyzes firm price-setting post-COVID using UK survey data, finding that energy prices and supply factors drove inflation since 2021.[4]

Outline. The remainder of the paper is structured as follows. In Section 2, we introduce our data and present stylized facts regarding the impact of supply chain disruptions on inflation and inflation expectations in the post-pandemic period in the euro area. Additionally, we contextualize and interpret these stylized facts through the lens of a conceptual framework (Figure 1), illustrating how the supply chain disruptions generalized into widespread inflation. In our empirical analysis in Section 3 to Section 5, we provide corroborative evidence for this framework. Section 6 concludes.

2 Data, stylized facts, and theoretical background

Our analysis is based on several data sets for the euro area with different units of observation. Specifically, we use data about (i) firms' production constraints, price expectations, and their order book, all at the *industry-country-time level*; (ii) household inflation expectations at the *country-time level* and *household-time level*; (iii) PPI and CPI growth at the *industry-country-time level* and *product-country-time level*, respectively; and, (iv) *firm-time-level* financials.

We obtain information about firms' production constraints and order book as well as household inflation expectations from the Joint Harmonised EU Programme of Business and Consumer Surveys (BCS) conducted by the European Commission's Directorate-General for

[4]Moreover, there is a large body of work on how inflation expectations affect households' economic decisions, showing that higher inflation expectations are associated with higher desired consumption (Crump et al., 2022; Dräger and Nghiem, 2021; D'Acunto et al., 2022; Ichiue and Nishiguchi, 2015; Duca-Radu et al., 2021; Armantier et al., 2015; Malmendier and Nagel, 2016; Coibion et al., 2023).

Economic and Financial Affairs (DG ECFIN). These surveys are administered to a total of 37,990 corporations from manufacturing, services, retail trade, and construction industries and 31,810 households across the 27 EU member countries, on a monthly and quarterly basis. The BCS follows a common methodology, employing a harmonized questionnaire and a consistent timetable across countries. Manufacturing firms are asked about firm-specific factors, such as production capacity, competitive position, price expectations, and factors constraining production. Consumers are questioned on both objective variables (e.g., inflation and the country's general economic situation) and subjective assessments (e.g., major purchases and savings).

From the BCS firm survey, we use responses to the following three questions. First, the monthly Question 6 that asks firms: *"How do you expect your selling prices to change over the next 3 months?"* Firms can answer: (i) increase, (ii) stay the same, or (iii) decrease. These firm-time-level responses are then aggregated at the industry-country-time level (for the industry 2-digit CPA) and reported as a balance, that is, the share of firms that answer prices will increase minus the share of firms that answer prices will decrease.

Second, we employ responses to the quarterly Question 8, which asks firms: *"What main factors are currently limiting your production?"* Firms can respond with (only) one of the following factors: (i) none, (ii) insufficient demand, (iii) shortage of labour force, (iv) shortage of material and/or equipment, (v) financial constraints, and (vi) other factors. The BCS then reports, at the industry-country-time level, the share of firms that respond that their production is constrained by the respective factor.

Employing survey data to gauge constraints to firms' production stemming from supply chain disturbances offers two key advantages: (i) Survey data offers more immediate and direct evidence regarding firms' production constraints in comparison to raw supply chain data, which may not fully capture their full extent due to firms' ability to adapt, either through sourcing alternative material inputs or adjusting their supply chains; (ii) Survey data about constraints to production can serve as a leading indicator for increases in supply-side costs since firms are often able to anticipate the impact of supply shocks, such as a container ship congestion, before they translate into a tangible material shortage.

Third, we use the firms' responses to the monthly Question 2 that asks: *"Do you consider your current overall order books to be...?"*, to which firms can answer: (i) + more than sufficient (above normal), (ii) = sufficient (normal for the season), or (iii) − not sufficient (below normal). The BCS reports the share of firms in an industry-country pair that respond that their order book is more than sufficient net of the share of firms responding that their order book is not sufficient.

From the BCS consumer survey, we obtain inflation expectations at the country-time level from Question 6 that asks households: *"By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months?"* Respondents can reply: (i) increase more rapidly, (ii) increase at the same rate, (iii) increase at a slower rate, (iv) stay about the same, or (v) fall. Following D'Acunto et al. (2022), we use the share of households expecting prices to increase more rapidly to measure high inflation expectations.[5]

Furthermore, we use newly available anonymized household-time-level inflation expectations microdata from the ECB Consumer Expectations Survey (CES) launched in 2020. Its sample covers six key euro area countries: Belgium, France, Germany, Italy, Spain, and the Netherlands, and it is representative of the euro area population.[6] The CES comprises monthly *core*, *background*, and *recruitment* questionnaires, along with a quarterly questionnaire. The core questionnaire addresses households' expectations in areas such as macroeconomic conditions, housing markets, and their financial situation. The quarterly and background modules contain additional questions on household expenditures, savings, employment, borrowing, risk attitudes, financial knowledge, and income. A total of 18,492

[5]The survey also asks households for a point estimate on the 12-months-ahead inflation, but these responses are not publicly disclosed.

[6]See Bańkowska et al. (2021) for a detailed description of the survey data.

distinct respondents participated in the 12 CES waves and households appear repeatedly in the survey, allowing us to compare responses of the same household over time.

To measure inflation expectations at the country-time and household-time level consistently across the two surveys (BCS and CES), we use the responses to CES' Question C1110 that asks households: *"Looking ahead to 12 months from now, what do you think will happen to prices in general?"* Similar to the BCS, households can answer: (i) prices will increase a lot, (ii) prices will decrease a lot, (iii) prices will increase a little, (iv) prices will decrease a little, or (v) prices will be exactly the same (that is 0% change). We again classify a household as having high inflation expectations if the household responds that prices will increase a lot.

Moreover, we use monthly data on producer and consumer prices from Eurostat, which provides information for various producer and consumer price indices for all European countries. In this granular data, we observe producer prices at the industry-country-time level (for the industry 2-digit CPA) and consumer prices at the product-country-time level, respectively. Products are grouped in COICOP categories.[7] From Eurostat, we also obtain an industry-country level input-output table as well as data about industry-country-time level energy input use and energy prices at the country-time level.

Finally, we use firm-time-level financial data from Compustat Global to estimate firm markups following De Loecker et al. (2020).

Stylized facts from the data. Figure 2 shows a contemporaneous increase in production constraints (top panel) and in PPI and CPI (bottom panel) from the onset of the pandemic to

[7] The Classification of Individual Consumption According to Purpose (COICOP) is the international reference classification of household expenditure (UN, 2018). The objective of COICOP is to provide a framework of homogeneous categories of goods and services, which are considered a function or purpose of household consumption expenditure.

late 2022. Specifically, the top panel shows a substantial shortage of material inputs starting in 2021:Q1, followed by a labor shortage from 2021:Q2. Both supply chain constraints and labor shortages began to ease from 2022:Q1 and 2022:Q3, respectively.

The bottom panel shows the increase in the PPI in the second half of 2020, followed by the increase in the CPI in 2021:Q1. This relationship has generally been ascribed to the interconnected nature of the production chain, which links the prices of different goods and, ultimately, connects changes in producer prices to changes in consumer prices (Clark et al., 1995). The slight lag of CPI behind PPI points towards a cost-push supply-side inflation dynamic where movements in particular price indices lags behind movements in prices at early stages of production (Smets et al., 2019). Both the PPI and CPI peak in the second half of 2022 (PPI in August and CPI in October), before gradually decreasing until the end of the sample period. Notably, the CPI exhibits only a modest decline, which is consistent with inflation becoming more entrenched in consumer prices.

Concurrent with the escalation in production constraints triggered by supply chain disruptions and the subsequent uptick in realized inflation, there is also a notable rise in inflation expectations among households and firms, commencing around mid-2020 (see the top panel of Figure 3). These expectations are measured as the share of firms or households expecting prices to increase more rapidly minus the share of firms or households expecting inflation to fall over the next 12 months. While both household and firm expectations peak in summer 2022, firms' expectations lead households' expectations in the run-up.

The bottom panel of Figure 3 shows three snapshots of the distribution of one-year ahead household inflation expectations. Between 2020 and 2022, the standard deviation of the distribution increased and the median initially shifted slightly upwards from 2020 to 2021, and then saw a decisive increase from 2021 to 2022. This shift in the distribution of expectations mirrors past episodes where inflation expectations became unanchored (see Reis, 2022b).

Over time, there seems to be a transition from transient supply-driven inflation to a

Figure 2: Constraints to firm production and inflation in the euro area. This figure shows the time-series evolution of firm production constraints (first panel) and inflation (second panel) in the euro area. The first panel shows the share of firms answering the following survey question: *"What main factors are currently limiting your production?"* as follows: (i) shortage of labor, (ii) shortage of material/equipment, (iii) financial constraints. The monthly data runs at a monthly frequency from January 2016 to April 2023 and is obtained from "The Joint Harmonised EU Programme of Business and Consumer" firm survey for 27 EU countries, where the unit of observation is industry-country. The second panel shows the CPI growth at a monthly frequency from January 2016 to April 2023.

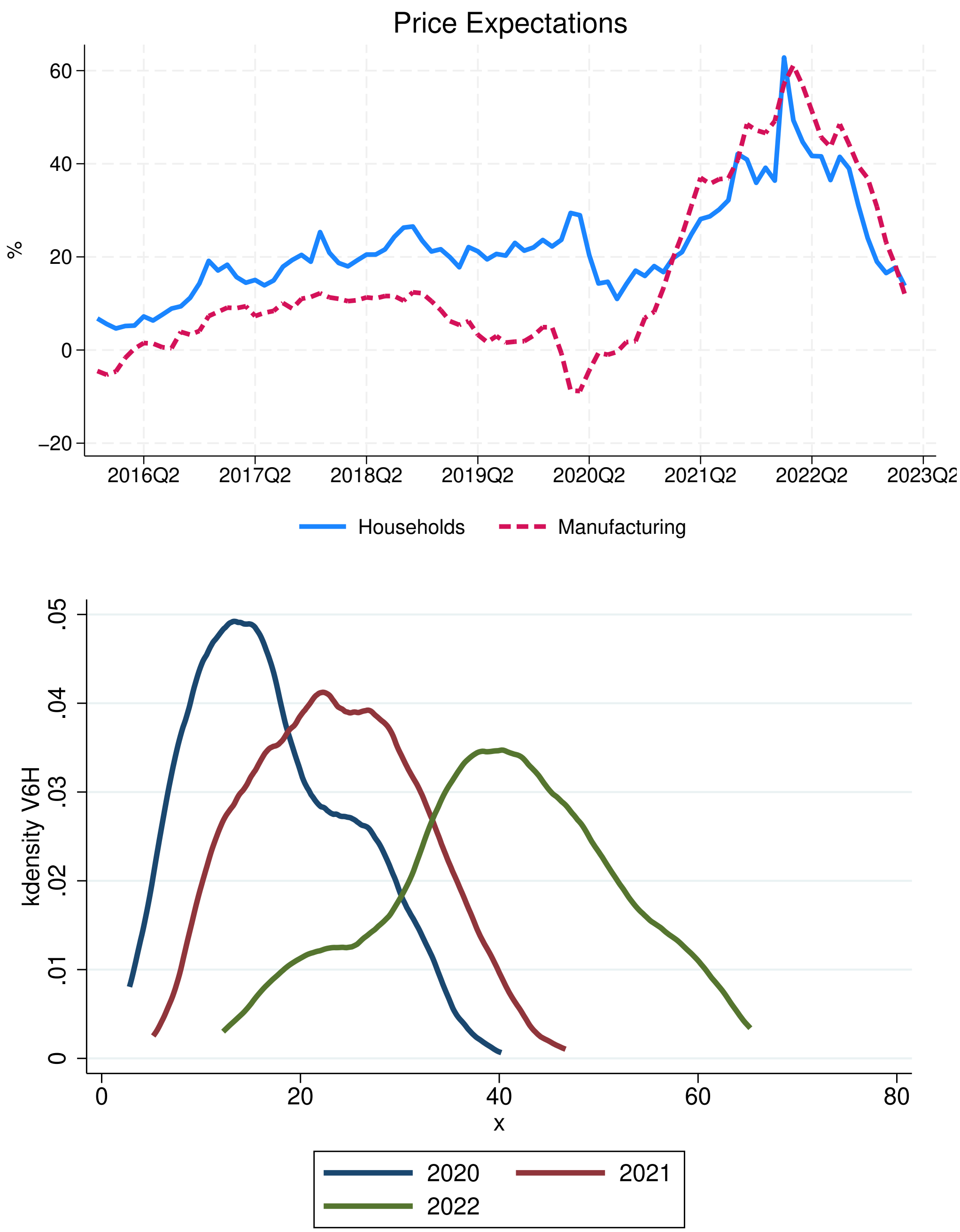

Figure 3: Inflation expectations. The top panel of this figure shows the evolution of households' and manufacturing firms' inflation expectations over time. These expectations are measured as the share of households/firms expecting prices to increase more rapidly minus share of households/firms expecting inflation to fall over 12 months (for households) and 3 months (for manufacturing firms). The data source is the monthly survey on euro area households' and firms' inflation expectations. The bottom panel shows three snapshots of the distribution of one-year ahead household inflation expectations.

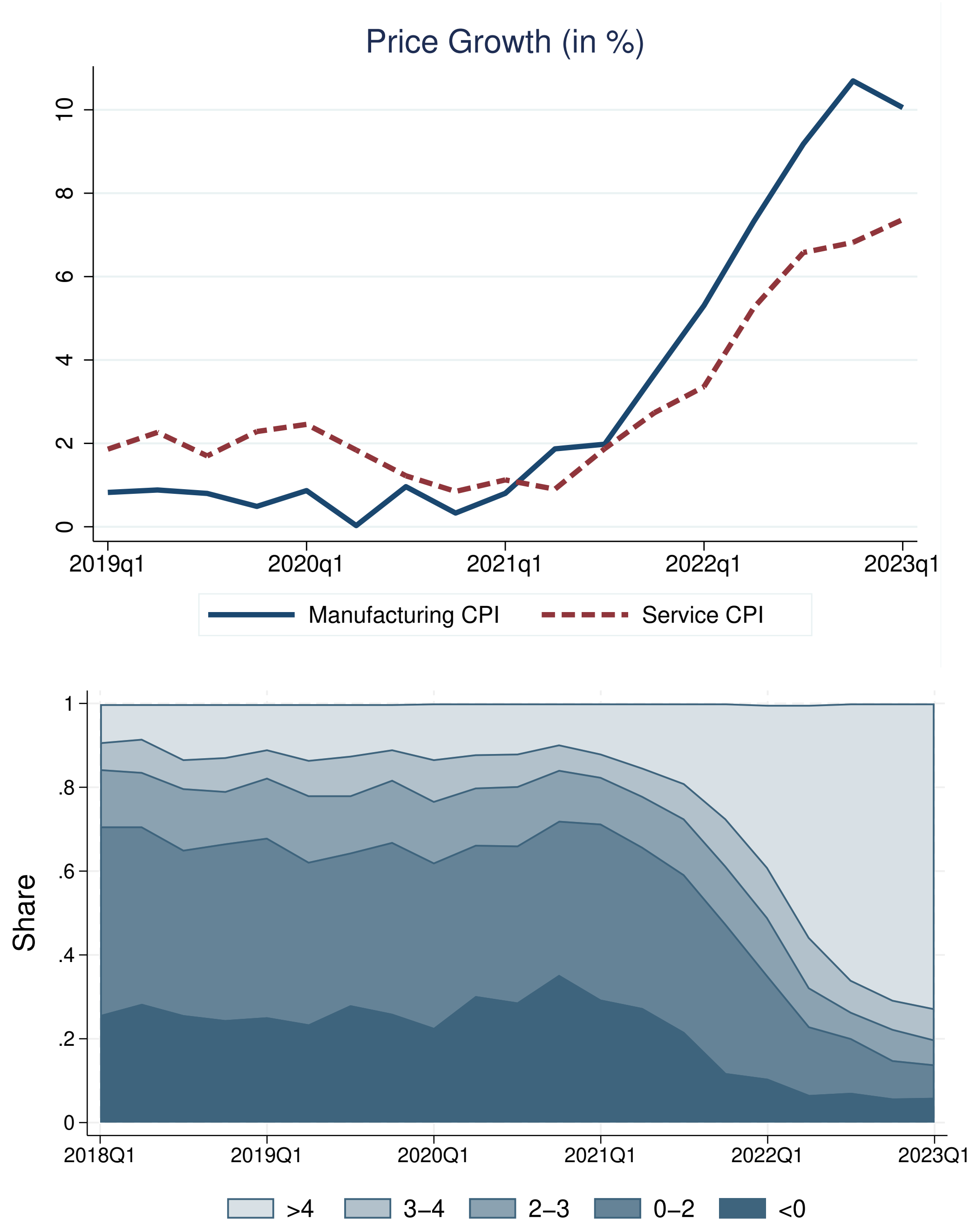

Figure 4: Inflation becoming more broad-based. The first panel of this figure shows the average inflation for markup and service sectors in our sample. The second panel provides a visual representation of inflation trends at the product-country-time level in the euro area. Each shaded area shows the share of product-country pairs that, in each quarter, have a specific CPI year-over-year growth as outline in the legend.

more persistent, widespread inflationary environment, as shown in Figure 4. The top panel of the figure shows that products heavily reliant on manufacturing sectors—which are more vulnerable to supply chain disruptions—initially see a more significant inflation increase compared to services. However, as the manufacturing CPI begins to decline, the CPI for services continues to rise, eventually catching up.

The bottom panel of Figure 4 confirms that inflation, initially confined to a subset of product-country pairs, becomes more widespread starting in the second half of 2021. By the end of 2021, CPI year-over-year growth was around 5% with 27% of products experiencing inflation above 4% and 50% of products experiencing inflation below 2%. By the end of 2022, in an environment with CPI year-over-year growth around 9%, 70% of products experienced an inflation above 4%. Figure C.3 confirms this broadening inflationary trend. It plots the time-series evolution of the supply chain constraints (red line) and an inflation diffusion index (blue line). While supply chain constraints eased toward the end of the sample period, the diffusion index keeps increasing as inflation becomes more broad-based.

An example of this transition across products is given by "furniture and furnishings, carpets and other floor coverings" (COICOP 051) and "recreational and cultural services" (COICOP 094). On the one hand, the industries producing the former product were severely hit by supply chain bottlenecks in 2021, leading Germany to CPI year-over-year growth reaching 4.2% in mid-2021 compared to 0.0% growth in mid-2020. On the other hand, the latter product was shielded by supply chain bottlenecks in 2021, but nevertheless experienced a surge in inflation in 2022. For example, in Germany, CPI year-over-year growth reached 3.5% in mid-2022, up by 1.8 percentage points compared to mid-2021. Interestingly, this generalization was even more pronounced in Portugal where, in an environment with particularly elevated inflation expectations, CPI year-over-year growth for "recreational and cultural services" reached 4.0% in 2022:Q3, up by 4.0 percentage points compared to mid-2021.

Interpreting the stylized facts: Conceptual framework. Figure 1 summarizes the overarching framework that drives our empirical inquiry. Here, we explain it in further detail. Supply-side shocks, such as supply chain constraints, give rise to localized inflation as producers increase product prices to defend their profit margins in response to challenges in procuring material inputs. While higher prices might spillover through firm-to-firm linkages, the initial *cost-push* inflationary impulse is somewhat confined within related products.

While their effect on inflation is localized, supply-side constraints lead to increased inflation expectations as households that experience higher prices and observe news coverage about the supply shocks tend to adjust their inflation expectations upwards. Coincidentally, higher aggregate cost and price uncertainty, also induced by supply chain shocks and elevated inflation, can result in households becoming less informed about the distribution of prices across firms and products through two mechanisms.

First, when exposed to supply shocks and/or positive price shocks, households need to assess the extent to which individual producers are impacted to make optimal decisions about their search efforts and subsequent consumption. If they perceive the shock to be widespread, affecting many suppliers (i.e., more akin to a common shock), they might be inclined to deduce that it is not worth exerting search effort to find more favorable deals elsewhere (Benabou and Gertner, 1993; Gaballo and Paciello, 2022). Second, the higher price variability, a consequence of inflationary pressures, can depreciate the value of information about future prices contained in current ones, giving repeat-purchase customers less incentives to acquire price information (Tommasi, 1994).[8]

Having less information about prices translates into higher reservation (acceptance) prices; that is, households become less choosy and tend to bargain for less while entering into less

[8]There is extensive evidence that inflation is positively correlated with the variability of prices across markets (e.g., Marquez and Vining, 1984; Domberger, 1987) and across sellers of the same good (see e.g., Van Hoomissen, 1988; Lach and Tsiddon, 1992).

adequate transactions. The increase in households' acceptance prices thus reduces the likelihood that they decrease their consumption in response to a price increase, shifting up the demand curve faced by individual producers. Consequently, *all* producers can "hide" behind aggregate cost and inflationary noise to maintain, or even increase, their markups without risking a considerable decline in sales (Benabou and Gertner, 1993; Tommasi, 1994; Gaballo and Paciello, 2022).[9]

This way, via an interaction of household expectations and firms' pricing power, supply-side inflation impulses can generalize and spiral upwards into broad-based inflation. In our empirical analysis in Section 3 to Section 5, we provide corroborative evidence for this framework. Specifically, in Section 3.1 and Section 3.2, we confirm that production constraints led to localized cost-push inflation and that they raised household inflation expectations, respectively. In Section 4, we confirm the transition from localized supply-driven inflation to broad-based inflation, and link this generalization to the elevated household inflation expectations. In Section 5, we analyze firms' pricing behavior, showing that firms with pricing power were more likely to maintain, or even increase, their markups (i) when facing supply chain constraints and a high demand for their products, and (ii) in an environment with elevated inflation expectations.

3 Pass-through of supply chain constraints

In this section, we present evidence consistent with a post-COVID pass-through of supply chain constraints to price levels through a cost-push channel (Section 3.1) and to household

[9] While both Benabou and Gertner (1993) and Tommasi (1994) study a single product market, their findings are also applicable to multiple product markets where the consumption of different products is interconnected through a positive cross-elasticity of demand. Less information among households about the price distribution of different products reduces the cross-price elasticity of demand. This reduction, in turn, causes an upward shift in the demand curve for individual producers.

inflation expectations via experience and news channels (Section 3.2).

3.1 Pass-through to localized inflation

Baseline analysis. We start our analysis by examining the possibility of a *localized* cost-push inflation induced by the supply chain disruptions and the resulting higher production costs. Factors contributing to increased production and transportation (especially shipping) costs include higher prices of scarce raw materials, the need to switch to costlier alternatives, and production delays that reduce output and increase per-unit costs. Due to these elevated costs, producers may increase their prices to maintain profit margins.

We test the effect of increasing supply chain pressures (as perceived by firms) on CPI growth by estimating the following specification at the product-country-quarter level:

$$\textit{CPI Growth}_{pct+1} = \beta_1 Material_{pct} + \beta_2 Material_{pct} \times Covid_t + \nu_{ct} + \mu_{pc} + \epsilon_{pct}, \qquad (1)$$

where p is a product, c is a country, and t is a quarter. *Material* measures the share of firms producing product p for the market in country c that indicates that their production is constrained by supply chain problems. The sample period spans 2019:Q1 to 2022:Q4 at a quarterly frequency. We use 2019 as our "base year". The *Covid* dummy is equal to one for the period after the start of the COVID-19 pandemic (i.e., after and including 2020:Q2) and zero otherwise. We measure the CPI growth in quarter t as the yearly CPI growth from quarter $t-3$ to quarter $t+1$. This approach allows us to gauge the effect of our independent variable of interest (i.e., *Material*) in quarter t on the one-quarter ahead dependent variable of interest (*CPI Growth* in Specification (1)), while accounting for seasonality by taking the same quarter in the previous year as base for the growth calculation.

By including country-quarter and product-country fixed effects, we isolate the effect of firms' perceived supply constraints holding constant the time-varying demand at the country level. Specifically, the country-quarter fixed effects absorb all shocks at the national level that could affect price levels (e.g., country-level demand shocks, energy shocks, government support packages, changes in tax legislation and national regulations). The product-country fixed effects control for time-invariant product-country characteristics.

We construct our variables at the product-country-quarter level in two steps. First, we use a EU inter-country input-output table (Eurostat Figaro) to capture industries from different countries contributing to the sales of a specific product in a specific country.[10] For example, cars sold in Germany are produced not only in Germany but also in Italy, Spain, etc. Second, we use the inverse of the COICOP-CPA matrix from Cai and Vandyck (2020) to transform the production constraints from the industry-country-time level to the product-country-time level by calculating a weighted constraints measure of all CPA categories that are related to a COICOP category (two digits). Consider, for example, the product category "Food and non-alcoholic beverages" (COICOP 01). This product's COICOP is a weighted average of, among others, the following CPA categories: (i) products of agriculture, hunting, and related services, (ii) fish and fishing products, and (iii) food products.

Our analysis includes both manufacturing firms and services. For manufacturing firms, we observe supply chain constraints (*Material*) in addition to the other supply factors (*Labor*, *Financial*, and *Other*). For services, the supply chain constraint is defined differently (*Equipment*; capturing equipment shortages), while all other supply factors are defined as for manufacturing (*Labor*, *Financial*, and *Other*). We conservatively decide to measure supply chain constraints solely using the *Material* variable.[11] However, we will later separately account for the potential transmission of these constraints through firm-to-firm linkages.

The first column of Table 1 shows that reported supply chain constraints are positively associated with the CPI growth in the post-pandemic period (i.e., after 2020:Q2) relative

[10]The Figaro data is available at https://ec.europa.eu/eurostat/web/esa-supply-use-input-tables.

[11]Observing supply chain constraints (*Material*) only for manufacturing firms attenuates the estimated magnitude of an eventual supply chain constraint pass-through in the full sample.

	(1) CPI Growth	(2) CPI Growth	(3) CPI Growth	(4) CPI Growth	(5) CPI Growth	(6) CPI Growth
$\text{Material}_{pct} \times \text{Covid}_t$	0.087***	0.086***				
	(0.023)	(0.022)				
$\text{Material}_{pct} \times 2020$			0.126***	0.126***	0.127***	0.095**
			(0.025)	(0.027)	(0.028)	(0.034)
$\text{Material}_{pct} \times 2021$			0.076**	0.074**	0.074**	0.064**
			(0.027)	(0.027)	(0.026)	(0.027)
$\text{Material}_{pct} \times 2022$			0.074**	0.071**	0.070**	0.060**
			(0.027)	(0.027)	(0.026)	(0.027)
$\text{Energy Use}_{pc} \times \text{Energy Inflation}_{ct}$		1.448***		1.454***	1.471***	1.515***
		(0.481)		(0.482)	(0.481)	(0.478)
Observations	9,187	9,187	9,187	9,187	9,187	9,187
R-squared	0.537	0.545	0.537	0.546	0.546	0.550
Controls						
Other constraints					✓	✓
Other constraints interacted						✓
Fixed effects						
Country-time	✓	✓	✓	✓	✓	✓
Product-country	✓	✓	✓	✓	✓	✓

Table 1: Supply chain constraint pass-through to CPI. This table presents estimation results from Specification (1) in Column (1)-(2) and Specification (2) in Columns (3)-(6). The subscript notation is defined as follows: p is a product, c is a country, and t is a quarter. The dependent variable is the one-quarter ahead annual CPI growth at the product-country-time level. *Covid* is a dummy equal to one for the period after the start of the COVID-19 pandemic (i.e., after and including 2020:Q2) and zero otherwise. *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the product-country-time level using an input-output table and the share of consumption that each industry contributes to the final household consumption of a particular product. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) uninteracted in Columns (5)-(6) and, in addition, these other constraints interacted with the three year dummies in Column (6). *Energy Inflation* is the country-time-level CPI index for energy. *Energy Use* is a product-country pair's energy input before the COVID-19 pandemic, measured in 2019 and scaled by the country's total energy use. We exclude the product "Energy" from the regression. Standard errors are double-clustered at the country-product and quarterly level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

to 2019. Specifically, a one standard deviation higher supply chain constraint is associated with a 1.3pp higher annual CPI growth in the COVID-19 pandemic period. This evidence suggests a pass-through of supply-side frictions to consumer prices.

In Column (2), we additionally control for the contemporaneous energy cost shock to isolate the impact of supply chain frictions on inflation from the impact of the surge in energy costs. To this end, we employ the interaction *Energy Use* × *Energy Inflation*. *Energy Inflation* is the time-varying country-level CPI index for energy (from Eurostat), capturing the evolution of a country's overall energy costs over time. *Energy Use* is an industry-country pair's energy input before the COVID-19 pandemic, measured in 2019 and scaled by the country's total energy use.[12] The year 2019 provides a pre-COVID baseline for energy usage, reflecting "normal" economic conditions without pandemic-related distortions. The results in Column (2) show that accounting for energy costs does not significantly alter the coefficient pertaining to the impact of supply chain frictions. This evidence suggests that, in terms of pass-through to CPI growth, the shocks from supply chain issues are largely orthogonal to those from energy costs.

Time variation of pass-through. Having established a correlation between supply chain frictions and consumer prices for the COVID-19 pandemic period, we proceed to examine its potential time variation throughout this period (i.e., from 2020:Q2 to 2022:Q4). Additionally, to ensure that the observed effect is not driven by production constraints other than those related to the supply chain we modify Specification (1) as follows:

$$\begin{aligned} \mathit{CPI\ Growth}_{pct+1} = & \sum_{f \in \text{Constraint}} \beta_{1f}\, f_{pct} + \sum_{f \in \text{Constraint}} \sum_{\tau=20,21,22} \boldsymbol{\beta_{2f\tau}}\, f_{pct} \times Year_{\tau} \\ & + \nu_{ct} + \mu_{pc} + \epsilon_{pct}, \end{aligned} \tag{2}$$

where $Year_{20}$, $Year_{21}$, $Year_{22}$ are dummies equal to one in 2020, 2021, and 2022, respectively—where the year dummy for 2020 equals one for Q2-Q4 only (i.e., only after the COVID-19 outbreak). The four types of constraints to production (*Constraint*) are *Material*, *Labor*, *Financial*, and *Other*, which capture, respectively, supply chain constraints, labor-supply constraints, financial constraints, and other production constraints.[13]

Columns (3)-(6) of Table 1 indicate that the link between reported supply chain con-

[12] Our results are robust to employing the nonscaled energy input level.

[13] Specifically, we know (from the BCS survey) the share of firms that indicate that their production is constrained by each of the four potential constraints at the industry-country-time level.

straints and CPI growth exists for all years. Note that these columns estimate progressively more stringent specifications. The third column only includes the supply chain constraint (*Material*). In Column (4), we again additionally control for energy cost shocks. The fifth column also includes the other constraints to production (*Labor*, *Financial*, and *Other*), omitted from the table for brevity. The sixth column includes each of these supply-side constraint variables interacted with the three year dummies (again omitted for brevity). The estimated coefficients for the supply chain constraint variable (*Material*) are stable across all specifications. Note that, while the estimated coefficient in 2020 is the largest, CPI growth is not (yet) elevated in 2020.

Cost-push along the supply chain. Next, we validate our survey data as a reliable indicator of production constraints faced by firms due to supply chain disruptions and confirm that these disruptions contribute to localized inflation through downstream effects. Material frictions and the associated cost increases faced by suppliers are likely to inflate costs for downstream firms. Consequently, these firms are likely to increase their prices to offset the higher input costs, ultimately leading to increased consumer prices.

To verify that material frictions indeed travel downstream, we shift our focus to the material constraints of upstream suppliers who provide goods to producers for final household consumption. Utilizing the Figaro input-output table from Eurostat, we first identify the supplier industries and calculate their supply shares for each EU industry that produces goods for final consumption. Based on this information, we construct the variable *Material Supply* as:

$$\begin{aligned} &\textit{Material Supply}_{pct} = \qquad (3) \\ &\sum_{\bar{j},\bar{c}} \left[\textit{COICOP Share}_{pc\bar{j}} \times \textit{Consumption Share}_{c\bar{j}\bar{c}} \times \left(\sum_{\underline{j},\underline{c}} \textit{Supply Share}_{\bar{j}\bar{c}\underline{j}\underline{c}} \times \textit{Constraint}_{\underline{j}\underline{c}t} \right) \right] \end{aligned}$$

This variable measures the share of firms that indicate that their production is constrained by material input constraints in quarter t among the suppliers that provide input goods to firms that sell product p in country c in year t. The indices $\overline{j}$ and $\overline{c}$ refer to the customer industries and countries selling to final consumers, respectively, while $\underline{j}$ and $\underline{c}$ denote the supplier industries and countries. The variable $\textit{COICOP Share}_{pc\overline{j}}$ captures the relative weights of CPA categories linked to a COICOP category, whereas $\textit{Consumption Share}_{c\overline{j}\overline{c}}$ reflects the contribution of CPA categories to final household consumption.

We then rerun Specification (2), but this time substituting the immediate production constraints (*Constraint*) of industries that produce and sell goods for final household consumption with the weighted constraints reported by their upstream suppliers (*Material Supply*). Table B.1 presents the results from this analysis. Across all specifications, the results provide robust evidence that frictions reported by upstream suppliers propagate through the supply chain, ultimately leading to localized inflation.

In Column (6) of Table B.1, we conduct a test to assess whether the other production constraints identified in the survey—namely, financial, labor, and other frictions—also propagate downstream. For each type of constraint, we construct a measure analogous to *Material Supply* and interact these measures with the different year dummies. The results of this placebo test indicate that it is specifically material frictions, not the other constraint types, that travel downstream. This finding highlights a unique connection between material constraints, the supply chain dynamics of firms, and their contribution to localized inflation.

IV estimation. Next, we conduct an instrumental variable (IV) regression approach. This analysis serves two purposes: first, to further validate our survey data; and second, to pinpoint exogenous variations in supply chain frictions. Most importantly, it ensures that the reported material constraints are truly a result of supply chain disruptions, rather than from rising consumer demand paired with a lack of scalability in material inputs. By employing an instrument for supply chain frictions, we can thus provide more direct evidence of the causal effect of the pass-through of increased supply chain costs.

In particular, we instrument a market's degree of material input frictions with the reliance of firms in this market on imports from China prior to the COVID-19 pandemic and their resulting susceptibility to disruptions caused by COVID-19 lockdowns in China. Formally, our shift-share instrument is:

$$\widetilde{B}_{pct} = \text{China Dependence}_{pc,2019} \times \text{Lockdown Stringency}_t, \tag{4}$$

where *China Dependence* represents the share of material inputs that the respective firms imported from China in 2019 to produce and sell product p in country c (using data from Eurostat Figaro), while *Lockdown Stringency* measures the severity of lockdown measures implemented in the top-5 exporting provinces of China.[14] We obtain the data about the lockdown severity from the Oxford COVID-19 Government Response Tracker project (OxCGRT). The OxCGRT provides the COVID-19 Stringency Index, a composite measure based on nine response indicators including school closures, workplace closures, and travel bans, rescaled to a value from 0 to 100 (100 = strictest).[15] Our instrument thus gets all of the cross-sectional variation in the exposure of a products's supply chain to material imports sourced from China, and all of its time-series variation from the lockdown-induced disruptions.

Table 2 presents the results for the IV estimation, for the first stage in Column (2) and for the second stage in Column (1). The instrument has a positive and significant effect on the reported material frictions (*Material*), with an F-statistic of 423.17 and a p-value

[14] These top-5 exporting provinces are Guangdong, Jiangsu, Shandong, Shanghai, and Zhejiang.

[15] For China, the OxCGRT COVID-19 Stringency Index is also available at the province-time level. To more precisely capture the impact of COVID-19 lockdowns on supply chains, we focus on the five leading Chinese provinces in export contributions, since export volumes do not significantly correlate with the severity of COVID-19-related government policies at the provincial level. For instance, Guangdong, despite being a top exporter, experienced relatively moderate COVID-19 restrictions. Conversely, Xinjiang, with some of the most stringent lockdown measures, ranks low in export volumes. To create the consolidated top-5 export COVID-19 stringency index, we take the average of the province-time-level index for the top-5 export provinces, collectively representing 67% of the national export total. See Figure C.1 for the time-series evolution of this aggregate lockdown stringency index.

	(1) CPI Growth$_{pct}$	(2) Material$_{pct}$
Material$_{pct}$	0.081***	
	(0.017)	
China Dependence$_{pc}$ $\times$ Lockdown Stringency$_t$		6.973***
		(0.339)
F-Test		423.17
Observations	9,187	9,187
R-squared		0.782
Fixed effects		
Product-country	✓	✓
Country-time	✓	✓

Table 2: Supply chain constraint pass-through to CPI: IV estimation. This table presents the estimation results from the IV specification. The subscript notation is defined as follows: p is a product, c is a country, and t is a quarter. The first stage results are shown in Column (2). The second stage results in Column (1). The dependent variables are the one-quarter ahead annual CPI growth at the product-country-time level in Column (1). *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the product-country-time level using input-output tables and the share of consumption that each industry contributes to the final household consumption of a particular product. *China Dependence* represents the share of inputs to produce product p in country c that are imported from China in 2019. *Lockdown Stringency* measures the severity of lockdown measures implemented in China's top-5 exporting provinces. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) and, in addition, the interaction of *Energy Inflation* and *Energy Use*. *Energy Inflation* is the country-time-level CPI index for energy. *Energy Use* is a product-country pair's energy input before the COVID-19 pandemic, measured in 2019 and scaled by the country's total energy use. We exclude the product "Energy" from the regression. Standard errors are double-clustered at the country-product and quarterly level. We report standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

below 0.01, confirming the *relevance* and the strength of the instrument. In the second-stage estimation, we replace the *Material* frictions with the predicted $\widehat{Material}$ frictions from the first stage. The dependent variable is again the one-quarter ahead annual CPI growth at the product-country-time level. The IV estimated coefficients confirm the positive effect of an increase in the reported material frictions on CPI growth, suggesting a causal impact of supply chain disruptions on CPI growth.

These results on the pass-through of supply chain constraints on price levels are consistent with the evidence from research examining the recent supply-side disruptions in Europe. Finck and Tillmann (2022), Binici et al. (2022), and Celasun et al. (2022) find that supply chain constraints have contributed to inflation, while Kuehl et al. (2022) finds that supply-side disruptions have been mostly driven by the recovery in global demand.

3.2 Pass-through to higher inflation expectations

In this section, we provide evidence of a pass-through of supply chain constraints to household inflation expectations. Supply-side shocks can influence inflation expectations through two primary channels of learning: the *experience* channel and the *news* channel. The experience channel operates through the observable effect of supply-side shocks on the price level. When agents experience price increases caused by supply chain disruptions, they revise their inflation expectations, anticipating similar price movements in the future. The experience channel is consistent with behavioral models like adaptive expectations (expectations based on lagged experience; e.g., Cagan, 1956), diagnostic expectations (Bordalo et al., 2018), and adaptive learning models (see Evans and Honkapohja, 2001; Eusepi and Preston, 2011; Malmendier and Nagel, 2016; D'Acunto et al., 2021).

According to the news channel, agents adjust their inflation expectations in response to news about supply-side shocks (see, e.g., Carroll, 2003; Pfajfar and Santoro, 2010; Dräger and Lamla, 2017; Larsen et al., 2021; and Mazumder, 2021 for empirical evidence); for example, reading reports about containers piling up at ports in China due to lockdowns and thereby causing costs to increase for producers. This adjustment can occur even before agents witness any actual price changes, reflecting the influence of information on expectations formation. The news channel aligns with the formation of inflation expectations through Bayesian updating (Armantier et al., 2016; Cavallo et al., 2017; Binder and Rodrigue, 2018; Coibion et al., 2018) as well as diagnostic expectations (Bordalo et al., 2018).[16]

To tease out these channels, our analysis of household inflation expectations encompasses

[16] These channels also make inflation persistent since shocks that increase inflation expectations seem to have stronger effects than shocks that decrease inflation expectations (Ascari et al., 2023).

three sets of empirical tests: (i) an analysis at the country-quarter level using BCS consumer survey data, (ii) an analysis at the household-quarter level using data from the ECB's CES, and (iii) expanding on the second, an analysis in which we add measures that allow us to gauge households' awareness of past inflation and their attention to supply chain disruptions.

Country-quarter level analysis. In the first set of tests, we conduct an analysis at the *country-quarter level* employing the following two specifications:

$$\hat{\pi}^e_{ct} = \beta_1 Material_{ct} + \beta_2 Material_{ct} \times Covid_t + \beta_3 Food\ Inflation_{ct} + \beta_4 Energy\ Inflation_{ct} + \beta_5 Core\ Inflation_{ct} + \beta_6 High\ Perception_{ct} + \nu_c + \epsilon_{ct}, \quad (5)$$

and

$$\hat{\pi}^e_{ct} = \sum_{f \in \text{Constraint}} \beta_{1f}\, f_{ct} + \sum_{f \in \text{Constraint}} \sum_{\tau=20,21,22} \boldsymbol{\beta_{2f\tau}}\, f_{ct} \times Year_\tau + \beta_3 Food\ Inflation_{ct} + \beta_4 Energy\ Inflation_{ct} + \beta_5 Core\ Inflation_{ct} + \beta_6 High\ Perception_{ct} + \nu_c + \epsilon_{jct}, \quad (6)$$

where $Year_{20}$, $Year_{21}$, and $Year_{22}$ denote the same set of dummies and f_{ct} the same set of constraints to production as in Specification (2), but the latter is now transformed with the COICOP-CPA matrix from Cai and Vandyck (2020) from the industry-country-time level to the country-time level using the share of consumption that each industry contributes to the final household consumption.[17]

In these two specifications we use, for the dependent variable at the country-quarter level, the BCS consumer survey data, employing the share of households in a country that believe

[17] Consider, for example, the textiles industry (CPA 13). This industry's CPI is a weighted average of, among others, the following COICOP categories: (i) clothing, (ii) furniture and furnishings, carpets and other floor coverings, and (iii) household textiles.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\hat{\pi}^e_{ct}$	$\hat{\pi}^e_{ct}$	$\hat{\pi}^e_{ct}$	$\hat{\pi}^e_{ct}$	$\hat{\pi}^e_{ct}$	$\hat{\pi}^e_{ct}$	$\hat{\pi}^e_{ct}$	$\hat{\pi}^e_{ct}$
Material_{ct} x Covid	1.187***							
	(0.175)							
Material_{ct} x 2020		2.298***	2.416***	2.679***	2.766***	2.158***	1.804***	1.933***
		(0.374)	(0.373)	(0.400)	(0.395)	(0.386)	(0.562)	(0.534)
Material_{ct} x 2021		0.900***	1.179***	1.105***	1.052***	0.889***	0.410*	0.556**
		(0.166)	(0.201)	(0.200)	(0.214)	(0.211)	(0.232)	(0.224)
Material_{ct} x 2022		1.062***	1.147***	1.039***	0.963***	0.851***	0.507*	0.624**
		(0.164)	(0.153)	(0.171)	(0.181)	(0.182)	(0.280)	(0.242)
Food Inflation_{ct}			0.497***	0.343*	-0.057	-0.135	-0.126	
			(0.152)	(0.168)	(0.236)	(0.239)	(0.275)	
Energy Inflation_{ct}				0.142**	0.134**	0.125**	0.121***	
				(0.057)	(0.052)	(0.046)	(0.042)	
Core Inflation_{ct}					1.016*	1.159**	0.835	
					(0.504)	(0.483)	(0.535)	
High Perception_{ct}								0.154***
								(0.042)
Observations	305	305	305	305	305	305	305	305
R-squared	0.535	0.571	0.603	0.622	0.629	0.653	0.679	0.679
Controls								
Other constraints						✓	✓	✓
Other constraints interacted							✓	✓
Fixed effects								
Country	✓	✓	✓	✓	✓	✓	✓	✓

Table 3: Supply chain constraint pass-through to household inflation expectations: Country-level evidence. This table presents estimation results from Specification (5) in Column (1) and Specification (6) in Columns (2)-(7). The subscript notation is defined as follows: c is a country and t is a quarter. The dependent variable is the share of households that believe consumer prices will increase more rapidly at the country-time level. *Covid* is a dummy equal to one for the period after the start of the COVID-19 pandemic (i.e., after and including 2020:Q2) and zero otherwise. *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the country-time level using the share of consumption that each industry contributes to the final household consumption. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) uninteracted in Columns (6)-(7) and, in addition, these other constraints interacted with the three year dummies in Column (7). *Food Inflation*, *Energy Inflation*, and *Core Inflation* are the country-time-level CPI indices for food, energy, and core, respectively. *High Perception* is the share of households at the country-time level that believe prices have risen a lot over the last 12 months. Standard errors are double-clustered at the country and quarterly level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

consumer prices will increase more rapidly. Moreover, we control for realized inflation and alternatively directly for households' perceptions of past inflation (*High Perception*) since the literature has identified households' beliefs about the inflation over the recent past as strong predictor of their inflation forecast (Ranyard et al., 2008). Furthermore, we decompose realized inflation into core, energy, and food inflation, given that the latter two have been highlighted by the literature as particularly strong drivers of household inflation expectations (Coibion and Gorodnichenko, 2015; D'Acunto et al., 2019; Cavallo et al., 2017; D'Acunto et al., 2021; Wong, 2015). In our most stringent specification, we additionally include year interactions for all our controls.

Table 3 presents the estimation results for this test, where in the different specifications we incorporate an increasingly rigorous set of controls. The regression results for the specification without controls (Column (1)) suggest a strong impact of material constraints to production on household inflation expectations. Even when we introduce controls for the experience channel, namely realized inflation and households' perception about past inflation (the latter being the most precise control for the experience channel), the correlation between production constraints and household inflation expectations remains robust though its magnitude diminishes for 2021 and 2022 by about 40-50% with stringent controls of Specification (7)-(8). This reduction in the correlation between reported material constraints to production and household inflation expectations is consistent with the experience channel but suggests other channels are likely at work too (which we explore below).

Overall, the results show that supply chain constraints are positively associated with household inflation expectations across all specifications. Based on the most stringent specification (Column (8)), a one standard deviation higher supply chain constraint in 2021 increases the share of households who believe that prices will increase more rapidly by 4pp. Note that the average share of households who think that prices will increase more rapidly is 23% in 2021.

To further substantiate the causal link between supply chain disruptions and rising household inflation expectations, we again run an IV estimation following our approach from Section 3.1. As before, we use the interaction between a market's *China Dependence* and *Lockdown Stringency* as our instrumental variable. The dependent variable here is the share of households that believe consumer prices will increase more rapidly. Table 4 presents the results. The IV estimated coefficients confirm the positive, plausibly causal, effect of an

	(1)	(2)
	$\hat{\pi}^{e}_{ct}$	Material_{pct}
Material_{pct}	2.371***	
	(0.496)	
$\text{China Dependence}_{pc} \times \text{Lockdown Stringency}_{t}$		2.973***
		(0.612)
F-Test		23.6
Observations	305	305
R-squared		0.738
Fixed effects		
Country	✓	✓

Table 4: Supply chain constraint pass-through to household inflation expectations: IV estimation. This table presents the estimation results from the IV specification. The subscript notation is defined as follows: p is a product, c is a country, and t is a quarter. The first stage result is shown in Column (2). The second stage results in Column (1). The dependent variable is the share of households that believe consumer prices will increase more rapidly at the country-time level in Column (1). *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the product-country-time level using input-output tables and the share of consumption that each industry contributes to the final household consumption of a particular product. *China Dependence* represents the share of inputs to produce product p in country c that are imported from China in 2019. *Lockdown Stringency* measures the severity of lockdown measures implemented in China's top-5 exporting provinces. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) and, in addition, the interaction of *Energy Inflation* and *Energy Use* in Columns (1) and (2). *Energy Inflation* is the country-time-level CPI index for energy. *Energy Use* is a product-country pair's energy input before the COVID-19 pandemic, measured in 2019 and scaled by the country's total energy use. Standard errors are double-clustered at the country and quarterly level. We report standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

increase in the prevalence of reported supply chain frictions on CPI growth.

Household-quarter level analysis. In the second set of tests, we switch to a more granular analysis at the *household-quarter level* using data from ECB's CES from six countries (Germany, Spain, Italy, France, Belgium, and Netherlands) available from 2020:Q2 to 2022:Q4. The CES data allows us to observe both households' short-term (one-year ahead) inflation expectations as well as their longer term (three-year ahead) expectations. For these tests we employ the following two dependent variables for $\hat{\pi}^{e}_{ht}$. First, a dummy equal to one if household h responds *"Prices will increase a lot"* to the question *"How do you think prices will evolve over the next 12 months?"* Second, a dummy equal to one if household h answers

"Prices will increase a lot" to the question *"Please think further ahead to <survey month year+2 >. What do you think will happen to prices in general in the country you currently live in over the 12-month period between <survey month year+2 and survey month year+3 >?"*

Figure C.2 shows that while the rise in inflation expectations is more pronounced for short-term expectations, there is a notable increase in long-term expectations as well. This increase in longer-term expectations suggests that household perceptions of inflation is not only a transient concern and but a more entrenched expectation.

To gauge the impact of material constraints on production on households' inflation expectations from the CES data, we estimate the following specification:

$$\hat{\pi}^e_{ht} = \sum_{f \in \text{Constraint}} \boldsymbol{\beta_{1f}} f_{ct} + \beta_2 \textit{Food Inflation}_{ct} + \beta_3 \textit{Energy Inflation}_{ct} + \beta_4 \textit{Core Inflation}_{ct} + \beta_5 \textit{High Perception}_{ht} + \mu_h + \epsilon_{ht}, \tag{7}$$

where h is a household, c is a country, and t is a quarter. For these tests, we again transform all production constraints (*Material*, *Labor*, *Financial*, and *Other*) measured at the industry-country-time level to the country-time level using the share of consumption that each industry contributes to the final household consumption using the COICOP-CPA matrix. Finally, similar to Specifications (5) and (6), we control for realized inflation and alternatively for households' perception about inflation in the last 12 months (now at the household-time level).

The estimation results in Table 5 confirm the positive association between supply chain constraints and households' inflation expectations, both for their short-term (Panel A) and long-term (Panel B) expectations. For instance, the results in Column (5) of Panel A suggest that increasing the share of firms reporting material frictions from the 10th to the 90th percentile during the COVID-19 period leads to a 9.5pp higher probability for a household to believe prices will increase lot in the following year. This corresponds to 31% of the average

Panel A: Short-Term Expectations	(1) $\hat{\pi}^e_{ht}$	(2) $\hat{\pi}^e_{ht}$	(3) $\hat{\pi}^e_{ht}$	(4) $\hat{\pi}^e_{ht}$	(5) $\hat{\pi}^e_{ht}$	(6) $\hat{\pi}^e_{ht}$
Material_{ct}	0.951***	0.593***	0.296***	0.261***	0.281***	0.110**
	(0.037)	(0.034)	(0.041)	(0.041)	(0.059)	(0.050)
$\text{Food Inflation}_{ct}$		1.715***	1.359***	0.949***	1.032***	
		(0.050)	(0.050)	(0.067)	(0.088)	
$\text{Energy Inflation}_{ct}$			0.192***	0.175***	0.158***	
			(0.011)	(0.011)	(0.013)	
$\text{Core Inflation}_{ct}$				1.468***	1.731***	
				(0.201)	(0.207)	
$\text{Perceived (realized) Inflation}_{ht}$						1.178***
						(0.030)
Observations	126,080	126,080	126,080	126,080	126,080	126,080
R-squared	0.512	0.526	0.530	0.530	0.531	0.539

Panel B: Long-Term Expectations	(1) $\hat{\pi}^e_{ht}$	(2) $\hat{\pi}^e_{ht}$	(3) $\hat{\pi}^e_{ht}$	(4) $\hat{\pi}^e_{ht}$	(5) $\hat{\pi}^e_{ht}$	(6) $\hat{\pi}^e_{ht}$
Material_{ct}	0.242***	0.157***	0.097***	0.082***	0.110***	0.100***
	(0.019)	(0.020)	(0.023)	(0.024)	(0.038)	(0.034)
$\text{Food Inflation}_{ct}$		0.410***	0.338***	0.160***	0.212***	
		(0.037)	(0.040)	(0.061)	(0.071)	
$\text{Energy Inflation}_{ct}$			0.039***	0.031***	0.025***	
			(0.009)	(0.009)	(0.010)	
$\text{Core Inflation}_{ct}$				0.636***	0.747***	
				(0.162)	(0.173)	
$\text{Perceived (realized) Inflation}_{ht}$						0.518***
						(0.023)
Observations	126,080	126,080	126,080	126,080	126,080	126,080
R-squared	0.498	0.499	0.499	0.500	0.500	0.504
Controls						
Other constraints					✓	✓
Fixed effects						
Household	✓	✓	✓	✓	✓	✓

Table 5: Supply chain constraint pass-through to household inflation expectations: Household-level evidence. This table presents estimation results from Specification (7). The subscript notation is defined as follows: h is a household, c is a country, and t is a quarter. The dependent variables are a household-time-level dummy equal to one if household h believes prices will increase a lot over the next 12 month in Panel A and equal to one if household h believes prices will increase a lot over the 12-month period between current year+2 and current year+3 in Panel B. *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the country-time level using the share of consumption that each industry contributes to the final household consumption. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) in Columns (5)-(6). *Food Inflation*, *Energy Inflation*, and *Core Inflation* are the country-time-level CPI indices for food, energy, and core, respectively. *Perceived (realized) Inflation* is household h's perception about the inflation over the last 12 months. Standard errors are clustered at the country-demographics level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

share of households thinking inflation will increase a lot. Similarly, results in Column (6) suggest a 4pp higher probability for a household to believe prices will increase lot in the following year, corresponding to 14% of the average share of households thinking inflation will increase a lot.

The results in Panel B for long-term household inflation expectations show a qualitatively similar but a quantitatively smaller effect to that for short-term expectations in Panel A by a factor between 2.5 and 4 (except in Column (6) where it is almost as similar in magnitude).

Overall, comparing the magnitude of the effect of material input constraints on short-term versus long-term household inflation expectations across the different specifications shows that controlling for realized inflation and households' perceptions about past inflation brings impacts on short-term and long-term expectations closer. This evidence indicates that the experience channel has a stronger effect on short-term expectations, while the effect of other channels (e.g., the news channel) seems to be more uniform across short-term and long-term expectations. This finding suggests an important role of these other channels in the unanchoring of household inflation expectations, which we explore next.

Household-quarter level analysis with interactions. In the third set of tests, we extend our analysis at the *household-quarter level* to further investigate the mechanisms—notably the news channel—through which supply shocks influence households' inflation expectations.

To this end, we employ two additional explanatory variables in Specification (7) measuring (i) the degree to which households are informed about inflation trends and (ii) their attentiveness to supply chain disruptions. Specifically, we measure the accuracy of a household's inflation information based on the *within-household* correlation (in 2020:Q2-2022:Q4) between the point estimates for how high realized inflation was over the last 12 months and the actual realized inflation. *Accurate* is a household-level dummy with a value of one for those households whose accuracy in estimating past inflation is above the sample median. A well-informed household is likely to have also closely monitored the causes of the inflationary pressures (e.g., whether inflation is supply-driven).

The second measure gauges households' general attentiveness to supply shocks at the country-quarter level. In particular, we employ the variable *Search* measuring the intensity of Google searches for "delays in shipping" in a specific country.[18] This intensity is a number assigned by Google Trends based on the *"search interest relative to the highest point for the given region and time"*, where *"a value of 100 is the peak popularity for the term."* We obtain Google searches from Germany, Italy, France, and Spain—the countries with a sufficient number of searches for "delays in shipping."[19]

The estimation results in Columns (1) of Table 6 show (see the coefficient on $Material_{ct} \times Accurate_h$) that households that are better informed about realized past inflation expect a more significant increase in CPI growth in response to escalating supply chain constraints. Column (2) confirms this result for a specification in which we additionally control for country-quarter fixed effects, which account for other country-specific factors influencing household inflation expectations, including realized inflation. Column (3) highlights a stronger correlation between reported supply chain disruptions and household inflation expectations in countries where there is heightened awareness and interest in searching news of supply chain issues, as observed in the coefficient on $Material_{ct} \times Search_{ct}$.

Finally, Columns (4) and (5) report results for specifications including interaction terms of $Material_{ct}$ jointly with both $Accurate_h$ and $Search_{ct}$, which show that the relationship between households' precision in evaluating past inflation and supply chain shocks is stronger in countries where there is heightened awareness of supply chain issues. These results suggest that the positive association between supply chain constraints and household inflation expectations is driven by households that are more attentive to inflation trends and exhibit

[18]Similarly, Korenok et al. (2022) employs the frequency of Google searches regarding inflation as a metric to gauge household attentiveness towards inflation.

[19]Specifically, we search for "Lieferschwierigkeiten" and "Lieferengpasse" for Germany, "tempi consegna" for Italy, "tiempo entrega" for Spain, and "delai de livraison" for France. These words maximized the number of searches available.

	(1)	(2)	(3)	(4)	(5)
	$\hat{\pi}^e_{ht}$	$\hat{\pi}^e_{ht}$	$\hat{\pi}^e_{ht}$	$\hat{\pi}^e_{ht}$	$\hat{\pi}^e_{ht}$
Material_{ct}	-0.461***		0.067	-0.260**	
	(0.052)		(0.081)	(0.110)	
$\text{Material}_{ct} \times \text{Accurate}_h$	1.547***	1.209***		0.694***	0.503***
	(0.048)	(0.047)		(0.152)	(0.120)
$\text{Material}_{ct} \times \text{Accurate}_h \times \text{Search}_{ct}$				1.408***	1.308***
				(0.275)	(0.220)
Search_{ct}			-0.254***	-0.230***	
			(0.033)	(0.035)	
$\text{Material}_{ct} \times \text{Search}_{ct}$			0.882***	0.099	
			(0.138)	(0.177)	
$\text{Accurate}_h \times \text{Search}_{ct}$				-0.089	-0.172***
				(0.057)	(0.042)
Food Inflation_{ct}	1.020***		1.205***	1.156***	
	(0.084)		(0.097)	(0.093)	
Energy Inflation_{ct}	0.139***		0.095***	0.090***	
	(0.013)		(0.018)	(0.017)	
Core Inflation_{ct}	2.027***		2.476***	2.695***	
	(0.202)		(0.282)	(0.268)	
Perceived (realized) Inflation_{ht}		0.849***			0.841***
		(0.028)			(0.026)
Observations	122,096	122,096	106,144	102,551	103,088
R-squared	0.534	0.554	0.536	0.539	0.556
Controls					
Other constraints	✓		✓	✓	
Fixed effects					
Country-time		✓			✓
Household	✓	✓	✓	✓	✓

Table 6: Supply chain constraint pass-through to household inflation expectations: Interactions with household characteristics. This table presents estimation results from Specification (7). The subscript notation is defined as follows: h is a household, c is a country, and t is a quarter. The dependent variable is a household-time-level dummy equal to one if household h believes prices will increase a lot over the next 12 month. *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the country-time level using the share of consumption that each industry contributes to the final household consumption. *Accurate* is a dummy equal to one for households with an above median within household correlation between realized inflation over the last 12 months and the household's inflation estimate for the last 12 months. *Search* is a country-time-level variable measuring the intensity of Google searches for "delays in shipping" (in the respective country's language). Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) in Columns (1), (3), and (4). *Food Inflation*, *Energy Inflation*, and *Core Inflation* are the country-time-level CPI indices for food, energy, and core, respectively. *Perceived (realized) Inflation* is household h's perception about the inflation over the last 12 months. Standard errors are clustered at the country-demographics level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

a higher level of concern or awareness regarding supply chain constraints. This evidence is consistent with other recent research showing an increase in the degree of attention and awareness about the aggregate price level for higher levels of inflation (Cavallo et al., 2017; Bracha and Tang, 2022; Korenok et al., 2022; Pfäuti, 2022; Weber et al., 2023).

In Table B.2, we show that the results from Table 6 are robust to including interaction terms between the variable *Accurate* and the different inflation categories—namely, food, energy, and core inflation—as well as perceived inflation. Specifically, in Column (1), we introduce double interactions between *Accurate* and the different inflation categories. In Column (2), we add the interaction between *Accurate* and households' perceived inflation. In Column (3), we add another layer by including triple interactions between *Accurate*, the different inflation categories, and *Search*. Finally, in Column (4), we include a triple interaction with *Search* and households' perceived inflation.

The findings indicate that when households' general attentiveness to supply shocks, as measured by *Search*, is low and inflation rises, the inflation expectations of households well-informed about inflation trends (those with high *Accurate*) tend to be higher than those of less informed households (indicated by a positive interaction between *Accurate* and the different inflation categories). However, this difference in expectations decreases as the overall level of attentiveness increases, as indicated by the negative coefficient of the triple interaction with *Search*.

We observe similar patterns in the specifications that involve interactions with perceived inflation, suggesting that when less informed households become more aware of supply-driven inflationary trends, they adjust their inflation expectations more closely to those of generally more attentive households.

In sum, the findings from this section indicate that the supply chain pressures in the period after the outbreak of the COVID-19 pandemic influenced household inflation expectations through *both* the experience and the news channel.

4 Generalization into broad-based inflation

We now turn to the final, but perhaps the most novel set of our results, on the generalization of supply constraints into broad-based inflation. The mechanism detailed in Section 2 and the rightmost plot of Figure 1 posits that households that become aware of supply-side constraints (either through news reports or the resultant effects on prices) raise their inflation expectations and become less inclined to search for better prices, bargain for better deals, and reduce their consumption, even when facing price hikes. This shift in household behavior provides all firms more broadly (i.e., not only the ones affected by supply-side constraints) the leeway to raise their price markups. The degree to which firms can increase their markups should thus be positively associated with the extent of household exposure to supply-side shocks in a given country besides to firms' pricing power in an industrial organization sense. This mechanism predicts a broader inflationary trend in countries that are hit more severely by supply shocks, as price levels should also rise more strongly in markets not directly affected by these supply-side disturbances.

Baseline spillover analysis. To test this mechanism, we compare the CPI growth in product-country pairs (hereafter termed "markets") not materially affected by supply chain disruptions, across countries with varying degrees of aggregate (country-time-level) growth in inflation expectations. Specifically, we focus on the CPI growth of service-based products, which were largely unaffected by supply chain constraints during the pandemic, across countries that exhibit varying increases in inflation expectations. To this end, we estimate the following "spillover specification" at the product-country-quarter level:

$$
\begin{aligned}
\textit{CPI Growth}_{pct+1} = {} & \beta_1 \textit{Service}_{pc} \times \textit{High Infl Exp}_c + \sum_{\tau=20,21,22} \beta_{2\tau} \textit{Service}_{pc} \times \textit{Year}_\tau \\
& + \sum_{\tau=20,21,22} \boldsymbol{\beta_{3\tau}} \textit{Service}_{pc} \times \textit{High Infl Exp}_c \times \textit{Year}_\tau \\
& + \textit{Controls} + \nu_{ct} + \theta_{pc}, + \epsilon_{cpt} \qquad (8)
\end{aligned}
$$

where p is a product, c is a country, and t is a quarter.

The dependent variable is the one-quarter ahead annual CPI growth for a product-country pair and *Year* is the same set of year dummies as in Specification (2). *Service* is the time-invariant contribution of service sectors to the consumption of product p in country c.[20] *High Infl Exp* is an indicator equal to one if the increase in the share of households expecting that prices will rise more rapidly is above the median in a country between 2021:Q1 and 2022:Q1.

We also include country-time and product-country fixed effects, as well as the following set of control variables: the other production constraints (*Labor*, *Financial*, and *Other*) interacted with the three year dummies and *Energy Inflation* interacted with the *Service* variable and the three year dummies. Finally, we exclude the product "Energy" from the sample. Controlling for the *Energy Inflation* interactions and excluding the product "Energy" alleviates concerns about bias coming from the rise in energy inflation during our sample period, due to manifestation of pent-up demand in 2021 and notably after the Russian invasion of Ukraine in March 2022, which severely affected energy supply to several European countries.

The estimation results in Table 7 present evidence consistent with a generalization of inflation going from markets affected by supply-side constraints to more service-oriented markets, which are less affected, or not affected at all, by these constraints. Specifically, in line with supply chain constraints being passed through to higher consumer prices in the manufacturing sector, the first three rows of Column (1) show that more service-oriented markets have a lower CPI growth than more manufacturing-based markets in the same country. However, the coefficient for the interaction *Service* $\times$ *High Infl Exp* with the year 2022 confirms that the CPI growth of service-oriented markets tends to be higher in 2022 when the inflation expectations significantly increased in the respective country, relative to

[20]We use the BCS classification to identify service sectors and obtain the service sector contribution to consumption from the COICOP-CPA matrix from Cai and Vandyck (2020).

similar markets in countries that experienced a less pronounced increase in inflation expectations. Moreover, the coefficients for *Service* $\times$ *Energy Inflation* interacted with the three post-COVID years in Column (1) of Table 7 indicate that energy prices do not seem to substantially affect the differential CPI growth rates between service- and manufacturing-oriented markets. This observation implies that energy prices are unlikely to be the driver of the spillover and generalization of inflation that we are documenting.

In Columns (2)-(4), we conduct three additional analyses to rule out that the observed generalization of inflation is not merely a result of positive demand shocks. Specifically, in Column (2), we additionally incorporate product-country-time fixed effects, using the 1-digit COICOP level as product category. These fixed effects control for the impact of demand shocks affecting broad product categories. In Column (3), we further control for the country-level severity of lockdown measures in 2021 (using OxCGRT's COVID-19 Stringency Index) as a proxy for pent-up demand for services. Finally, in Column (4), we control for the final consumption expenditure of households at the product-country-time level, employing data from Eurostat at the 2-digit COICOP level. This variable helps control for shifts in demand across different product categories.

Columns (1) and (2) of Table 9 show estimation results in the subsamples of *High Market Power* and *Low Market Power* markets, which consist of industry-country pairs with an above and below median average markup in 2018, respectively.[21] The results show that the generalization into broad-based inflation is driven by markets with high market power. This is consistent with services firms that have pricing power enabling inflation to generalize as they extract higher markups in an environment of heightened household inflation expectations.

[21] For this analysis, we obtain average markups at the industry-country level from the 9th vintage of the CompNet database.

Testing for the influence of labor costs. Another potential concern is that the higher price levels in service-oriented markets in countries with rapidly rising inflation expectations could stem from firms anticipating a steeper rise in labor costs, driven by heightened household inflation expectations and subsequent wage hike demands (e.g., see Reis, 2023). To address this concern, we employ the OECD/AIAS ICTWSS database; specifically, this database includes an adjusted collective bargaining coverage rate, which is defined as the number of employees covered by a collective agreement in force as a proportion of the number of eligible employees equipped (i.e., the total number of employees minus the number of employees legally excluded from the right to bargain).

We then re-estimate Specification (8) separately in the subsample of high collective bargaining countries with a collective bargaining coverage rate above 75% and the subsample of low collective bargaining countries with a coverage rate below this threshold.[22] If the effects in Column (1) of Table 7 are driven by firms' elevated labor costs expectations, the effects should be stronger for countries with a higher share of employees covered by collective bargaining agreements. Columns (3) and (4) of Table 7 report the results for this sample split, showing that the estimated coefficients are similar across both subsamples. This evidence thus suggests that the generalization into broad-based inflation does not seem to be primarily driven by firms anticipating a rise in labor costs.

Controlling for spillovers along the supply chain. Another potential concern is that the observed generalization of inflation from markets directly affected by supply-side constraints to those less impacted is, at least partially, driven by spillover effects along the supply chain. Specifically, disruptions in production among upstream suppliers can cascade down-

[22] We have set the threshold for the sample split to 75% since the distribution of the collective bargaining coverage rate across countries is clustered into two distinct groups as shown in Figure C.4: countries that all have a coverage ratio below 56.9% and countries that all have a coverage ratio above 77.2%.

stream, influencing the prices of final goods sold to consumers. This dynamic might bias our results if more service-oriented product-country pairs tend to be markets that are initially less impacted by supply-side shocks in the early post-COVID period, yet are indirectly affected later due to their reliance on upstream suppliers who experience these shocks.

To ensure our findings are not biased by this dynamic, we expand the analysis from Table 7 by incorporating controls for such supply shock spillovers. To control for spillovers along the supply chain caused by material input disruptions, we add *Material Supply*, which measures the share of suppliers facing material shortages in year t, supplying to firms selling product p in country c in the same year. Column (1) of Table 9 reports our baseline estimation from Table 7. The results in Column (2) indicate that while increased material input constraints among suppliers correlate with higher price growth in the products they supply, the generalization effect remains unchanged, as indicated by the coefficient of *Service* $\times$ *High Infl Exp* $\times$ *2022*.

To control for spillovers along the supply chain caused by energy shocks, we also incorporate the control *Energy Use Supply* $\times$ *Energy Inflation*, which captures the impact of rising energy costs on the production of suppliers. We construct this variable as the product between the energy usage of suppliers and the growth in energy costs. Column (3) shows that the inflation generalization effect to the services sector is also robust to adding this control. In a last step, we incorporate again both supply chain spillover controls, but apply a one-quarter lag to accommodate a potential delay in the transmission of supply shocks through the supply chain. Columns (4) and (5) confirm that the generalization effect is robust to these lagged specifications.

Taken together, this evidence is consistent with inflation caused by supply-side shocks becoming more broad-based with time—shifting in particular from manufacturing to services—through the change in household inflation expectations and firms' optimal pricing response to the resulting lower price elasticity of household demand. As noted earlier, this behavioral response is grounded in theoretical work evaluating the consequences of cost shocks and inflation on search markets (e.g., Benabou and Gertner, 1993; Tommasi, 1994; Gaballo and Paciello, 2022).

	(1)	(2)	(3)	(4)
	CPI Growth	CPI Growth	CPI Growth	CPI Growth
Specification	Full Sample Baseline	Demand 1-Digit	Lockdown Intensity	Household Expenditure
$\text{Service}_{pc} \times 2020$	-0.246	-0.454	0.121	0.047
	(0.669)	(0.517)	(0.704)	(0.616)
$\text{Service}_{pc} \times 2021$	-2.219***	-3.230***	-2.379***	-1.871**
	(0.675)	(0.783)	(0.805)	(0.709)
$\text{Service}_{pc} \times 2022$	-4.709***	-3.874***	-4.933***	-4.789***
	(0.903)	(0.884)	(0.990)	(0.983)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2020$	-1.256	-1.627*	-1.212*	-1.315*
	(0.787)	(0.835)	(0.691)	(0.671)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2021$	0.106	-0.286	0.131	0.394
	(0.734)	(0.976)	(0.732)	(0.725)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2022$	2.675**	2.806**	2.755**	2.779**
	(1.073)	(1.241)	(1.083)	(1.068)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2020$	0.065	0.093	0.049	0.073
	(0.063)	(0.058)	(0.049)	(0.050)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2021$	0.001	0.065	0.004	0.006
	(0.038)	(0.039)	(0.036)	(0.037)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2022$	-0.047	-0.001	-0.041	-0.034
	(0.036)	(0.028)	(0.034)	(0.033)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct}$	0.042	0.004	0.036	0.036
	(0.034)	(0.030)	(0.031)	(0.031)
$\text{Energy Use}_{pc} \times \text{Energy Inflation}_{ct}$	1.467***	1.298***	1.480**	1.476***
	(0.268)	(0.252)	(0.505)	(0.480)
Observations	8,099	7,262	8,051	8,051
R-squared	0.580	0.776	0.579	0.533
Controls				
Other constraints	✓	✓	✓	✓
Other constraints interacted	✓	✓	✓	✓
Lockdown intensity			✓	
Household expenditure				✓
Fixed effects				
Country-time	✓	✓	✓	✓
Product-country	✓	✓	✓	✓
1-digit product-country-time		✓		

Table 7: Pass-through of supply chain constraints to generalized inflation. This table presents estimation results from Specification (8). The subscript notation is defined as follows: p is a product, c is a country, and t is a quarter. The dependent variable is the one-quarter ahead annual CPI growth at the product-country level. *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the country-time level using the share of consumption that each industry contributes to the final household consumption. *Service* is the time-invariant contribution of service sectors to the consumption of product p in country c. *High Infl Exp* is an indicator equal to one if the increase in the share of households expecting that prices will rise more rapidly is above the median in a country between 2021:Q1 and 2022:Q1. In Column (2), we additionally include product-country-time fixed effects, using the 1-digit COICOP level as product category. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) uninteracted and, in addition, these other constraints interacted with the three year dummies. In Column (3), we additionally control for the country-level severity of lockdown measures in 2021, as well as for its double and triple interactions with *Service* and the different year dummies. *Energy Inflation* is the country-time-level CPI index for energy. *Energy Use* is an industry-country pair's energy input before the COVID-19 pandemic, measured in 2019 and scaled by the country's total energy use. We exclude the product "Energy" from the regression. Standard errors are double-clustered at the country-product and quarterly level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1) CPI Growth	(2) CPI Growth	(3) CPI Growth	(4) CPI Growth
Sample	High Market Power	Low Market Power	High Collective Bargaining	Low Collective Bargaining
$\text{Service}_{pc} \times 2020$	-0.728	0.460	-0.581	-0.669
	(1.203)	(0.928)	(0.821)	(1.127)
$\text{Service}_{pc} \times 2021$	-3.156***	-1.389	-1.528**	-2.657**
	(1.173)	(1.149)	(0.747)	(1.082)
$\text{Service}_{pc} \times 2022$	-5.406***	-4.885***	-4.615***	-4.788***
	(1.310)	(1.852)	(1.209)	(1.404)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2020$	0.550	-1.634	-0.221	-2.399
	(1.006)	(1.532)	(0.789)	(2.039)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2021$	1.503	-1.921	-0.568	-0.079
	(1.242)	(1.358)	(0.842)	(1.659)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2022$	4.445**	0.029	2.111*	3.336*
	(1.788)	(1.995)	(1.245)	(2.012)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2020$	0.041	-0.054	0.003	0.236
	(0.103)	(0.108)	(0.077)	(0.320)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2021$	0.020	-0.088	-0.011	0.037
	(0.068)	(0.060)	(0.036)	(0.166)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2022$	-0.065	-0.083	-0.035	-0.012
	(0.067)	(0.057)	(0.034)	(0.165)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct}$	0.061	0.085	0.027	0.028
	(0.061)	(0.054)	(0.031)	(0.162)
$\text{Energy Use}_{pc} \times \text{Energy Inflation}_{ct}$	1.077***	1.437***	1.213***	2.580***
	(0.385)	(0.343)	(0.282)	(0.879)
Observations	3,645	3,430	5,062	3,037
R-squared	0.604	0.630	0.513	0.630
Controls				
Other constraints	✓	✓	✓	✓
Other constraints interacted	✓	✓	✓	✓
Fixed effects				
Country-time	✓	✓	✓	✓
Product-country	✓	✓	✓	✓

Table 8: Pass-through of supply chain constraints to generalized inflation. This table presents estimation results from Specification (8). The subscript notation is defined as follows: p is a product, c is a country, and t is a quarter. The dependent variable is the one-quarter ahead annual CPI growth at the product-country level. *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the country-time level using the share of consumption that each industry contributes to the final household consumption. *Service* is the time-invariant contribution of service sectors to the consumption of product p in country c. *High Infl Exp* is an indicator equal to one if the increase in the share of households expecting that prices will rise more rapidly is above the median in a country between 2021:Q1 and 2022:Q1. *High Market Power* markets are defined as industry-country pairs with an above median average markup. *High Collective Bargaining* countries are countries with a share of employees covered by a collective agreement as a proportion of the number of eligible employees above 75%. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) uninteracted and, in addition, these other constraints interacted with the three year dummies. *Energy Inflation* is the country-time-level CPI index for energy. *Energy Use* is an industry-country pair's energy input before the COVID-19 pandemic, measured in 2019 and scaled by the country's total energy use. We exclude the product "Energy" from the regression. Standard errors are double-clustered at the country-product and quarterly level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1) CPI Growth	(2) CPI Growth	(3) CPI Growth	(4) CPI Growth
	Contemp. Supply	Contemp. Supply	Lagged Supply	Lagged Supply
$\text{Service}_{pc} \times 2020$	-0.330	-0.226	-0.529	-0.473
	(0.774)	(0.765)	(0.733)	(0.727)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2020$	-1.307*	-1.327*	-1.290	-1.307*
	(0.783)	(0.781)	(0.784)	(0.784)
$\text{Service}_{pc} \times 2021$	-0.996	-1.050	-1.254*	-1.279*
	(0.676)	(0.678)	(0.662)	(0.664)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2021$	-0.139	-0.122	-0.108	-0.121
	(0.721)	(0.720)	(0.720)	(0.722)
$\text{Service}_{pc} \times 2022$	-4.361***	-4.374***	-4.630***	-4.641***
	(1.097)	(1.099)	(1.100)	(1.102)
$\text{Service}_{pc} \times \text{High Infl Exp}_c \times 2022$	2.624**	2.610**	2.657**	2.695**
	(1.075)	(1.077)	(1.076)	(1.085)
$\text{Material Supply}_{pct} \times 2020$	-0.001	0.013		
	(0.070)	(0.070)		
$\text{Material Supply}_{pct} \times 2021$	0.127***	0.123***		
	(0.025)	(0.025)		
$\text{Material Supply}_{pct} \times 2022$	0.030	0.029		
	(0.036)	(0.037)		
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct}$	0.035	0.033	0.034	0.031
	(0.033)	(0.033)	(0.033)	(0.034)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2020$	0.062	0.133*	0.059	0.087
	(0.063)	(0.074)	(0.063)	(0.065)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2021$	0.029	0.035	0.033	0.039
	(0.038)	(0.042)	(0.038)	(0.040)
$\text{Service}_{pc} \times \text{Energy Inflation}_{ct} \times 2022$	-0.038	-0.036	-0.037	-0.032
	(0.036)	(0.038)	(0.036)	(0.036)
$\text{Energy Use}_{pc} \times \text{Energy Inflation}_{ct}$	1.479***	1.293**	1.472***	1.275***
	(0.270)	(0.562)	(0.270)	(0.361)
$\text{Energy Use Supply}_{pc} \times \text{Energy Inflation}_{ct} \times 2020$		8.181**		
		(3.634)		
$\text{Energy Use Supply}_{pc} \times \text{Energy Inflation}_{ct} \times 2021$		0.682		
		(1.660)		
$\text{Energy Use Supply}_{pc} \times \text{Energy Inflation}_{ct} \times 2022$		0.087		
		(1.441)		
$\text{Material Supply}_{pct-1} \times 2020$			-0.055	-0.043
			(0.058)	(0.058)
$\text{Material Supply}_{pct-1} \times 2021$			0.140***	0.138***
			(0.027)	(0.027)
$\text{Material Supply}_{pct-1} \times 2022$			0.011	0.009
			(0.035)	(0.035)
$\text{Energy Use Supply}_{pc} \times \text{Energy Inflation}_{ct-1} \times 2020$				4.652
				(2.944)
$\text{Energy Use Supply}_{pc} \times \text{Energy Inflation}_{ct-1} \times 2021$				0.981
				(1.521)
$\text{Energy Use Supply}_{pc} \times \text{Energy Inflation}_{ct-1} \times 2022$				0.596
				(1.082)
Observations	8,099	8,099	8,099	8,099
R-squared	0.583	0.584	0.582	0.583
Fixed effects				
Country-time	✓	✓	✓	✓
Product-country	✓	✓	✓	✓

Table 9: Pass-through of supply chain constraints to generalized inflation with controls for spillovers along the supply chain. This table extends the analysis from Table 7 by incorporating controls for supply chain spillovers. Column (1) introduces interactions with *Material Supply*, which measures the share of firms that indicate that their production is constrained by material input constraints in year t among the suppliers that provide input goods to firms that sell product p in country c in year t. Column (2) further includes controls for the energy cost exposure in year t of the suppliers that provide input goods to firms that sell product p in country c in year t. Columns (3) and (4) replicate the analysis of Columns (1) and (2), respectively, but with variables lagged by one year. Standard errors are double-clustered at the country-product and quarterly level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5 The role of firm pricing power and behavior

Building on the evidence in the previous sections, we zoom in on the role of firm pricing power and behavior (i) for the pass-through of supply chain constraints to price levels, as well as (ii) for the entrenchment and generalization of inflationary impulses amid persistently high inflation expectations. To this end, we present a set of parametric tests at the firm-time level consistent with supply constraints and higher inflation expectations allowing firms with pricing power to charge higher markups. Specifically, in Section 5.1, we show that these firms were more likely to maintain, or even increase, their markups when facing supply chain constraints. In Section 5.2, we show that even after supply chain pressures eased, firms with pricing power were able to sustain relatively higher markups when they operated in a country with elevated inflation expectations in services as well as in manufacturing, i.e., irrespective of whether they are active in markets affected by supply chain constraints.

5.1 Supply-side constraints and firm pricing behavior

For our firm-level analysis on the interaction between supply-side constraints, pricing power, and firms' price-setting behavior, we use data from Compustat Global and the following triple-interaction specification at the firm-quarter level:

$$
\begin{aligned}
Markup_{it+1} = & \sum_{\tau=20,21,22} \boldsymbol{\beta_{1\tau}} Markup_i^{2018} \times Constraints_{jct} \times Year_\tau \\
& + \beta_2 Markup_i^{2018} \times Constraints_{jct} \\
& + \sum_{\tau=20,21,22} \beta_{3\tau} Markup_i^{2018} \times Year_\tau + \beta_6 Markup_i^{2018} + \xi_{jct} + \epsilon_{it}, \qquad (9)
\end{aligned}
$$

where i is a firm, t is a quarter, c is a country, and j is an industry. We estimate firm markups following De Loecker et al. (2020), which relies on the insight that the output elasticity of a variable production factor is only equal to its expenditure share in total revenue when price equals marginal cost of production. Under any form of imperfect competition, however, the relevant markup drives a wedge between the input's revenue share and its output elasticity.

$Markup_i^{2018}$ is the firm-level markup measured at the end of 2018 and $Constraints_{jct}$ refers to either the material constraint, the labor constraint, or the combination of both measured at the industry-country-quarter level. *Year* is a set of dummy variables for 2020 (from Q2 onwards), 2021, and 2022 (2019 is the base year). Finally, we include industry-country-time fixed effects to absorb any time varying shocks to an industry-country pair.

The first column of Table 10 shows the estimation results in the subsample of manufacturing firms, namely those mostly affected by supply chain constraints, especially in 2021. There are three main takeaways. First, in industry-country pairs where we do not observe a surge in supply-side constraints to production, higher ex-ante markups (i.e., ex-ante higher pricing power) are associated with a larger *drop* in markups during the pandemic period. That is, high pricing power firms were not able to sustain their markups if they did not face supply constraints, and, as a result, experienced a profit margin reduction. Second, higher ex-ante pricing-power allows firms to sustain higher markups during the pandemic period, in particular in 2021 and 2022, only if their sector faces more severe supply chain constraints. Third, given the first two observations, the influence of pricing power on the effect of supply chain constraints on markups during the pandemic period depends on how binding the constraints are in the respective industry-country pair.

Specifically, in Column (1) the threshold value for the *Material* variable above which ex-ante higher pricing power leads to higher markups for a higher level of supply chain pressure is equal to 35.5 in 2021 (=0.142/0.004), well above the median of *Material* (its mean is 28.8). Firms with higher ex-ante pricing power in industry-country pairs that experienced supply chain pressures above this threshold value were able to raise their markups more than firms with ex-ante lower pricing power. Conversely, firms with higher ex-ante markups in industry-country pairs that experienced supply chain pressures below this threshold value

	(1) Markup	(2) Markup	(3) Markup	(4) Markup	(5) Markup	(6) Markup
Sample	Manufacturing	Services	All	Manufacturing	Services	All
$\text{Material}_{jct} \times \text{Markup}_i^{2018}$	-0.003**			-0.003***		-0.003***
	(0.001)			(0.001)		(0.001)
$\text{Markup}_i^{2018} \times 2020$	-0.111***	-0.111	-0.084***	-0.126***	-0.107	-0.141***
	(0.037)	(0.074)	(0.031)	(0.037)	(0.126)	(0.051)
$\text{Markup}_i^{2018} \times 2021$	-0.142**	-0.089	-0.089*	-0.170**	-0.154	-0.154
	(0.062)	(0.130)	(0.046)	(0.076)	(0.189)	(0.112)
$\text{Markup}_i^{2018} \times 2022$	-0.192**	-0.126	-0.164***	-0.327***	-0.282*	-0.290**
	(0.092)	(0.107)	(0.049)	(0.108)	(0.165)	(0.121)
$\text{Material}_{jct} \times \text{Markup}_i \times 2020$	0.001			0.001		0.001
	(0.001)			(0.001)		(0.001)
$\text{Material}_{jct} \times \text{Markup}_i^{2018} \times 2021$	0.004**			0.004***		0.004***
	(0.002)			(0.001)		(0.001)
$\text{Material}_{jct} \times \text{Markup}_i \times 2022$	0.003*			0.005***		0.005***
	(0.002)			(0.001)		(0.001)
$\text{Labor}_{jct} \times \text{Markup}_i^{2018}$		-0.004**			-0.003	0.001
		(0.002)			(0.002)	(0.001)
$\text{Labor}_{jct} \times \text{Markup}_i^{2018} \times 2020$		0.001			0.001	0.001
		(0.002)			(0.003)	(0.002)
$\text{Labor}_{jct} \times \text{Markup}_i^{2018} \times 2021$		0.001			0.001	-0.001
		(0.002)			(0.003)	(0.003)
$\text{Labor}_{jct} \times \text{Markup}_i \times 2022$		0.002			0.004	-0.001
		(0.002)			(0.003)	(0.002)
$\text{High Infl Exp}_c \times \text{Markup}_i^{2018}$			0.150***	0.129**	0.098	0.141***
			(0.051)	(0.056)	(0.095)	(0.052)
$\text{High Infl Exp}_c \times \text{Markup}_i^{2018} \times 2020$			0.017	0.056	0.004	0.070
			(0.059)	(0.076)	(0.123)	(0.075)
$\text{High Infl Exp}_c \times \text{Markup}_i^{2018} \times 2021$			0.066	0.074	0.135	0.068
			(0.058)	(0.073)	(0.161)	(0.083)
$\text{High Infl Exp}_c \times \text{Markup}_i^{2018} \times 2022$			0.118**	0.176**	0.207*	0.161**
			(0.057)	(0.081)	(0.125)	(0.079)
Markup^{2018}	0.902***	0.943***	0.797***	0.855***	0.883***	0.827***
	(0.033)	(0.069)	(0.033)	(0.029)	(0.109)	(0.034)
Observations	12,420	6,420	18,840	12,420	6,420	12,420
R-squared	0.797	0.619	0.765	0.800	0.621	0.801
Fixed effects						
Industry-country-time	✓	✓	✓	✓	✓	✓

Table 10: Supply-side constraints and firm markups. This table presents estimation results from Specifications (9) and (10). The subscript notation is defined as follows: i is a firm, j is an industry, c is a country, and t is a quarter. The dependent variable is a firm's markup, which we estimate following De Loecker et al. (2020). *Material* and *Labor* measure the share of firms that indicate that their production is constrained by supply chain problems and by labor shortages at the industry-country-time level, respectively. $Markup^{2018}$ measures a firm's markup in the fiscal year 2018. *High Infl Exp* is a dummy equal to one if the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months has increased above the median level in a country between 2021:Q1 and 2022:Q1. Columns (4) and (6) are estimated in the full sample. Columns (1) and (3) are estimated in the sample of manufacturing firms. Columns (2) and (5) are estimated in the sample of firms operating in services. All specifications include industry-country-quarter year fixed effects. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

were less able to maintain their markups compared to firms with lower ex-ante markups.[23] The timing of these results aligns well with the strong surge in the reported supply chain constraints in 2021 (see the first panel of Figure 2).

We can rationalize these results as follows. The production bottleneck for firms in industry-country pairs with a low level of supply chain constraints was likely a lack in demand. As a result, firms in these industries had to be more accommodating in their pricing policy, which is especially true for firms that enjoyed high pricing power and thus high markups before the COVID-19 shock. In contrast, in industry-country pairs that experienced material supply chain constraints, firms with high pricing power were able to maintain or even increase their markups, in addition to passing-through eventual input cost increases.

Moreover, Column (2) shows the estimation results in the subsample of firms operating in the services sector, namely those relatively unaffected by supply chain constraints, but somewhat more affected by labor constraints. For this subsample, we substitute the supply chain constraint variable (*Material*) with the labor constraint variable (*Labor*). We do not observe a cost-push pass-through of labor costs to inflation for services.

We interpret these findings aas evidence that the pass-through of supply chain constraints to inflation can be influenced by firms' pricing power. Firms with higher ex-ante pricing power were more likely to be able to maintain, or even increase, their markups when facing supply-side constraints to production (resulting in constrained aggregate supply). In industry-country pairs with well-functioning supply chains (resulting in unconstrained aggregate supply), firms with higher ex-ante pricing power experienced a stronger reduction in markups. Firms with pricing power, therefore, seem to better pass on increased production

[23]Interestingly, in a context where material input costs are increasing, even simply maintaining the same markup suggests that these firms were able to enhance their gross margins in absolute terms—and consequently, their absolute profits—per unit sold. Markups are defined as the ratio of price to marginal costs. Take, for instance, an initial markup of 1.5. If marginal costs rise from 1 to 2 due to supply-side shocks, the per-unit gross margin in absolute terms then grows from 0.5 ($= 1.5 \times 1 - 1$) to 1 ($= 1.5 \times 2 - 2$).

costs to their customers.

5.2 Household inflation expectations and firm pricing behavior

Next, we show that firms with pricing power were more likely to maintain, or even increase, their markups in an environment with elevated inflation expectations, irrespective of whether they are affected by supply-side constraints. In other words, firms' pricing power interacts with inflation expectations to generalize inflation beyond sectors originally affected by supply chain constraints. To this end, we investigate the relationship between firms' markups and households' inflation expectations employing the following specification:

$$\begin{aligned} Markup_{it+1} = & \sum_{\tau=20,21,22} \boldsymbol{\beta_{1\tau}} Markup_i^{2018} \times Material_{jct} \times Year_\tau \\ & + \sum_{\tau=20,21,22} \boldsymbol{\beta_{2\tau}} Markup_i^{2018} \times HH\ Infl\ Exp_{ct} \times Year_\tau \\ & + \beta_3 Markup_i^{2018} \times Material_{jct} + \beta_4 Markup_i^{2018} \times HH\ Infl\ Exp_{ct} \\ & + \sum_{\tau=20,21,22} \beta_{5\tau} Markup_i^{2018} \times Year_\tau + \beta_6 Markup_i^{2018} + \xi_{jct} + \epsilon_{it}, \end{aligned} \tag{10}$$

which largely follows Specification (9). In addition, however, we now include interactions with *HH Infl Exp*, which is a dummy equal to one if the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months has increased above the median level in a country between 2021:Q1 and 2022:Q1.

Column (3) in Table 10 shows the estimation results for the full firm sample. These results show the positive association between household inflation expectations and markups in 2022 for firms with higher ex-ante pricing power (i.e., higher pre-pandemic markups). Column (4) shows that this correlation is also present in the subsample of manufacturing firms. Column (5) replicates Column (2) for the services firms, again adding the interaction between firm pricing power and the country-level growth in inflation expectations. Specifically, there is no cost-push for labor constraints in services sector, but services firms with high pricing power ($Markup_i^{2018}$) are able to maintain relatively higher markups in countries with high inflation expectations, and especially so in 2022. Column (6) is estimated in the full sample, confirming again that firms with pricing power were better able to pass-through their increased costs to prices in the initial cost-push phase and, crucially, also during the subsequent emergence of generalized inflation due to elevated inflation expectations.[24]

Finally, we test the theoretical prediction that an elevated price variability, which depreciates information that current relative prices convey about future ones, combined with elevated household inflation expectations, lowers households' perceived value of obtaining more price information, which in turn allows firms to charge higher markups (Tommasi, 1994). To measure the change in the price variability within each consumer product category (i.e., 2-digit COICOP), we calculate the change in the variation of prices of consumer products in the respective subcategories (i.e., 3-digit COICOP) in the early stage of the pandemic (i.e., 2020:Q2 to 2021:Q2).

We report the results for this test in Table 11. Column (1) confirms the earlier result that firms with higher market power are indeed better able to raise markups in response to elevated household inflation expectations in 2022. The results in Column (2) to (4) indicate that this effect is driven by markets with a higher price variability across products, and observable in *both* manufacturing and service sectors.

To summarize, the combination of high inflation expectations and firms' pricing power can entrench inflation arising from supply-side shocks by generalizing it to all sectors of the

[24]These results are in line with Konczal et al. (2022), which analyzes data on profit margins in the U.S. supporting both demand and supply explanations for high inflation and finds evidence that pricing power has also been a factor as many firms have substantially increased markups in 2021. The authors extend the analysis of De Loecker et al. (2020) and find that 2021 had the highest markups on record and the largest annual increase between 1955 and 2021. Interestingly, the analysis suggests that firms that increased markups the most were those with the higher markups prior to the economic shocks.

	(1)	(2)	(3)	(4)
	Markup	Markup	Markup	Markup
Sample	Full	Full	Manufacturing	Service
High Infl Exp$_c$ × $Markup_i^{2018}$	0.006**	0.006*	0.007**	0.002
	(0.003)	(0.003)	(0.004)	(0.004)
High Infl Exp$_c$ × $Markup_i^{2018}$ × SD(Price Growth)$_{jc}$		3.664***	5.299**	3.420**
		(1.299)	(2.333)	(1.556)
Observations	4,371	3,591	2,231	1,360
R-squared	0.732	0.729	0.768	0.596
Fixed effects				
Industry-country-time	✓	✓	✓	✓

Table 11: Household inflation expectations, price variability, and firm markups. The subscript notation is defined as follows: i is a firm, j is an industry, c is a country, and t is a quarter. The dependent variable is a firm's markup, which we estimate following De Loecker et al. (2020). *High Infl Exp* is a dummy equal to one if the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months has increased above the median level in a country between 2021:Q1 and 2022:Q1. $Markup^{2018}$ measures a firm's markup in the fiscal year 2018. *SD(Price Growth)* is the standard deviation in the prices within each consumer product category (i.e., 2-digit COICOP) in the early stage of the pandemic (i.e., 2020:Q2 to 2021:Q2) at the industry-country level. Columns (1) and (2) include the full sample of firms in Compustat for which markups can be estimated. Column (3) focuses on firms operating in manufacturing industries, whereas Column (4) shows results for service sectors. All specifications include industry-country-quarter year fixed effects. All specifications include industry-country-quarter year fixed effects. Standard errors are clustered at the industry-country level and reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

economy. Their interaction can create a feedback loop. Firms with pricing power raise prices, leading to higher inflation expectations among households, which, in turn, lead to further price increases by firms with pricing power (including firms that did not participate in the first-round price hikes). What starts as localized inflation in specific sectors or products can thus generalize into broad-based inflation that can persist even after the initial shocks have subsided.

6 Conclusion

The post-pandemic era witnessed supply-side shocks that, combined with a swift economic recovery, resulted in a dramatic rise in inflation rates, levels which had not been observed in many decades. In this paper, we document complex interactions between supply chain pressures, firm pricing power, and household inflation expectations in contributing to the surge, generalization, and persistence of post-pandemic inflation in the euro area.

We find that in 2021, disruptions in the supply chain not only drove inflation upwards through a cost-push mechanism but also elevated household inflation expectations. The influence of market power exacerbated this cost-push effect as firms with pricing power could sustain or even enhance their profit margins. In 2022, high-pricing power firms further increased their markups in response to heightened household inflation expectations, but this effect prevailed not just in the initially-affected manufacturing sectors but also in the services sectors. These mechanisms together generated a lagged and persistent impact of initial localized shocks into wholesale price inflation and eventually into broad-based consumer price inflation. Overall, our findings suggest that supply-side inflation impulses can generalize and spiral upwards, via an interaction of firms' pricing power and household expectations.

From a policy perspective, three main implications emerge. First, "see through the shock" policy approaches may need to take into account the possibility of persistent and intertwined inflationary pressures. Policymakers may need to be prepared to act decisively to adjust the monetary policy stance if inflation expectations show the first signs of becoming unanchored. Second, the ability of firms with substantial pricing power to capitalize on supply chain disruptions and elevated inflation expectations can be considered as an empirically tangible version of "greedflation". This implication provides support for measures that promote competition, thereby curbing the inflationary tendencies of dominant market players. Third, transparent communication about the nature (for instance, magnitude and longevity) of supply-side shocks by policymakers as well as their commitment to price stability can help prevent a self-fulfilling prophecy where unanchored expectations drive up actual inflation.

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Appendix

B Additional Tables

	(1) CPI Growth	(2) CPI Growth	(3) CPI Growth	(4) CPI Growth	(5) CPI Growth	(6) CPI Growth
Material Supply$_{pct}$ x Covid$_t$	0.277***	0.272***				
	(0.072)	(0.069)				
Material Supply$_{pct}$ x 2020			0.266***	0.270***	0.270***	0.248***
			(0.065)	(0.065)	(0.066)	(0.078)
Material Supply$_{pct}$ x 2021			0.282***	0.276***	0.276***	0.286***
			(0.083)	(0.081)	(0.081)	(0.083)
Material Supply$_{pct}$ x 2022			0.284***	0.270***	0.270***	0.277***
			(0.084)	(0.081)	(0.081)	(0.084)
Financial Supply$_{pct}$ x 2020						-0.036
						(0.063)
Financial Supply$_{pct}$ x 2021						0.022
						(0.055)
Financial Supply$_{pct}$ x 2022						-0.138
						(0.095)
Labor Supply$_{pct}$ x 2020						0.052
						(0.078)
Labor Supply$_{pct}$ x 2021						-0.055
						(0.036)
Labor Supply$_{pct}$ x 2022						-0.054
						(0.057)
Other Supply$_{pct}$ x 2020						0.013
						(0.030)
Other Supply$_{pct}$ x 2021						-0.006
						(0.032)
Other Supply$_{pct}$ x 2022						0.045
						(0.041)
Energy Use$_{pc}$ x Energy CPI$_{ct}$		1.420**		1.422**	1.423***	1.429***
		(0.485)		(0.485)	(0.479)	(0.481)
Observations	9,187	9,187	9,187	9,187	9,187	9,187
R-squared	0.537	0.545	0.537	0.545	0.545	0.546
Controls						
Other constraints					✓	✓
Fixed effects						
Country-time	✓	✓	✓	✓	✓	✓
Product-country	✓	✓	✓	✓	✓	✓

Table B.1: Supply chain constraint pass-through to CPI. This table presents estimation results from Specification (1) in Column (1)-(2) and Specification (2) in Columns (3)-(6). The subscript notation is defined as follows: p is a product, c is a country, and t is a quarter. The dependent variable is the one-quarter ahead annual CPI growth at the product-country-time level. *Covid* is a dummy equal to one for the period after the start of the COVID-19 pandemic (i.e., after and including 2020:Q2) and zero otherwise. *Material Supply*, *Labor Supply*, *Financial Supply*, and *Other Supply* measure the share of firms that indicate that their production is constrained by the respective input constraint in year t among the suppliers that provide input goods to firms that sell product p in country c in year t. All constraints are transformed from the industry-country-time level to the product-country-time level using an input-output table and the share of consumption that each industry contributes to the final household consumption of a particular product. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) uninteracted in Column (5). *Energy Inflation* is the country-time-level CPI index for energy. *Energy Use* is a product-country pair's energy input before the COVID-19 pandemic, measured in 2019 and scaled by the country's total energy use. We exclude the product "Energy" from the regression. Standard errors are double-clustered at the country-product and quarterly level and are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

	(1)	(2)	(3)	(4)
	$\hat{\pi}^e_{ht}$	$\hat{\pi}^e_{ht}$	$\hat{\pi}^e_{ht}$	$\hat{\pi}^e_{ht}$
Accurate_h x Search_{ct} x Material_{ct}	1.341***	1.308***	2.227***	1.493***
	(0.225)	(0.220)	(0.295)	(0.222)
Material_{ct} x Accurate_h	0.140	0.514***	-0.497***	0.368***
	(0.119)	(0.120)	(0.173)	(0.121)
Accurate_h x Search_{ct}	-0.293***	-0.163***	-0.089*	-0.147***
	(0.047)	(0.042)	(0.054)	(0.044)
Accurate_h x Food Inflation_{ct}	0.542***		1.963***	
	(0.115)		(0.673)	
Accurate_h x Food Inflation_{ct} x Search_{ct}			-2.096*	
			(1.191)	
Accurate_h x Energy Inflation_{ct}	0.186***		0.262**	
	(0.022)		(0.133)	
Accurate_h x Energy Inflation_{ct} x Search_{ct}			-0.085	
			(0.228)	
Accurate_h x Core Inflation_{ct}	2.560***		8.960***	
	(0.365)		(1.752)	
Accurate_h x Core Inflation_{ct} x Search_{ct}			-11.845***	
			(3.156)	
Perceived (realized) inflation_{ht}		0.900***		1.555***
		(0.035)		(0.151)
Accurate_h x Perceived (realized) inflation_{ht}		-0.126**		0.516**
		(0.052)		(0.250)
Perceived (realized) inflation_{ht} x Search_{ct}				-1.179***
				(0.262)
Accurate_h x Perceived (realized) inflation_{ht} x Search_{ct}				-0.957**
				(0.415)
Observations	103,088	103,088	103,088	103,088
R-squared	0.549	0.556	0.549	0.556
Controls				
Other constraints	✓		✓	✓
Fixed effects				
Country-time		✓		
Household	✓	✓	✓	✓

Table B.2: Supply chain constraint pass-through to household inflation expectations: Interactions with household characteristics. This table presents estimation results from an adjusted version of Specification (7). The subscript notation is defined as follows: h is a household, c is a country, and t is a quarter. The dependent variable is a household-time-level dummy equal to one if household h believes prices will increase a lot over the next 12 month. *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint. All constraints are transformed from the industry-country-time level to the country-time level using the share of consumption that each industry contributes to the final household consumption. *Accurate* is a dummy equal to one for households with an above median within household correlation between realized inflation over the last 12 months and the household's inflation estimate for the last 12 months. *Search* is a country-time-level variable measuring the intensity of Google searches for "delays in shipping" (in the respective country's language). Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) in Columns (1), (3), and (4). *Food Inflation*, *Energy Inflation*, and *Core Inflation* are the country-time-level CPI indices for food, energy, and core, respectively. *Perceived (realized) Inflation* is household h's perception about the inflation over the last 12 months. Standard errors are clustered at the country-demographics level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

C Additional Figures

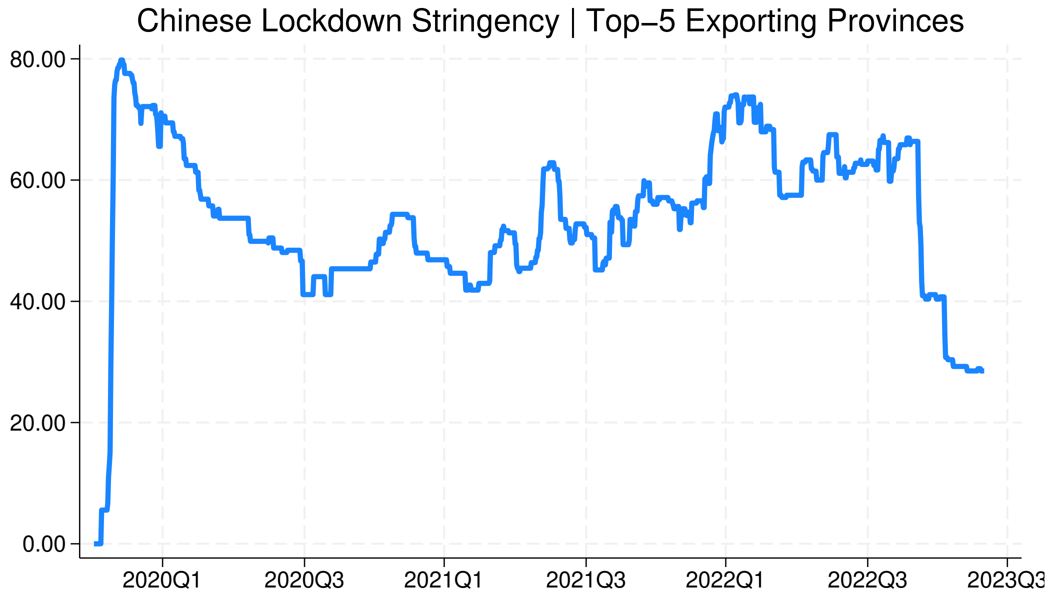

Figure C.1: Chinese lockdown stringency index. This figure shows the time-series evolution of the aggregate stringency index of the top-5 exporting provinces in China.

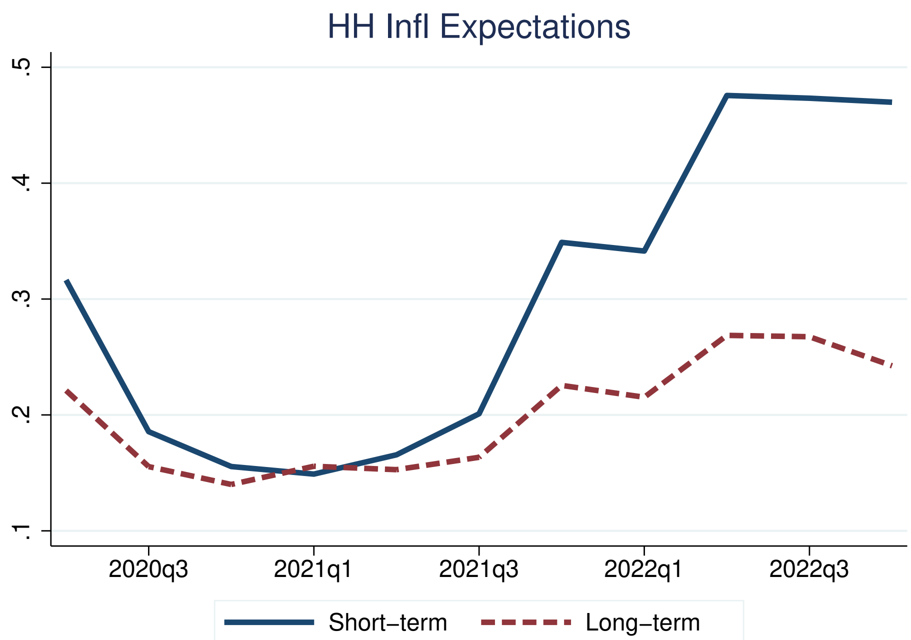

Figure C.2: Short-term and long-term household inflation expectations. The figure plots the averages of household-time-level dummies equal to one if household h believes prices will increase a lot over the next 12 month (short-term expectations; blue line) and equal to one if household h believes prices will increase a lot over the 12-month period between current year+2 and current year+3 (long-term expectations; dotted red line).

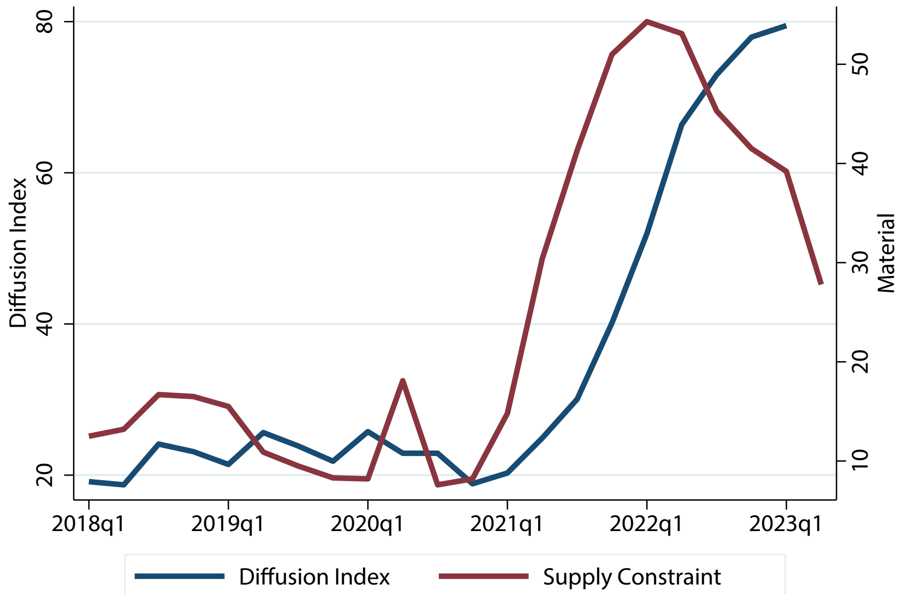

Figure C.3: Diffusion index vs. material shortages. This figure shows the time-series evolution of an inflation diffusion index (blue line) and the time-series evolution of the supply chain constraint (red line). The diffusion index is defined by assigning a value of 0 to product-quarters that have an annual inflation of less than 2%, a value of 50 to product-quarters with an annual inflation between 2% and 4%, and a value of 100 to product-quarters with an annual inflation of more than 4%.

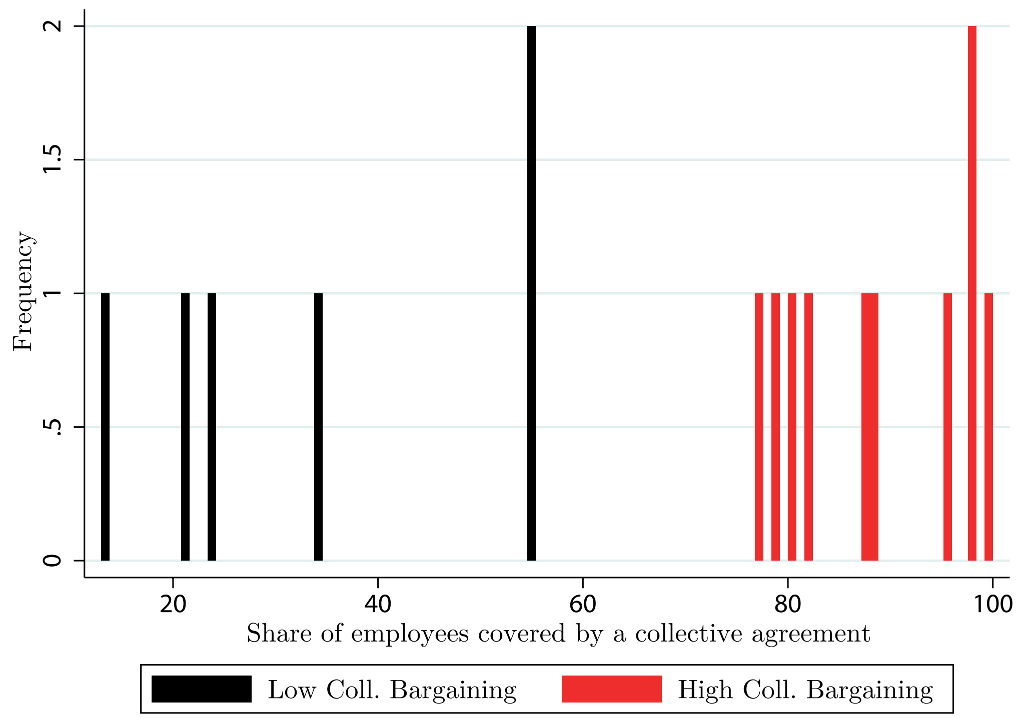

Figure C.4: Share of employees covered by a collective agreement. This figure shows the distribution of the adjusted collective bargaining coverage rate from the OECD/AIAS ICTWSS database for our sample countries. This coverage rate is defined as the number of employees covered by a collective agreement in force as a proportion of the number of eligible employees equipped (i.e., the total number of employees minus the number of employees legally excluded from the right to bargain).