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 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. 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, as evidenced by the increasing share of firms reporting material input and labor constraints to their production. 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.

In this paper, we show how supply-chain pressures, household inflation expectations, and firm pricing power interacted, fueling the pandemic-era surge 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 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 show that localized supply-chain constraints also led to an increase in *generalized inflation expectations* and, consequently, generalized inflation—a pass-through particularly pronounced where firms had high pricing power. These firms (i) were more likely to maintain, or

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

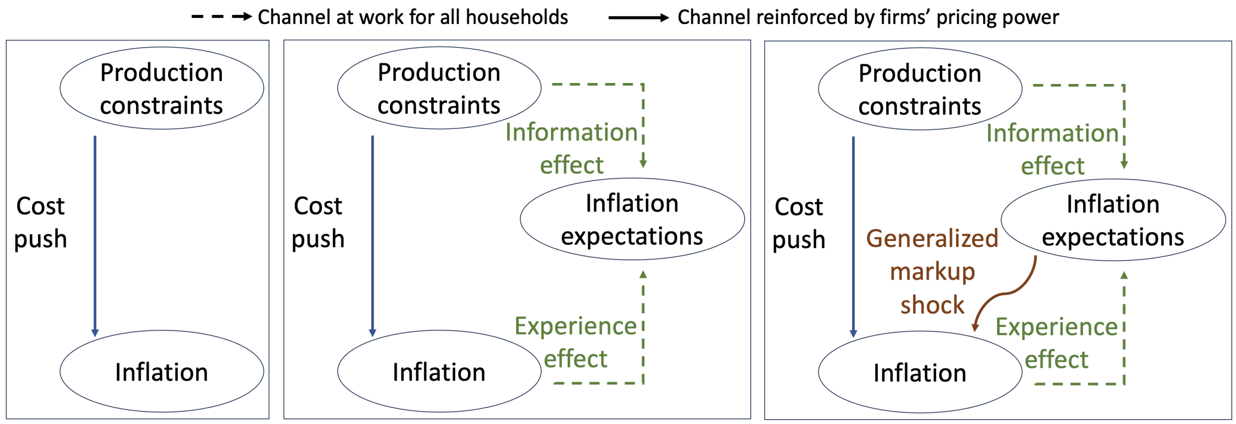

Figure 1: From supply-chain constraints and localized inflation to high inflation expectations and generalized inflation. This figure shows the main channels at the core of our hypotheses. The left panel shows how production constraints might affect inflation through a cost-push channel. The middle panel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

even increase, their markups when facing supply-chain constraints and high demand, and (ii) were more likely to sustain relatively higher markups when generalized inflation expectations became elevated and sticky, even after supply-chain pressures eventually eased.

Our empirical tests help understand the mechanisms via which supply-side shocks, such as global value-chain interruptions, can contribute to generalized inflation through their effects on household 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 (*information channel*), households might revise their inflation expectations, anticipating a rise in *aggregate prices*.

In an environment characterized by heightened inflation expectations and aggregate cost and price uncertainty, however, 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 results 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.

Ultimately, 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.

To conduct our tests, we combine several data sets at various units of observations. At the industry-country 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 PPI data from Eurostat. At the country and at the household level, we observe inflation expectations from the BCS and the ECB Consumer Expectations Survey (CES), respectively. At the product-country level, we observe CPI data from Eurostat. Finally, at the firm level, we observe financial data from Compustat Global, which we use to estimate firm markups.

The analysis is structured in five 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-level data on lockdown stringency. We find similar evidence for PPI growth, this time estimating a regression at the industry-country level. We employ granular energy consumption data to isolate 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 expectations. 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 and (ii) individual household inflation expectations. We further substantiate the causal link between supply-chain disruptions and rising household inflation expectations with the IV estimation described above. The household-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, lending support for both the experience and the information 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. In particular, we document that in countries with more pronounced aggregate supply-chain constraints, products not significantly affected by these constraints exhibit higher relative CPI growth in 2021-22 compared to similar products in countries with less severe supply-chain disruptions. This effect (i) is driven by countries whose households have elevated inflation expectations and (ii) is present in both countries with a high and low share of employees covered by a collective bargaining agreement, suggesting that inflation does not seem to be primarily driven by firms anticipating a rise in labor costs. Moreover, a horse race analysis does not support the notion that recent energy cost shocks have similarly generalized into broad-based inflation in the European economy's post-COVID landscape.

Fourth, we show that 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 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 and even after these constraints eventually subsided. 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.

Our results 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 temporary in nature. The conventional monetary policy response to a temporary 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, expectations help pull inflation back towards target levels, making most inflation shocks short-lived. If expectations become unanchored, e.g., because localized supply-shocks generalize into broad-based inflation as we document, then supply-side shocks may disproportionately and persistently drive up actual inflation. Such generalization can be further exacerbated by its interaction with firm pricing power, necessitating a proactive monetary policy response to supply-side shocks.

The remainder of the paper is structured as follows. Section 2 discusses how our analysis contributes to the existing literature. Section 3 lists our data sources and presents our data construction. Section 4 presents a few empirical facts on the evolution of realized inflation, inflation expectations, and production constraints in 2019-2022, and discusses five hypotheses that we test in the rest of the paper. Section 5 shows that production constraints induced an increase in localized inflation, an increase in generalized inflation expectations, and eventually an increase in generalized inflation. Section 6 presents evidence consistent with supply constraints and higher inflation expectations allowing firms with pricing power to charge higher markups. Section 7 concludes.

2 Related literature

The literature on supply-side factors and their connection to inflation and inflation expectations covers several interconnected areas of research, such as (i) the effect of supply shocks on producer and consumer 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 and bottlenecks 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 outcomes, particularly in the U.S. and the euro area.

A growing body of country-specific research has also focused on the effects of supply-side factors on inflation. In the U.S., Isaacson and Rubinton (2022) and Amiti et al. (2022) explore the role of shipping costs, import prices, and labor supply constraints in driving inflation. Ball et al. (2022) explains the rise in U.S. inflation with tightening of the labor market, increases in energy prices, and supply-chain problems. Bernanke and Blanchard (2023) also finds that most of the U.S. inflation surge that began in 2021 was caused by shocks to prices given wages (shocks being sharp increases in commodity prices and sectoral shortages). Comin et al. (2023) finds that binding capacity constraints explain half of the increase in U.S. inflation during 2021-2022. In the euro area, Finck and Tillmann (2022) and Kuehl et al. (2022) analyze the effect of global supply-chain shocks on economic activity and inflation. Celasun et al. (2022) and Binici et al. (2022) study the effects of supply bottlenecks and global factors on manufacturing output, GDP, and inflation in Europe.[2]

More closely related to our paper, Franzoni et al. (2023) provides evidence that supply-chain constraints lead to a decrease in competition, showing that these 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 cost-push 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.

One of the strongest predictor of agents' inflation forecast is what they believe inflation has been over the recent past, which is true for both households (see Ranyard et al., 2008 for a literature survey) and firms (e.g., Coibion et al., 2018; Kumar et al., 2015). The

[2]A related stream of literature delves into the transmission of shocks through the production network. Smets et al. (2019) finds that price stickiness and sectoral shocks play a crucial role in understanding headline/disaggregated inflation. Auer et al. (2019) emphasizes the importance of international input-output linkages in synchronizing PPI across countries. Wei and Xie (2022) documents a decreasing correlation between CPI and PPI and proposes a model based on expanding global supply-chains to understand this divergence.

economic environment that agents have experienced can shape their attentiveness and views in long-lasting ways. Households and firms in high-inflation countries tend to be much better informed than households and firms in low-inflation countries about inflation (Bracha and Tang, 2022; Korenok et al., 2022; Pfäuti, 2022; Weber et al., 2023; Cavallo et al., 2017; Frache and Lluberas, 2018; Coibion and Gorodnichenko, 2015a), and people who lived through high inflation have systematically higher inflation expectations and stronger aversion for inflation than people who did not share this experience (Ehrmann and Tzamourani, 2012; Malmendier and Nagel, 2016).

At the same time, households' and firms' adjustment of beliefs to new information seems to be consistent with Bayesian updating (Armantier et al., 2016; Cavallo et al., 2017; Binder and Rodrigue, 2018; Coibion et al., 2018). An important source of signals about inflation for households and firms is the prices that they regularly observe (i.e., "easy-to-collect" prices), especially oil and food prices (Bryan and Venkatu, 2001; D'Acunto et al., 2019; Cavallo et al., 2017; D'Acunto et al., 2021 Coibion and Gorodnichenko, 2015b; Harris et al., 2009; Kumar et al., 2015; Wong, 2015; Clark and Davig, 2008; Coibion and Gorodnichenko, 2015a). Given the variation in consumption patterns, expected inflation can thus vary widely across households (e.g., Coibion et al., 2015; Kaplan and Schulhofer-Wohl, 2017; Johannsen, 2014). For the pandemic era, Coibion et al. (2022) analyzes U.S. households' inflation expectations noting increased disagreement and varied experiences by demographic variation, which aligns with a view that supply-side frictions and their effect on prices during the pandemic affected inflation experience and expectations. Besides observed price signals, media coverage of inflation also has an important influence on inflation expectations (Carroll, 2003; Dräger, 2015; Pfajfar and Santoro, 2010; Dräger and Lamla, 2017; Lamla and Maag, 2012; Larsen et al., 2021; Kumar et al., 2015; Mazumder, 2021).

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 little 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.[3]

Our paper contributes to the literature on inflation expectations by providing further evidence on the transmission of supply-side shocks into elevated inflation expectations. Moreover, we spotlight a novel mechanism through which an unanchoring of inflation expectations affects firms' optimal price-setting and, in turn, inflation.

3 Data

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 level*, (ii) household inflation expectations at the *country level* and *household level*, (iii) PPI and CPI growth at the *industry-country level* and *product-country level*, respectively, and (iv) *firm-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

[3]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 corporations from manufacturing, services, retail trade, and construction industries (including responses from 37,990 firms) 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 either: (i) increase, (ii) stay the same, or (iii) decrease. These firm-level responses are then aggregated at the industry-country 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 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 level, the share of firms that respond that their production is constrained by the respective factor.

Employing survey data to gauge production constraints stemming from supply-chain disturbances offers two key advantages. First, survey data offers more immediate and direct evidence regarding firms' production constraints in comparison to raw supply-chain data which may not fully capture the extent of these constraints due to the inherent ability of firms to adapt, either through sourcing alternative material inputs or adjusting their supply chains.[4] Second, survey data can provide early indications of potential increases in supply-side costs, such as those resulting from container ship congestion. This foresight is possible because firms can predict future supply shocks before they manifest in actual material shortages.

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 either: (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 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 either: (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]

Moreover, we use newly available anonymized household-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

[4]In Section 5.1, we establish a strong correlation between firms' supply-chain vulnerabilities to Chinese export disruptions during the COVID-19 pandemic and the material input bottlenecks reported in our survey data.

[5]Note that 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.

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 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 ensure that we measure inflation expectations at the country and household 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 either: (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 answers 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 level (for the industry 2-digit CPA) and consumer prices at the product-country level, respectively. In addition, we obtain industry-country level input-output tables as well as data about industry-country level energy input use and energy prices at the country level from Eurostat.

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

4 Hypotheses development

We now discuss the evolution of production constraints, realized inflation, and inflation expectations before and after the outbreak of the COVID-19 pandemic and present five hypotheses that we bring to the data. In Section 4.1, we document evidence consistent with a localized cost-push inflation (i.e., inflation for products and in sectors directly affected by the supply-side shocks) starting in late 2020/early 2021, leading to a hypothesis on the pass-through of production constraints to higher inflation. In Section 4.2, we document a rise in inflation expectations starting around mid-2020 and in broad-based inflation beginning in the second half of 2021, and develop two hypotheses on the link between supply-chain shocks and household inflation expectations, as well as their role in contributing to the rise of generalized inflation. Finally, in Section 4.3, we develop two hypotheses on how both the initial localized cost-push inflation and the subsequent emergence of broad-based inflation can interact with firms' pricing power to give rise to generalized markup shocks.

Figure 1 provides a visual on the transmission channels characterizing the initial localized inflation and the eventual generalization into broad-based inflation through heightened household inflation expectations.

4.1 Supply constraints and localized inflation

The localized cost-push inflation effect of supply-side shocks arises from the rise in production costs due to challenges in procuring material inputs. First, the price of raw materials that are scarce or hard to procure might increase. Second, firms may have to switch to more expensive alternatives if certain inputs are hard to procure. Third, issues with securing material inputs might cause production delays, reducing output and increasing per-unit costs.

Due to these elevated costs, producers may increase their output prices to maintain profit margins, leading to an increase in producer prices. A high pass-through might cause price increases in some parts of the economy to spill over to other parts of the economy (e.g., a price increase of suppliers might inflate costs for downstream firms, which may, in turn, also increase their prices). The cost-driven producer price increases, when passed on to final goods, can elevate consumer prices.

Figure 2 shows a contemporaneous increase in production constraints (left panel) and in

PPI and CPI (right panel) from the onset of the pandemic to late 2022. Specifically, the left 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 right panel shows the increase in PPI in the second half of 2020, closely followed by the increase in CPI in 2021:Q1. These indices peak in the second half of 2022 (PPI in August and CPI in October), before gradually decreasing until the end of the sample period.

This evolution of PPI and CPI is consistent with empirical evidence showing that movements in PPI anticipate or parallel movements in the same direction in CPI (see, e.g., Silver and Wallace, 1980; Colclough and Lange, 1982; Jones, 1986; Clark et al., 1995). This relationship can be 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. This localized cost-push inflation effect of supply-side shocks leads us to the following hypothesis:

Hypothesis 1. *Supply constraints are positively associated with a surge in prices through a cost-push channel.*

In Section 5.1, we formally test this hypothesis, confirming that production constraints induced an increase in localized inflation through a cost-push channel.

4.2 Inflation expectations and generalized inflation

Households and firms, observing the production constraints and resulting price changes, might adjust their inflation expectations upwards, giving rise to broad-based inflation. The left panel of Figure 3 indeed documents a rise in inflation expectations of manufacturing firms and households starting around mid-2020. These expectations are measured as the share of firms or households expecting prices to increase more rapidly minus the share of

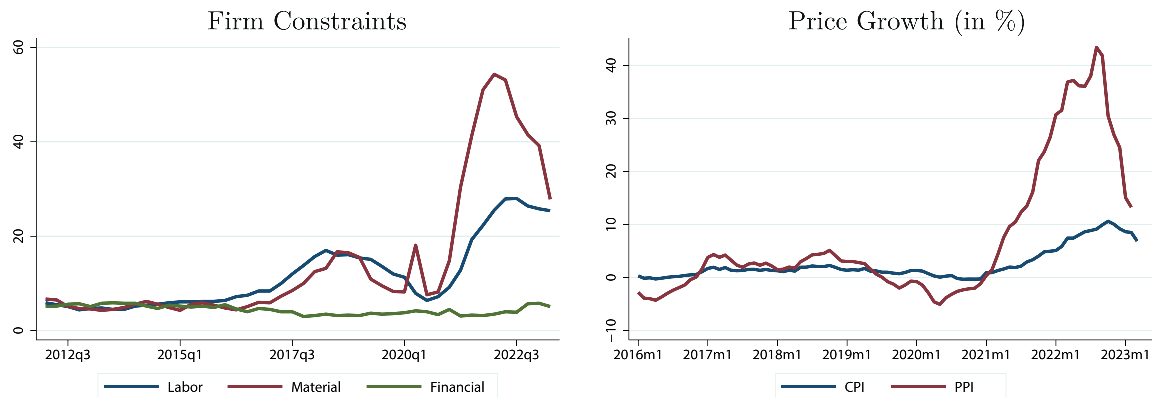

Figure 2: Constraints to firm production and inflation in the euro area. This figure shows the time-series evolution of firm production constraints (left panel) and inflation (right panel) in the euro area. The left panel shows the share of firms answering the following survey question: *"What main factors 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 right panel shows CPI and PPI growth at a monthly frequency from January 2016 to April 2023.

firms or households expecting inflation to fall over the next 12 months. While both peak in summer 2022, firms' expectations lead households' expectations in the run-up.

Supply-side shocks can influence inflation expectations through two primary channels: the *experience* channel and the *information* channel. The experience channel operates through the observable effect of supply-side shocks on the price level. When supply-side shocks affect production costs, firms may adjust their prices accordingly, leading to a surge in producer and consumer prices. Agents experiencing these price changes then update 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 information channel, agents adjust their inflation expectations in re-

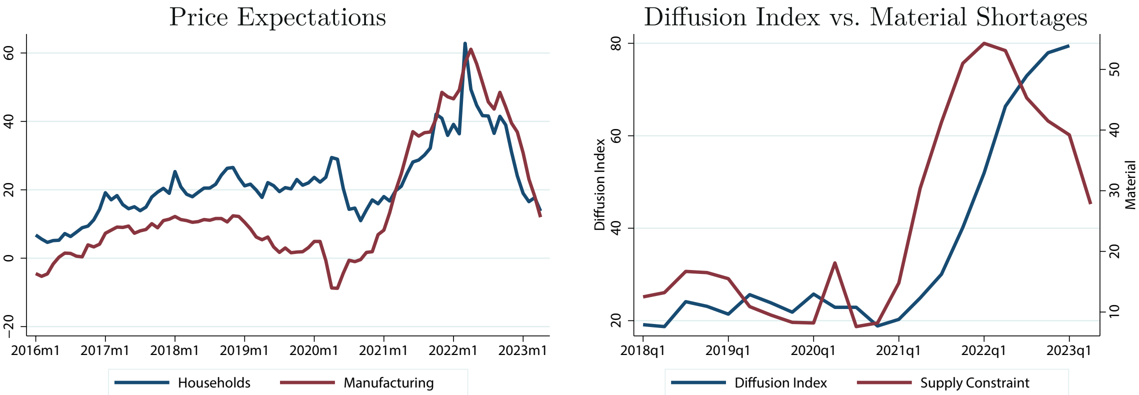

Figure 3: Inflation expectations and inflation becoming more broad-based in the euro area. The left panel of this figure shows the evolution of households' and manufacturing firms' inflation expectations over time. These expectations are measured as the share of households/firms expecting prices to increase 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 right panel 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%.

sponse 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 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.[7] The information channel aligns with the formation of inflation expectations through diagnostic expectations (Bordalo et al., 2018). Diagnostic expectations, which unify the concepts of extrapolation and risk neglect, cause agents to overweight future outcomes that become more likely in light of current news relative to what they know already. In the pandemic era,

[7]This channel can make inflation persistent since shocks that increase inflation expectations seem to have stronger effects than shocks that decrease inflation expectations (Ascari et al., 2023).

this means they might overly emphasize the likelihood of high inflation due to news about supply-chain disruptions.

These two channels through which supply-side shocks can affect inflation expectations suggest the following hypothesis:

Hypothesis 2. *The supply constraints, given their extreme tightness and persistence during the post-pandemic period, are positively associated with an increase in household inflation expectations.*

Once supply-side shocks raise actual inflation and household inflation expectations, firms may recalibrate their pricing strategies, irrespective of whether their production is actually affected by the initial supply-side shock. This behavioral response is grounded in theoretical work evaluating the consequences of costs shocks and inflation on search markets (e.g., Benabou and Gertner, 1993; Tommasi, 1994; Gaballo and Paciello, 2022).

Specifically, a firm's optimal pricing strategy is influenced by the price elasticity, that is, its customers' sensitivity to price changes, which inherently hinges on their perception of the company's product offering relative to its competitors. Heightened inflation expectations and the higher aggregate cost and price uncertainty, induced by supply-chain shocks and elevated inflation, can result in households becoming less informed about prices.[8]

First, when households experience a positive price shock and/or observe news about a supply-chain shock, they 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 cost and subsequent price shock to be widespread, affecting many suppliers (i.e.,

[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).

more akin to a common shock), they are 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 real price variability depreciates the information about future prices contained in current ones, giving repeat-purchase customers little incentives to acquire price information. (Tommasi, 1994).

As a result, when cost and price uncertainty is high and households' inflation expectations are elevated, households might have less information about the distribution of prices across firms and products. Having less information about prices translates into higher reservation (acceptance) prices; that is, households become less choosy and tend to enter into less 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, when households have less precise price information, 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). Then, via household expectations and firms' pricing power, supply-side inflation impulses can potentially generalize and spiral upwards into broad-based inflation.[9]

The right panel of Figure 3 shows how inflation, initially confined to a subset of product-country pairs, indeed becomes more broad-based starting in the second half of 2021. Specifically, the figure plots the time-series evolution of an inflation diffusion index (blue line), which we construct 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

[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 reduce the cross-price elasticity of demand. This reduction, in turn, causes an upward shift in the demand curve for individual producers.

2% and 4%, and a value of 100 to product-quarters with an annual inflation of more than 4%. While supply-chain constraints (red line) eased toward the end of the sample period, the diffusion index keeps increasing as inflation becomes more broad-based.[10] Building on this suggestive evidence, our third hypothesis is:

Hypothesis 3. *Inflation caused by supply-side shocks becomes more broad-based with time through the change in household inflation expectations.*

In Section 5.2 and Section 5.3, we formally test the two hypotheses developed in this section, showing how inflation expectations increased as a result of supply-side shocks, which led to a generalization of inflation.

4.3 The role of firms' pricing power

The pass-through of supply-chain constraints to inflation can be influenced by firms' pricing power, both in the initial cost-push transmission discussed in Section 4.1 and during the subsequent emergence of broad-based inflation discussed in Section 4.2.

In terms of the initial localized cost-push transmission, firms with significant pricing power can better pass on increased production costs to their customers. The extent to which increased producer prices translate to higher consumer prices depends on downstream firms' pricing power. These price adjustments may be particularly pronounced in markets with relatively high demand. Hence, our hypothesis is:

Hypothesis 4. *Firms with greater price-setting power are more likely to maintain, or even increase, their markups when facing supply-chain constraints and a high demand for their*

[10] Figure C.1 confirms this finding showing, in a heatmap, the propagation of inflation from product-country pairs hit by supply-chain constraints to others as time goes by.

products.

In terms of the subsequent emergence of broad-based inflation, households with high inflation expectations may have a lower price elasticity of demand (as explained before). This reduced sensitivity to price changes can increase the pricing power of firms, especially for those firms that operate in industries that produce/sell a relatively high share of final goods (marketed directly to households). This environment may be particularly favorable by firms that already possess significant pricing power prior to the onset of supply-side shortages. These firms might strategically hike prices aggressively, aware that consumers are less likely to respond adversely. Hence, we also test:

Hypothesis 5. *There is a stronger positive association between household inflation expectations and markups for firms with higher pricing power, even after initial supply-side shocks have abated.*

The combination of high inflation expectations and pricing power 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.

In Section 6, we formally test the two hypotheses developed in this section, 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.

5 Pass-through of supply-chain constraints

In this section, we test the first three hypotheses developed in Section 4. Specifically, we examine the effect of supply-chain constraints since the COVID-19 outbreak on price levels through a cost-push channel (Section 5.1), on generalized household inflation expectations (Section 5.2), and ultimately on broad-based inflation (Section 5.3).

5.1 Pass-through to localized inflation

Baseline analysis. 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:

$$\mathit{CPI\ Growth}_{pct+1} = \beta_1 Material_{pct} + \beta_2 Material_{pct} \times Post_t + \nu_{ct} + \mu_{pc} + \epsilon_{pct}, \quad (1)$$

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 indicate 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 *Post* 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.

Products are grouped in COICOP categories.[11] We construct our variables at the product-country-quarter level in two steps. First, we use the EU inter-country input-output tables (Eurostat Figaro) to capture industries from different countries contributing to the sales of a specific product in a specific country.[12] For example, cars sold in Germany are produced not only in Germany but also in Italy, Spain, and other countries. Second, we use the inverse of the COICOP-CPA matrix from Cai and Vandyck (2020) to transform the production constraints from the industry-country level to the product-country 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.

This 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 different in nature and thus defined differently (*Equipment*; capturing equipment shortages), while all other supply factors are unchanged (*Labor*, *Financial*, and *Other*). We conservatively decide to measure

[11] 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.

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

	(1) CPI Growth	(2) CPI Growth	(3) CPI Growth	(4) CPI Growth	(5) CPI Growth	(6) CPI Growth
Material × Post	0.087***	0.086***				
	(0.023)	(0.022)				
Material × 2020			0.126***	0.126***	0.127***	0.095**
			(0.025)	(0.027)	(0.028)	(0.034)
Material × 2021			0.076**	0.074**	0.074**	0.064**
			(0.027)	(0.027)	(0.026)	(0.027)
Material × 2022			0.074**	0.071**	0.070**	0.060**
			(0.027)	(0.027)	(0.026)	(0.027)
Energy Use × Energy CPI		1.448***		1.454***	1.471***	1.515***
		(0.481)		(0.482)	(0.481)	(0.478)
Controls						
Other constraints					✓	✓
Other constraints interacted						✓
Fixed effects						
Country-time	✓	✓	✓	✓	✓	✓
Product-country	✓	✓	✓	✓	✓	✓
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

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 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 level to the product-country level using input-output tables 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 CPI* is the country-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.

supply-chain constraints solely using the *Material* variable.[13]

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 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

[13]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.

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 CPI*. *Energy CPI* is the time-varying country-level CPI index for energy, 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.[14] 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 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:

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

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

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

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.[15]

Columns (3)-(6) of Table 1 indicate that the link between reported supply-chain constraints 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.[16]

Pass-through to PPI growth. In Appendix A, we confirm the pass-through of the supply-chain shocks to higher price levels also for producer prices. To further analyze the influence of firm pricing power on the pass-through of supply-side shocks to producer prices, we run the regression separately for the subsample of "concentrated" and "non-concentrated" industries. The evidence in Table A.1 suggests that firms are more able to pass on higher production costs in concentrated than in non-concentrated markets, which indicates that the pass-through is likely influenced by firm pricing power.

Taken together, the results in this section confirm the pass-through of supply-chain constraints on price levels and thus provide support for Hypothesis 1. These results are related to a large existing empirical literature. In Europe, Finck and Tillmann (2022) and Binici

[15]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 level.

[16]Note that, while the estimated coefficient in 2020 is the largest, CPI growth is not (yet) elevated in 2020.

et al. (2022) find that supply-chain constraints contributed to inflation, while Kuehl et al. (2022) finds that supply-side disruptions have been mostly driven by the recovery in global demand. In the U.S., Isaacson and Rubinton (2022) shows that the rise in shipping costs is an important factor in explaining inflation and Amiti et al. (2022) documents a pass-through from input costs to wage growth and, especially in the goods sector, from wages to prices. Bräuning et al. (2022) finds that the increase in industry concentration over the past two decades might have played an important role in amplifying the existing inflationary pressures. Looking globally, Carriere-Swallow et al. (2022) finds that spikes in shipping costs are followed by increases in inflation, and Jiménez-Rodríguez and Morales-Zumaquero (2022) documents a partial pass-through from commodity prices to producer prices and weak evidence for the pass-through to consumer prices.[17]

IV estimation. Next, we conduct an IV regression. This serves two primary purposes: firstly, to validate our survey data as an accurate indicator of firms' production constraints stemming from supply-chain disruptions; and secondly, 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 IV estimation, we can thus provide more direct evidence of the causal effect of the pass-through of increased supply-chain costs.

For this analysis, we instrument a market's degree of material input frictions (i.e., supply-chain disruptions) 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

[17]See also Benigno et al. (2022) for an index that captures global supply-chain pressures that is able to explain inflation outcomes.

lockdowns in China. Formally, our shift-share instrument is:

$$\widetilde{B}_{pct} = \text{China Dependence}_{pc,2019} \times \text{Lockdown Stringency}_t, \tag{3}$$

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. 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).[18] Our instrument thus gets all of the cross-sectional variation in the exposure 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 below 0.01, confirming 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

[18] For China, the OxCGRT COVID-19 Stringency Index is also available at the province 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, has 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-level index for the top-5 export provinces, collectively representing 67% of the national export total.

	(1)	(2)	(3)	(4)
	CPI Growth	Material	$\hat{\pi}^e$	Material
Material	0.081***		2.371***	
	(0.017)		(0.496)	
China Dependence ×		6.973***		
Lockdown Stringency		(0.339)		(0.612)
F-Test		423.17		23.6
Fixed effects				
Country			✓	✓
Country-time	✓	✓		
Product-country	✓	✓		
Observations	9,187	9,187	305	305
R-squared		0.782		0.738

Table 2: Supply-chain constraint pass-through to CPI and to household inflation expectations: IV estimation. This table presents the estimation results from the IV specification. The first stage results are shown in Columns (2) and (4) and the second stage results in Columns (1) and (3). The dependent variables are the one-quarter ahead annual CPI growth at the product-country level in Column (1) and the share of households that believe consumer prices will increase more rapidly at the country-time level in Column (3). *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 CPI* and *Energy Use* in Columns (1) and (2). *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 in Columns (1) and (2). Standard errors are double-clustered at the country-product and quarterly level in Columns (1) and (2) and at the country and quarterly level in Columns (3) and (4). We report standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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.

5.2 Pass-through to generalized higher inflation expectations

Next, we provide evidence of a pass-through of supply-chain constraints to generalized household inflation expectations. Our analysis encompasses three empirical tests: (i) an analysis at the country-quarter level using BCS consumer survey data, (ii) one at the household-quarter level using data from the ECB's CES, and (iii) expanding on the second analysis, one in which we add interaction terms that allow us to gauge households' awareness of past inflation and their attention to supply-chain disruptions.

Country-quarter level analysis. In the first test, we run an analysis at the *country-quarter level* employing the following two specifications:

$$\hat{\pi}^e_{ct} = \beta_1 Material_{ct} + \beta_2 Material_{ct} \times Post_t + \beta_3 Food\ Inflation_{ct} + \beta_4 Energy\ Inflation_{ct} + \beta_5 Core\ Inflation_{ct} + \beta_6 High\ Perception_{ct} + \nu_c + \epsilon_{ct}, \tag{4}$$

and

$$\hat{\pi}^e_{ct} = \sum_{f \in \text{Constraint}} \beta_{1f}\, f_{ct} + \sum_{f \in \text{Constraint}} \sum_{\tau=20,21,22} \boldsymbol{\beta_{2f\tau}}\, f_{ct} \times Year_\tau + \beta_3 Food\ Inflation_{ct} + \beta_4 Energy\ Inflation_{ct} + \beta_5 Core\ Inflation_{ct} + \beta_6 High\ Perception_{ct} + \nu_c + \epsilon_{jct}, \tag{5}$$

where $Year_{20}$, $Year_{21}$, and $Year_{22}$ denote the same set of dummies and *Constraint* 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 level to the country level using the share of consumption that each industry contributes to the final household consumption.[19]

In these two specifications we use the BCS consumer survey data, employing the share of households that believe consumer prices will increase more rapidly as a dependent variable at the country-quarter level. The dependent variable is the share of households in a country that believe consumer prices will increase more rapidly. Moreover, in these specifications we account for realized inflation alongside households' perceptions of past inflation—factors

[19] 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.

identified in the literature as drivers of household inflation expectations (see 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 (e.g., see Coibion and Gorodnichenko, 2015b and D'Acunto et al., 2019). In our most stringent specification in the last column, we additionally include year interactions for all our controls. In line with the literature, the estimated coefficients for realized inflation suggest that past inflation contributes to inflation expectations, but this effect subsides once we include the control for households' perception of past inflation.

Table 3 presents the estimation results for this test, where in the different specifications we incorporate an increasingly rigorous set of controls. The results show that supply-chain constraints are positively associated with household inflation expectations across all specifications. Based on the most stringent specification (Column (7)), 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 5.1. 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. Columns (3) and (4) of Table 2 present the results. The IV estimated coefficients confirm the positive effect of an increase in the prevalence of reported supply-chain frictions on CPI growth.

Finally, utilizing the detailed demographic data from the BCS consumer survey, we document in Appendix B that the pass-through of supply-chain constraints to household inflation expectations is a widespread phenomenon (see Table B.2 to Table B.5), affecting a diverse range of demographics including different age groups, income levels, educational

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$
Material × Post	1.187***						
	(0.280)						
Material × 2020		2.298**	2.416**	2.766***	2.779***	2.166***	2.014***
		(0.924)	(0.893)	(0.887)	(0.918)	(0.736)	(0.483)
Material × 2021		0.900***	1.179***	1.052***	1.000***	0.805***	0.547**
		(0.208)	(0.196)	(0.191)	(0.191)	(0.229)	(0.257)
Material × 2022		1.062***	1.147***	0.963***	0.913***	0.789***	0.568*
		(0.187)	(0.169)	(0.170)	(0.194)	(0.223)	(0.309)
Food Inflation			0.497***	-0.057	-0.362	-0.430	-0.430
			(0.167)	(0.289)	(0.356)	(0.342)	(0.426)
Energy Inflation				0.134**	0.068	0.062	0.080*
				(0.057)	(0.041)	(0.042)	(0.039)
Core Inflation				1.016	0.891*	0.964*	0.743
				(0.607)	(0.505)	(0.527)	(0.592)
High Perception					0.161**	0.166***	0.146*
					(0.061)	(0.056)	(0.073)
Controls							
Other constraints						✓	✓
Other constraints interacted							✓
Fixed effects							
Country	✓	✓	✓	✓	✓	✓	✓
Observations	305	305	305	305	305	305	305
R-squared	0.535	0.571	0.603	0.629	0.645	0.666	0.683

Table 3: Supply-chain constraint pass-through to household inflation expectations: Country-level evidence. This table presents estimation results from Specification (4) in Column (1) and Specification (5) in Columns (2)-(7). The dependent variable is the share of households that believe consumer prices will increase more rapidly at the country-time 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 level to the country 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). *Energy Inflation* and *Food Inflation* are the country-level CPI indices for energy and food, respectively. *High Perception* is the share of households 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.

backgrounds, and gender. Although the pass-through is observed consistently, it is slightly less pronounced for younger and low-income households.

Household-quarter level analysis. In the second test, we run an 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. Specifically, we estimate the

	(1)	(2)	(3)	(4)	(5)	(6)
	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$
Material	0.950***	0.582***	0.279***	0.244***	0.168***	0.165***
	(0.036)	(0.033)	(0.041)	(0.041)	(0.027)	(0.044)
Food Inflation		1.721***	1.358***	0.967***	0.348***	0.414***
		(0.049)	(0.049)	(0.067)	(0.058)	(0.073)
Energy Inflation			0.193***	0.176***	0.054***	0.030***
			(0.011)	(0.011)	(0.009)	(0.011)
Core Inflation				1.399***	0.068	0.428**
				(0.201)	(0.156)	(0.169)
High Perception					0.349***	0.350***
					(0.005)	(0.005)
Controls						
Other constraints						✓
Fixed effects						
Household	✓	✓	✓	✓	✓	✓
Observations	126,119	126,119	126,119	126,119	126,119	126,119
R-squared	0.508	0.522	0.526	0.526	0.583	0.584

Table 4: Supply-chain constraint pass-through to household inflation expectations: Household-level evidence. This table presents estimation results from Specification (6). The dependent variable is a household-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 level to the country 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 Column (6). *Energy Inflation* and *Food Inflation* are the country-level CPI indices for energy and food, respectively. *High Perception* is a dummy equal to one for households that believe prices increased a lot 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.

following specification:

$$\hat{\pi}^e_{ht} = \sum_{f \in \text{Constraint}} \boldsymbol{\beta_{1f}} f_{ct} + \beta_2 \mathit{Food\ Inflation}_{ct} + \beta_3 \mathit{Energy\ Inflation}_{ct} + \beta_4 \mathit{Core\ Inflation}_{ct}$$
$$+ \beta_5 \mathit{High\ Perception}_{ht} + \mu_h + \epsilon_{ht}, \quad (6)$$

where h is a household, c is a country, and t is a quarter. The dependent variable is 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?"*

For this test, we again transform all production constraints (*Material*, *Labor*, *Financial*, and *Other*) measured at the industry-country level to the country level using the share of consumption that each industry contributes to the final household consumption. Finally, similar to Specifications (4) and (5), we again control for realized inflation and households' perception about inflation in the last 12 months (now at the household level).

The estimation results in Table 4 confirm the positive association between supply-chain constraints and household inflation expectations. Increasing the share of firms reporting material frictions from the 10th to the 90th percentile during the COVID-19 period leads to a 5pp higher probability for a household to believe prices will increase lot in the following year. This corresponds to 16% of the average share of households thinking inflation will increase a lot.

Household-quarter level analysis with interactions. In the third test, we extend our analysis at the *household-quarter level* adding interaction terms with the two variables *Accurate* and *Search* to Specification (6). *Accurate* is a household-level dummy equal to one for households that have an accurate perception of realized inflation. We define a household as having accurate past inflation expectations if the within household correlation between point estimate the household provides for how high realized inflation was and the actual realized inflation is above the sample median of households. *Search* is a country-quarter level variable measuring the intensity of Google searches for "delays in shipping" in a specific country.[20] 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

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

Spain—the countries with a sufficient number of searches for "delays in shipping."[21]

The estimation results in Table 5 show (i) that households that more accurately assess realized past inflation expect CPI growth to increase more when supply-chain constraints become more prevalent (Columns (1)-(2)) and (ii) that this relationship is stronger in countries with more Google searches about supply-chain issues (Columns (4)-(5)). These results suggest that the positive association between supply-chain constraints and household inflation expectations is driven by households that are more accurate forecasters and countries where households are more concerned/aware of supply-chain constraints.[22] 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 sum, our evidence suggests that the supply-chain pressures that built up in the period after the outbreak of the COVID-19 pandemic (specifically 2021) caused an increase in inflation through a cost-push channel, as well as an increase in household inflation expectations, in line with Hypothesis 2.

5.3 Pass-through to generalized higher inflation

We now document the pass-through of supply constraints into generalized inflation. The mechanism detailed in Section 4.2 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 reduce their consumption even when facing

[21] 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.

[22] In a robustness test, we define a household as having an accurate perception of realized inflation if the absolute value of the difference between the household's estimate and the realized inflation is less than 2pp. Table B.1 shows that these results are robust to this alternative definition.

	(1)	(2)	(3)	(4)	(5)
	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$
Material	-0.139***		-0.133*	-0.185*	
	(0.044)		(0.072)	(0.095)	
Material × Accurate	0.674***	0.660***		0.164	0.208*
	(0.038)	(0.039)		(0.121)	(0.121)
Material × Accurate × Search				0.974***	0.880***
				(0.229)	(0.226)
Search			-0.265***	-0.194***	
			(0.030)	(0.033)	
Material × Search			0.917***	0.383**	
			(0.124)	(0.162)	
Accurate × Search				-0.160***	-0.160***
				(0.048)	(0.046)
Food Inflation	0.424***		0.518***	0.529***	
	(0.074)		(0.084)	(0.084)	
Energy Inflation	0.028**		-0.018	-0.016	
	(0.011)		(0.015)	(0.015)	
Core Inflation	0.666***		0.919***	1.104***	
	(0.172)		(0.219)	(0.218)	
High Perception	0.333***	0.327***	0.353***	0.337***	0.332***
	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
Controls					
Other constraints	✓		✓	✓	
Fixed effects					
Country-time		✓			✓
Household	✓	✓	✓	✓	✓
Observations	122,096	122,096	106,144	102,551	102,551
R-squared	0.582	0.590	0.593	0.589	0.595

Table 5: Supply-chain constraint pass-through to household inflation expectations: Interactions with household characteristics. This table presents estimation results from Specification (6). The dependent variable is a household-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 level to the country 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-level variable measuring the intensity of Google searches for "delays in shipping" (in the respective country's language) over time. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) in Columns (1), (3), and (4). *Energy Inflation* and *Food Inflation* are the country-level CPI indices for energy and food, respectively. *High Perception* is a dummy equal to one for households that believe prices increased a lot over the last 12 months. Standard errors are clustered at the country-demographics level and are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

price hikes, providing all firms more broadly (i.e., not only the ones affected by supply-side constraints) the leeway to raise their 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. 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 unaffected by these supply-side disturbances.

Baseline spillover analysis. To test the corresponding Hypothesis 3, 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-level) supply-chain constraints to production. To this end, we estimate the following "spillover specification" at the product-country-quarter level:

$$\begin{aligned} \mathit{CPI\ Growth}_{pct+1} = {} & \beta_1 \mathit{Low\ Material\ Growth}_{pc} \times \mathit{Material}_{ct} \\ & + \sum_{\tau=20,21,22} \beta_{2\tau} \mathit{Low\ Material\ Growth}_{pc} \times \mathit{Year}_\tau \\ & + \sum_{\tau=20,21,22} \boldsymbol{\beta_{3\tau}} \mathit{Low\ Material\ Growth}_{pc} \times \mathit{Material}_{ct} \times \mathit{Year}_\tau \\ & + \mathit{Controls} + \nu_{ct} + \theta_{pc} + \epsilon_{cpt} \end{aligned} \tag{7}$$

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). *Low Material Growth* is a dummy equal to one if the increase in the supply constraints for product p in country c in 2020:Q4-2021:Q4 is below the country median. *Material* denotes again the aggregate extent of supply constraints at the country level (aggregated using the share of consumption that each industry contributes to the final household consumption in a given country).

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*)

	(1) CPI Growth	(2) CPI Growth	(3) CPI Growth	(4) CPI Growth	(5) CPI Growth
Low Material Growth × 2020	-0.297	-0.380	-0.018	0.144	-2.457**
	(0.466)	(0.871)	(0.702)	(0.571)	(1.097)
Low Material Growth × 2021	-2.008***	-1.896***	-2.135**	-1.916***	-3.381**
	(0.512)	(0.571)	(0.782)	(0.565)	(1.232)
Low Material Growth × 2022	-3.252***	-3.896**	-2.596*	-2.910	-4.653***
	(0.866)	(1.342)	(1.459)	(1.735)	(1.468)
Low Material Growth × Material	-0.147**	-0.215**	-0.110	-0.287**	-0.251**
	(0.055)	(0.099)	(0.083)	(0.107)	(0.110)
Low Material Growth × Material × 2020	0.041	-0.173	0.069	0.012	0.322**
	(0.064)	(0.118)	(0.099)	(0.146)	(0.143)
Low Material Growth × Material × 2021	0.105*	0.168**	0.054	0.182*	0.248*
	(0.056)	(0.074)	(0.082)	(0.093)	(0.128)
Low Material Growth × Material × 2022	0.127*	0.238**	0.049	0.188*	0.211*
	(0.061)	(0.094)	(0.090)	(0.103)	(0.117)
Low Material Growth × Energy CPI × 2020	0.014	-0.076	0.114	0.067	-0.226
	(0.046)	(0.046)	(0.107)	(0.065)	(0.247)
Low Material Growth × Energy CPI × 2021	-0.031	-0.046	0.026	-0.003	-0.059
	(0.035)	(0.040)	(0.054)	(0.044)	(0.106)
Low Material Growth × Energy CPI × 2022	-0.061*	-0.066*	-0.045	-0.039	-0.010
	(0.031)	(0.037)	(0.055)	(0.042)	(0.103)
Energy Use × Energy CPI	1.410**	1.699**	1.036**	0.986*	3.081**
	(0.516)	(0.613)	(0.469)	(0.471)	(1.331)
Sample	Full Sample	High Inflation Expectations	Low Inflation Expectations	High Collective Bargaining	Low Collective Bargaining
Fixed effects					
Country-time	✓	✓	✓	✓	✓
Product-country	✓	✓	✓	✓	✓
Observations	9,187	4,582	4,605	5,110	3,053
R-squared	0.553	0.502	0.600	0.501	0.621

Table 6: Pass-through of supply-chain constraints to generalized inflation. This table presents estimation results from Specification (7). 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 level to the country level using the share of consumption that each industry contributes to the final household consumption. *Low Material Growth* is a dummy variable equal to one if the increase between 2020:Q4 and 2021:Q4 in the material supply constraint for the respective product is below the country median. *High Inflation Expectation* countries are defined as countries with an above median share of households responding that prices will increase more rapidly in 2022. *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, these other constraints interacted with the three year dummies. *Energy CPI* is the country-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. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

interacted with the three year dummies and *Energy Inflation* interacted with the indicator variable for low material growth industries 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, notably after the Russian invasion of Ukraine in March 2022, which severely affected energy supply to several European countries.

The estimation results in Table 6 present evidence consistent with a generalization of inflation going from markets affected by supply-side constraints to markets not affected by these constraints. Specifically, in line with Hypothesis 1 (i.e., supply-chain constraints are passed through to higher consumer prices), the first three rows of Column (1) show that markets that experienced little to no increase in material input costs (i.e., the supply constraint is below the country median; called in the following *Low Material Growth* markets) have lower CPI growth than markets in the same country with a higher increase in material costs. However, in line with Hypothesis 3, the coefficients for the interactions *Low Material Growth* $\times$ *Material* with the years 2021 and 2022 confirm that the CPI growth of *Low Material Growth* markets tend to be higher in these years when the average material costs within the respective country increases more, relative to *Low Material Growth* markets in countries that experienced, on average, only a small increase in material costs. More precisely, a one standard deviation higher material friction at the country level leads to 0.94pp higher inflation for *Low Material Growth* markets in 2022.

Moreover, the coefficients for *Low Material Growth* $\times$ *Energy CPI* interacted with the three post-COVID years in Column (1) of Table 6 indicate that, if anything, energy prices seem to increase rather than decrease the difference in CPI growth rates between *High* and *Low Material Growth* markets. This observation implies that energy prices are unlikely to be the driver of the spillover/generalization effect observed in *Low Material Growth* markets.

Columns (2) and (3) show estimation results in the subsample of high inflation expectation countries and low inflation expectation countries, respectively, where this definition is based on whether a country has an above or below median share of households responding that prices will increase more rapidly in 2022. Again, consistent with our third hypothesis, we find that the generalization into broad-based inflation is driven by countries whose households have elevated inflation expectations.

Horse race spillover analysis. In principle, similar to the supply-chain disruptions in the post-COVID period, the energy cost shocks during this period could also have affected household price information accuracy, thereby influencing demand elasticity and potentially leading to broad-based inflation. To explore this possibility, we undertake a horse race analysis by adding energy costs spillover interaction terms to our baseline spillover specification in Eq. (7), paralleling our approach for analyzing the generalization of supply-chain shocks. This "horse race" helps in understanding the relative contribution of the supply-chain disruptions and energy cost shocks for the generalization of supply-side impulses into broad-based inflation.

To identify markets not materially impacted by energy cost shocks, we utilize a dummy denoted *Low Energy*, equal to one if the increase between 2021:Q1 and 2022:Q2 in *Energy Use* $\times$ *Energy CPI* for the respective product is below the country median. Here, *Energy CPI* again refers to the country-level CPI index for energy, while *Energy Use* measures the pre-COVID energy input of an industry-country pair. This setup enables us to contrast the CPI growth in markets relatively unaffected by energy cost shocks, owing to their low energy consumption, across countries experiencing varying levels of aggregate energy price shocks.

Table B.6 reports the results for this horse race analysis. There are two main takeaways. First, the results suggest that the energy cost shocks did not generalize into broad-based inflationary pressures. Second, the integration of spillover interaction terms pertaining to energy costs does not significantly alter the magnitude of the observed supply-chain spillover effects. These findings highlight the distinctive effect of supply-chain disruptions and their relative significance over energy cost increases in driving broad-based inflation in the context of the European economy post-COVID.

This differential impact of the post-COVID supply-chain and energy cost shocks might be rooted in the different ways households perceive and react to these disturbances. The supply-chain shock, with its potential to influence nearly any industry, makes it challenging for households to discern which sectors were most affected, leading to a broad anticipation of widespread price increases. The lack of specific sectoral information enhances the generalization effect of these supply-chain disruptions across various industries. In contrast, the energy cost shock might have been perceived more confined to certain sectors, such as energy-intensive manufacturing or utilities like gas and heating. This narrower perception could lead households to believe they have a clearer understanding of which sectors are directly affected. Consequently, companies in less-impacted sectors may find it more difficult to raise their markups and prices, thus muting the generalization effect of the energy cost shock (see Benabou and Gertner, 1993 for a formalization of this argument).

Testing for the influence of labor costs. Another potential concern is that the higher price levels in *Low Material Growth* markets in countries more impacted by supply-chain shocks 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 (7) 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.[23] If the effects in Column (1) of Table 6 are driven by firms' elevated labor costs expectations, the

[23] 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.2: countries that all have a coverage ratio below 56.9% and countries that all have a coverage ratio above 77.2%.

effects should be stronger for countries with a higher share of employees covered by collective bargaining agreements. Columns (4) and (5) 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.

6 Effects on firms' pricing behavior

Finally, we analyze the impact of supply-side constraints, elevated inflation expectations, and firm pricing power on firms' price-setting behavior. As outlined in Section 4, surging inflation and inflation expectations might reduce the likelihood of consumers decreasing their consumption in response to a price increase. A lower price elasticity of demand, in turn, allows firms with pricing power to maintain, or even increase, their markups without risking a considerable decline in sales.

Figure 4 shows correlations consistent with this narrative. The left panel shows that household inflation expectations have risen substantially between 2021:Q1 and 2022:Q2 (using the inflation expectations data from Eurostat), before falling again below their pre-pandemic level at the beginning of 2023. The right panel shows the correlation between firm markups as of 2018 (x-axis) and the growth in markups between 2021:Q1 ad 2022:Q2, namely the period characterized by a substantial rise in household inflation expectation. The scatter plot shows that the majority of firms with high pricing power prior to the COVID-19 pandemic (evidenced by higher markups in 2018) managed to sustain or even increase their markups as household inflation expectations rose. 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

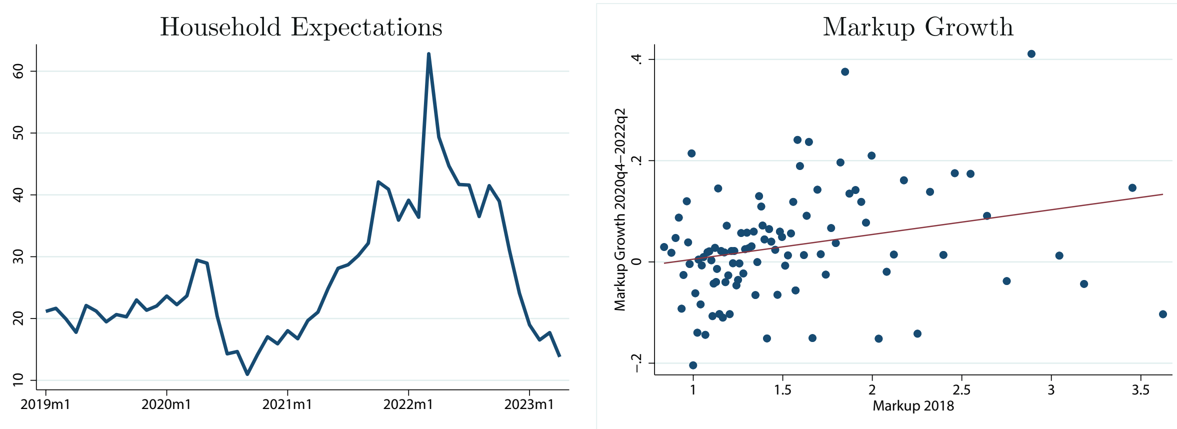

Figure 4: Inflation expectations and markup growth. The left panel shows the evolution of household inflation expectations for Euro area countries over time. It is defined as the share of households in a country-month that believe consumer prices will increase more rapidly minus the share of households that believe consumer prices will fall. The right panel shows a binscatter plot of the growth in markups from 2020:Q4 to 2022:Q2 against the ex-ante markup measured in fiscal year 2018. Markups are calculated following De Loecker et al. (2020).

absolute profits—per unit sold.[24]

Next, we present a set of parametric tests consistent with supply constraints and higher inflation expectations allowing firms with pricing power to charge higher markups. Specifically, in Section 6.1, we show that these firms were more likely to maintain, or even increase, their markups when facing supply-chain constraints and a high demand for their products, consistent with Hypothesis 4. In Section 6.2, we show that these firms were able to sustain relatively higher markups in an environment with elevated inflation expectations even after supply-chain pressures eased, consistent with Hypothesis 5.

[24] 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 $(1.5 \times 1 - 1 = 0.5)$ to $(1.5 \times 2 - 2 = 1)$.

6.1 Supply-side constraints and firm markups

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:

$$\begin{aligned} Markup_{it+1} = \beta_1 Markup_i^{2018} \times Material_{jct} \times Post_t + \beta_2 Markup_i^{2018} \times Post_t \\ + \beta_3 Markup_i^{2018} \times Material_{jct} + \beta_4 Markup_i^{2018} + \eta_{jct} + \epsilon_{it}, \end{aligned} \tag{8}$$

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 *Material* is in this specification the extent of supply-chain constraints measured at the industry-country-quarter level. *Post* is again a dummy equal to one from 2020:Q2 onward (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 7 shows the estimation results. 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 in the post-period. That is, high pricing power firms were not able to sustain their markups if they did not face supply constraints and experienced a profit margin reduction. Second, the positive association between supply-chain constraints and higher markups in the post-period is stronger for firms with ex-ante higher pricing-power. Third, the direction of the influence of higher pricing-power on the effect of higher supply-chain constraints on markups in the post-period depends on how binding the constraints are

	(1) Markup	(2) Markup	(3) Markup	(4) Markup
	Full	Full	High Order Book	Low Order Book
Material × Markup^{2018}	-0.330*	-0.330*	-0.419***	0.272
	(0.174)	(0.174)	(0.118)	(0.277)
Markup^{2018} × Post	-14.933**			
	(5.765)			
Material× Markup^{2018} × Post	0.366**			
	(0.154)			
Markup^{2018} × 2020		-11.151***	-19.571***	-3.432
		(4.159)	(5.140)	(5.563)
Markup^{2018} × 2021		-15.455**	-12.998*	-8.651
		(7.751)	(7.644)	(9.896)
Markup^{2018} × 2022		-22.399**	-26.186*	-0.057
		(9.610)	(14.114)	(11.687)
Material × Markup^{2018} × 2020		0.075	0.057	0.033
		(0.166)	(0.130)	(0.320)
Material × Markup^{2018} × 2021		0.464**	0.585***	-0.541
		(0.227)	(0.184)	(0.373)
Material × Markup^{2018} × 2022		0.436**	0.618***	-0.685*
		(0.205)	(0.211)	(0.376)
Markup^{2018}	90.210***	90.210***	88.058***	86.418***
	(2.667)	(2.668)	(2.890)	(4.062)
Fixed effects				
Industry-country-time	✓	✓	✓	✓
Observations	11,724	11,724	5,860	5,864
R-squared	0.705	0.705	0.681	0.733

Table 7: Supply-side constraints and firm markups. This table presents estimation results from Specification (8). The dependent variable is a firm's markup, which we estimate following De Loecker et al. (2020). *Material* measures the share of firms that indicate that their production is constrained by supply-chain problems at the industry-country level. $Markup^{2018}$ measures a firm's markup in the fiscal year 2018. *Order Book* is defined as the share of firms in an industry-country that answer that their order book is more than sufficient (above normal) minus the share of firms answering their order book is not sufficient (below normal). *High Order Book* and *Low Order Book* are indicators for industry-country-quarters with an above and median value of *Order Book*, respectively. Columns (1)-(2) include the full sample of firms in Compustat for which markups can be estimated. Column (3) focuses on firms operating in *High Order Book* industry-country pairs, whereas Column (4) shows results for *Low Order Book* industry-country pairs. All specifications include industry-country-quarter fixed effects. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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 ex-post markups for a higher level of supply-chain pressure is equal to 40.80 (=14.933/0.366), corresponding to roughly the 75% percentile of the *Material* distribution in 2021 (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 were less able to maintain their markups compared to firms with lower ex-ante markups.

In the second column of Table 7, we again break down the post-pandemic period by year. The results show that the positive association between perceived supply-chain constraint to production and higher markups for firms with higher ex-ante pricing power is most pronounced in 2021. This timing aligns well with the strong surge in the reported supply-chain constraints in 2021 (see the left 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.

To tease out this channel, we refine our firm-level markup analysis and split the sample into industry-country pairs facing high or low demand, respectively. We gauge the demand in a specific industry-country pair in a particular quarter with survey data about the firms' order book situation (see Section 3 for more details). Specifically, we employ the variable *Order Book*, defined as the share of firms in an industry-country with an order book that is more than sufficient (above normal) minus the share of firms with an order book that is not sufficient (below normal). We then split the sample into industry-country-quarters with an above median value of *Order Book* (*High Order Book*) and with a below median value (*Low Order Book*), respectively. Interestingly, the average *Material* value is 34.5 higher for *High Order Book* industry-country pairs, suggesting that lacking demand is indeed a less frequent bottleneck to production for these industry-country pairs: given the healthy demand, firms in these industry-country pairs would like to scale up production, but cannot due to insufficient material input.

Columns (3) and (4) of Table 7 report the results for this refined test. The positive association in 2021 between supply-chain constraints and higher markups for firms with higher pricing power is driven by firms in *High Order Book* industry-country pairs. In contrast, firms in *Low Order Book* industry-country pairs experience a drop in markups in 2021 (i.e., when perceived supply-chain constraints spike), irrespective of the *Material* value.

In sum, 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) and when aggregate demand was sufficiently high (which we gauge with firms' order book information). In industry-country pairs with well-functioning supply-chains (resulting in unconstrained aggregate supply) and limited demand (insufficient order books), firms with higher ex-ante pricing power experienced a stronger reduction in markups. This evidence provides support for Hypothesis 4.

6.2 Household inflation expectations and firm markups

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. To this end, we investigate the relationship between firms' markups and households' inflation expectations employing the following specification:

$$
\begin{aligned}
Markup_{it+1} = & \sum_{\tau=20,21,22} \boldsymbol{\beta_{1\tau}} Markup_i^{2018} \times Material_{jct} \times Year_\tau \\
& + \sum_{\tau=20,21,22} \boldsymbol{\beta_{2\tau}} Markup_i^{2018} \times \textit{HH Infl Exp}_{ct} \times Year_\tau \\
& + \beta_3 Markup_i^{2018} \times Material_{jct} + \beta_4 Markup_i^{2018} \times \textit{HH Infl Exp}_{ct} \\
& + \sum_{\tau=20,21,22} \beta_{5\tau} Markup_i^{2018} \times Year_\tau + \beta_6 Markup_i^{2018} + \xi_{jct} + \epsilon_{it}, \qquad (9)
\end{aligned}
$$

which largely follows the yearly breakdown version of Specification (8). In addition, however, we now include interactions with *HH Infl Exp*, which measures the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months.

Table 8 shows the estimation results. The evidence in the first and the second columns confirms the positive association between household inflation expectations and markups in 2022 for firms with higher ex-ante pricing power (i.e., higher ex-ante markups). Further analysis in Appendix B reveals that this correlation holds true across diverse demographic groups in terms of age (excluding the youngest cohort), income brackets, educational levels, and gender (see Table B.7 to Table B.10), underscoring the consistency of household expectations' influence on pricing strategies.

Finally, if this finding is indeed driven by a lower price elasticity of demand by households, we should observe a more pronounced relationship between household inflation expectations, pricing power, and markups, for firms that operate in industries that produce a relatively high share of final goods for which household inflation expectations should have the highest impact on firms' price-setting. Accordingly, we redo the test from the second column of Table 8 separately for industries with an above and below median share of final goods produced. The third and the fourth columns present the estimation results, confirming that firms with higher ex-ante pricing power are better able to maintain or even increase their markups in

	(1)	(2)	(3)	(4)
	Markup	Markup	Markup	Markup
Sample	Full	Full	High Share Final	Low Share Final
Material × Markup^{2018}	-0.330*	-0.330*	-0.419***	0.272
	(0.174)	(0.174)	(0.118)	(0.277)
Material × Markup^{2018} × 2020		0.131	-0.029	-0.092
		(0.187)	(0.159)	(0.340)
Material × Markup^{2018} × 2021		0.506**	0.606**	-0.092
		(0.203)	(0.285)	(0.296)
Material × Markup^{2018} × 2022		0.504**	0.466**	0.111
		(0.222)	(0.225)	(0.324)
HH Infl Exp × Markup^{2018}	-0.558	-0.553	-0.068	-0.574
	(0.460)	(0.388)	(0.770)	(0.374)
HH Infl Exp × Markup^{2018} × 2020	0.170	0.235	0.299	0.056
	(0.423)	(0.407)	(0.819)	(0.362)
HH Infl Exp × Markup^{2018} × 2021	-0.259	-0.428	-1.205	-0.024
	(0.571)	(0.543)	(0.959)	(0.456)
HH Infl Exp × Markup^{2018} × 2022	1.492*	1.584**	2.143*	1.082**
	(0.813)	(0.713)	(1.215)	(0.413)
Markup^{2018}	95.468***	99.763***	88.455***	97.811***
	(7.700)	(7.755)	(11.737)	(8.297)
Fixed effects				
Industry-country-time	✓	✓	✓	✓
Observations	11,724	11,724	3,666	7,464
R-squared	0.706	0.707	0.729	0.686

Table 8: Household inflation expectations and firm markups. This table presents estimation results from Specification (9). The dependent variable is a firm's markup, which we estimate following De Loecker et al. (2020). *Material* measures the share of firms that indicate that their production is constrained by supply-chain problems at the industry-country level. *HH Infl Exp* measures the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months. $Markup^{2018}$ measures a firm's markup in the fiscal year 2018. Columns (1)-(2) include the full sample of firms in Compustat for which markups can be estimated. Column (3) focuses on firms operating in industries that produce an above median share of final goods, whereas Column (4) shows results for industries with a below median share of final goods produced. All specifications include industry-country-quarter fixed effects. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

an environment of elevated inflation expectations when they are in more household-facing industries.

Overall, this evidence provides support for Hypothesis 5. The results in Table 7 and Table 8 are also in line with Konczal et al. (2022), which analyzes data on profit margins in the U.S. and argues that, as well as supporting demand and supply explanations for high inflation, there is 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.

7 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 post-pandemic inflation outburst 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, especially in sectors witnessing robust demand. In 2022, high-pricing power firms further increased their markups in response to heightened household inflation expectations. These effects 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 provides support for measures that promote competition, thereby curbing the inflationary tendencies of dominant market players. Third, transparent communication about the nature 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

A Pass-through to PPI growth

Similar to our CPI growth analysis in Specification (1), we test the effect of increasing supply-chain pressures (as perceived by firms) on PPI growth by estimating the following specification at the industry-country-quarter level:

$$PPI\ Growth_{jct+1} = \beta_1 Material_{jct} + \beta_2 Material_{jct} \times Post_t + \gamma_{jt} + \nu_{ct} + \mu_{jc} + \epsilon_{jct}, \quad \text{(A.1)}$$

where j is an industry, c is a country, and t is a quarter. We estimate this specification in the subsample of manufacturing firms, as PPI growth is only available for NACE codes 10–33. We again measure the PPI growth in quarter t as the yearly PPI growth from quarter $t-3$ to quarter $t+1$.

We include industry-quarter, country-quarter, and industry-country fixed effects to isolate the effect of firms' perceived supply constraints holding constant the time-varying demand at the industry and country level. Specifically, the country-quarter fixed effects again absorb all shocks at the national level that could affect firms. The industry-quarter fixed effects absorb all industry-level shocks (e.g., industry-level demand shocks). Finally, the industry-country fixed effects control for time-invariant industry-country characteristics.

The estimation results in the first column of Table A.1 show that supply-chain constraints are also positively related with PPI growth in the post-pandemic period relative to 2019.

Having established this correlation for the COVID-19 pandemic period, we again proceed to examine its time variation over time by modifying Specification (A.1) as follows:

$$\begin{aligned} PPI\ Growth_{jct+1} = & \sum_{f \in \text{Constraint}} \beta_{1f}\, f_{jct} + \sum_{f \in \text{Constraint}} \sum_{\tau = 20,21,22} \boldsymbol{\beta_{2f\tau}}\, f_{jct} \times Year_\tau \\ & + \gamma_{jt} + \nu_{ct} + \mu_{jc} + \epsilon_{jct}. \end{aligned} \quad \text{(A.2)}$$

The second to fourth columns of Table A.1 indicate that the link between reported supply-chain constraints and PPI growth also exists for all years.

To analyze the influence of firm pricing power on the pass-through of supply-side shocks to producer prices, we rerun our most stringent specification (Column 4 in Table A.1) separately

	(1) PPI Growth	(2) PPI Growth	(3) PPI Growth	(4) PPI Growth	(5) PPI Growth	(6) PPI Growth
Material × Post	0.021**					
	(0.008)					
Material × 2020		0.028***	0.013*	0.014*	0.025**	0.004
		(0.007)	(0.007)	(0.007)	(0.011)	(0.014)
Material × 2021		0.026**	0.023*	0.023*	0.033**	-0.007
		(0.011)	(0.012)	(0.012)	(0.015)	(0.021)
Material × 2022		0.036***	0.027**	0.027**	0.038**	0.017
		(0.010)	(0.009)	(0.009)	(0.016)	(0.016)
Energy Use × Energy CPI	13.957	12.452	13.487	13.596	22.413	20.097
	(14.310)	(11.766)	(14.500)	(14.306)	(14.923)	(25.958)
Sample	Full	Full	Full	Full	Concentrated	Non-Conc.
Controls						
Other constraints			✓	✓	✓	✓
Other constraints interacted				✓	✓	✓
Fixed effects						
Industry-time	✓	✓	✓	✓	✓	✓
Country-time	✓	✓	✓	✓	✓	✓
Industry-country	✓	✓	✓	✓	✓	✓
Observations	4,885	4,885	4,490	4,490	1,684	2,038
R-squared	0.898	0.881	0.897	0.898	0.906	0.916

Table A.1: Supply-chain constraint pass-through to PPI. This table presents estimation results from Specification (A.1) in Column (1) and Specification (A.2) in Columns (2)-(6). The dependent variable is the one-quarter ahead annual PPI growth at the industry-country level. *Material*, *Labor*, *Financial*, and *Other* measure the share of firms that indicate that their production is constrained by the respective constraint at the industry-country level. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) uninteracted in Columns (3)-(6) and, in addition, these other constraints interacted with the three year dummies in Columns (4)-(6). *Energy CPI* is the country-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. Columns (1)-(4) are estimated in the full sample. Columns (5)-(6) are estimated in the subsample of concentrated and non-concentrated industries, respectively, where this sample split is based on the median HHI calculated at the industry-quarter level. Standard errors are double-clustered at the industry-country and quarterly level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

for the subsample of Concentrated (Column 5) and Non-Concentrated (Column 6) industries. This sample split is based on the median Herfindahl–Hirschman index (HHI) calculated at the industry-quarter level based on firms' sales. The estimation results are consistent with firms being less able to pass on higher production costs in non-concentrated markets (Column 6) as customers can more easily switch to other suppliers following a price increase. This is not the case in concentrated markets (Column 5) where producers with higher pricing power are better able to avert a drop in their margins. This evidence indicates that the pass-through of supply-chain frictions to producer prices is influenced by firm pricing power.

B Additional Tables

	(1)	(2)	(3)
	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$
Material	0.095**		
	(0.044)		
Material × Accurate	0.163***	0.178***	-0.043
	(0.026)	(0.027)	(0.136)
Material × Accurate × Search			0.382*
			(0.232)
Accurate	-0.023***	-0.020***	-0.036*
	(0.004)	(0.004)	(0.019)
Accurate × Search			0.033
			(0.034)
Food Inflation	0.399***		
	(0.074)		
Energy Inflation	0.030***		
	(0.011)		
Core Inflation	0.479***		
	(0.170)		
High Perception	0.345***	0.338***	0.343***
	(0.005)	(0.005)	(0.006)
Controls			
Other constraints	✓		
Fixed effects			
Country-time		✓	✓
Household	✓	✓	✓
Observations	126,080	126,080	106,144
R-squared	0.587	0.594	0.600

Table B.1: Supply-chain constraint pass-through to household inflation expectations: Interactions with household characteristics – Robustness. This table presents estimation results from Specification (6). The dependent variable is a household-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 level to the country 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 a difference between realized inflation over the last 12 months and the household's inflation estimate for the last 12 months is less than 2pp. *Search* is a country-level variable measuring the intensity of Google searches for "delays in shipping" (in the respective country's language) over time. Non-reported controls include the other perceived constraints to production (*Labor*, *Financial*, and *Other*) in Column (1). *Energy Inflation* and *Food Inflation* are the country-level CPI indices for energy and food, respectively. *High Perception* is a dummy equal to one for households that believe prices increased a lot 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.

	(1)	(2)	(3)	(4)
	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$
Age range	16-29	30-49	50-65	65+
Material × 2020	0.963*	1.911***	2.568***	2.332***
	(0.457)	(0.510)	(0.475)	(0.605)
Material × 2021	0.282	0.415*	0.733**	0.772**
	(0.271)	(0.226)	(0.304)	(0.311)
Material × 2022	0.342	0.479	0.723**	0.821**
	(0.225)	(0.335)	(0.340)	(0.371)
Food Inflation	-0.110	-0.367	-0.548	-0.413
	(0.308)	(0.406)	(0.479)	(0.451)
Energy Inflation	0.024	0.071*	0.095*	0.131**
	(0.046)	(0.034)	(0.045)	(0.049)
Core Inflation	0.485	0.566	0.728	0.907
	(0.399)	(0.562)	(0.725)	(0.785)
High Perception	0.128**	0.153*	0.182**	0.059
	(0.053)	(0.080)	(0.071)	(0.070)
Controls				
Other constraints	✓	✓	✓	✓
Other constraints interacted	✓	✓	✓	✓
Fixed effects				
Country	✓	✓	✓	✓
Observations	305	305	305	305
R-squared	0.632	0.657	0.659	0.668

Table B.2: Supply-chain constraint pass-through to household inflation expectations: Age split. This table presents estimation results from Specification (5) separately for different respondent age ranges. The dependent variable is the share of households that believe consumer prices will increase more rapidly at the country-time 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 level to the country 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 and, in addition, these other constraints interacted with the three year dummies. *Energy Inflation* and *Food Inflation* are the country-level CPI indices for energy and food, respectively. *High Perception* is the share of households 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.

	(1)	(2)	(3)	(4)
	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$
Income range	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Material × 2020	1.818***	2.197***	2.209***	1.798***
	(0.567)	(0.541)	(0.486)	(0.447)
Material × 2021	0.456	0.653**	0.498*	0.627**
	(0.311)	(0.305)	(0.283)	(0.269)
Material × 2022	0.655*	0.657*	0.557	0.579*
	(0.340)	(0.367)	(0.345)	(0.329)
Food Inflation	-0.240	-0.487	-0.561	-0.713
	(0.419)	(0.437)	(0.462)	(0.445)
Energy Inflation	0.010	0.110**	0.110*	0.073
	(0.038)	(0.049)	(0.052)	(0.053)
Core Inflation	1.123*	1.061	0.776	0.793
	(0.577)	(0.691)	(0.681)	(0.611)
High Perception.	0.144*	0.143**	0.164**	0.136*
	(0.080)	(0.052)	(0.070)	(0.070)
Controls				
Other constraints	✓	✓	✓	✓
Other constraints interacted	✓	✓	✓	✓
Fixed effects				
Country	✓	✓	✓	✓
Observations	305	305	305	305
R-squared	0.670	0.654	0.630	0.610

Table B.3: Supply-chain constraint pass-through to household inflation expectations: Income split. This table presents estimation results from Specification (5) separately for different respondent income ranges. The dependent variable is the share of households that believe consumer prices will increase more rapidly at the country-time 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 level to the country 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 and, in addition, these other constraints interacted with the three year dummies. *Energy Inflation* and *Food Inflation* are the country-level CPI indices for energy and food, respectively. *High Perception* is the share of households 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.

	(1)	(2)	(3)
	$\hat{\pi}^e$	$\hat{\pi}^e$	$\hat{\pi}^e$
Education	Primary	Secondary	Further
Material × 2020	1.789***	2.246***	1.711***
	(0.524)	(0.571)	(0.409)
Material × 2021	0.426*	0.667**	0.428*
	(0.232)	(0.281)	(0.242)
Material × 2022	0.658**	0.638*	0.404
	(0.267)	(0.319)	(0.322)
Food Inflation	-0.021	-0.329	-0.772
	(0.441)	(0.413)	(0.466)
Energy Inflation	0.056	0.091**	0.096*
	(0.055)	(0.042)	(0.051)
Core Inflation	0.494	0.719	0.619
	(0.867)	(0.563)	(0.644)
High Perception.	0.119*	0.140*	0.165**
	(0.057)	(0.075)	(0.071)
Controls			
Other constraints	✓	✓	✓
Other constraints interacted	✓	✓	✓
Fixed effects			
Country	✓	✓	✓
Observations	305	305	305
R-squared	0.656	0.680	0.647

Table B.4: Supply-chain constraint pass-through to household inflation expectations: Education split. This table presents estimation results from Specification (5) separately for different respondent education groups. The dependent variable is the share of households that believe consumer prices will increase more rapidly at the country-time 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 level to the country 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 and, in addition, these other constraints interacted with the three year dummies. *Energy Inflation* and *Food Inflation* are the country-level CPI indices for energy and food, respectively. *High Perception* is the share of households 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.

	(1)	(2)
	$\hat{\pi}^e$	$\hat{\pi}^e$
Gender	Male	Female
Material × 2020	1.779***	2.211***
	(0.445)	(0.552)
Material × 2021	0.534**	0.533*
	(0.227)	(0.284)
Material × 2022	0.521*	0.598*
	(0.287)	(0.335)
Food Inflation	-0.538	-0.319
	(0.393)	(0.451)
Energy Inflation	0.094**	0.073
	(0.038)	(0.048)
Core Inflation	0.815	0.672
	(0.551)	(0.646)
High Perception.	0.118	0.163*
	(0.068)	(0.077)
Controls		
Other constraints	✓	✓
Other constraints interacted	✓	✓
Fixed effects		
Country	✓	✓
Observations	305	305
R-squared	0.664	0.680

Table B.5: Supply-chain constraint pass-through to household inflation expectations: Gender split. This table presents estimation results from Specification (5) separately for male and female respondents. The dependent variable is the share of households that believe consumer prices will increase more rapidly at the country-time 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 level to the country 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 and, in addition, these other constraints interacted with the three year dummies. *Energy Inflation* and *Food Inflation* are the country-level CPI indices for energy and food, respectively. *High Perception* is the share of households 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.

	(1) CPI Growth	(2) CPI Growth	(3) CPI Growth	(4) CPI Growth	(5) CPI Growth
Low Material Growth × 2020	-1.240**	-1.086	-0.932	-1.101	-2.309
	(0.514)	(0.930)	(0.615)	(0.686)	(1.410)
Low Material Growth × 2021	-1.619***	-1.482**	-1.694**	-1.745**	-2.484**
	(0.533)	(0.634)	(0.737)	(0.752)	(1.088)
Low Material Growth × 2022	-3.897***	-4.652***	-3.301***	-3.293**	-4.168**
	(0.874)	(1.293)	(1.078)	(1.266)	(1.455)
Low Material Growth × Material	-0.146**	-0.213**	-0.087	-0.282**	-0.246**
	(0.055)	(0.094)	(0.089)	(0.098)	(0.104)
Low Material Growth × Material × 2020	0.095	-0.143	0.166	-0.014	0.321
	(0.069)	(0.122)	(0.098)	(0.134)	(0.198)
Low Material Growth × Material × 2021	0.101*	0.166**	0.043	0.203**	0.217*
	(0.058)	(0.075)	(0.088)	(0.088)	(0.117)
Low Material Growth × Material × 2022	0.135**	0.242**	0.045	0.187*	0.218*
	(0.061)	(0.093)	(0.091)	(0.104)	(0.110)
Low Energy × 2020	0.844**	1.361*	0.431	1.752***	0.127
	(0.367)	(0.679)	(0.373)	(0.499)	(0.887)
Low Energy × 2021	-0.597	-0.837	-0.523	-0.037	-1.887**
	(0.456)	(0.526)	(0.659)	(0.532)	(0.746)
Low Energy × 2022	0.806	0.648	1.021	1.019	-1.184
	(0.888)	(0.978)	(1.137)	(0.792)	(1.332)
Low Energy × Energy CPI	0.090**	0.109***	0.063	0.055**	0.033
	(0.036)	(0.030)	(0.071)	(0.026)	(0.111)
Low Energy × Energy CPI × 2020	-0.080	-0.099**	-0.002	0.033	-0.441
	(0.048)	(0.041)	(0.100)	(0.058)	(0.271)
Low Energy × Energy CPI × 2021	-0.053	-0.067**	-0.005	-0.025	-0.018
	(0.037)	(0.029)	(0.078)	(0.029)	(0.110)
Low Energy × Energy CPI × 2022	-0.062	-0.070**	-0.047	-0.033	0.061
	(0.036)	(0.029)	(0.073)	(0.028)	(0.095)
Sample	Full Sample	High Inflation Expectations	Low Inflation Expectations	High Collective Bargaining	Low Collective Bargaining
Controls	✓	✓	✓	✓	✓
Fixed effects					
Country-time	✓	✓	✓	✓	✓
Product-country	✓	✓	✓	✓	✓
Observations	9,187	4,582	4,605	5,110	3,053
R-squared	0.557	0.509	0.601	0.505	0.631

Table B.6: Pass-through of supply-chain constraints to generalized inflation: Horse race between supply-chain and energy cost shocks. This table presents estimation results from Specification (7). 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 level to the country level using the share of consumption that each industry contributes to the final household consumption. *Low Material Growth* is a dummy variable equal to one if the increase between 2020:Q4 and 2021:Q4 in the material supply constraint for the respective product is below the country median. *High Inflation Expectation* countries are defined as countries with an above median share of households responding that prices will increase more rapidly in 2022. *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, these other constraints interacted with the three year dummies. *Energy CPI* is the country-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. *Low Energy* is a dummy variable equal to one if the increase between 2021:Q1 and 2022:Q2 in *Energy Use* × *Energy CPI* for the respective product is below the country median. 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) Markup	(2) Markup	(3) Markup	(4) Markup
Age range	16-29	30-49	50-65	65+
Material × Markup^{2018}	-0.344***	-0.331**	-0.325**	-0.323**
	(0.130)	(0.147)	(0.150)	(0.137)
Material × Markup^{2018} × 2020	0.131	0.128	0.141	0.119
	(0.180)	(0.181)	(0.189)	(0.198)
Material × Markup^{2018} × 2021	0.468***	0.485**	0.511**	0.539***
	(0.176)	(0.202)	(0.206)	(0.202)
Material × Markup^{2018} × 2022	0.521**	0.557**	0.450**	0.440**
	(0.230)	(0.241)	(0.222)	(0.207)
HH Infl Exp × Markup^{2018}	-0.566*	-0.429	-0.500	-0.742*
	(0.338)	(0.343)	(0.361)	(0.440)
HH Infl Exp × Markup^{2018} × 2020	0.140	0.073	0.185	0.543
	(0.333)	(0.358)	(0.418)	(0.521)
HH Infl Exp × Markup^{2018} × 2021	0.106	-0.391	-0.481	-0.045
	(0.579)	(0.517)	(0.561)	(0.483)
HH Infl Exp × Markup^{2018} × 2022	1.260	1.439*	1.345**	1.544**
	(0.947)	(0.732)	(0.626)	(0.624)
Markup^{2018}	100.422***	97.688***	99.331***	103.383***
	(6.930)	(7.168)	(7.790)	(8.797)
Fixed effects				
Industry-country-time	✓	✓	✓	✓
Observations	11,724	11,724	11,724	11,724
R-squared	0.706	0.707	0.707	0.707

Table B.7: Household inflation expectations and firm markups: Age split. This table presents estimation results from Specification (9) separately for different respondent age ranges. The dependent variable is a firm's markup, which we estimate following De Loecker et al. (2020). *Material* measures the share of firms that indicate that their production is constrained by supply-chain problems at the industry-country level. *HH Infl Exp* measures the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months. $Markup^{2018}$ measures a firm's markup in the fiscal year 2018. The analysis includes all firms in Compustat for which markups can be estimated. All specifications include industry-country-quarter fixed effects. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
	Markup	Markup	Markup	Markup
Income range	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Material × Markup^{2018}	-0.335**	-0.327**	-0.309**	-0.353**
	(0.152)	(0.144)	(0.145)	(0.138)
Material × Markup^{2018} × 2020	0.126	0.141	0.102	0.172
	(0.180)	(0.180)	(0.187)	(0.187)
Material × Markup^{2018} × 2021	0.498**	0.500**	0.475**	0.515***
	(0.213)	(0.200)	(0.202)	(0.197)
Material × Markup^{2018} × 2022	0.464**	0.501**	0.523**	0.538**
	(0.213)	(0.228)	(0.236)	(0.218)
HH Infl Exp × Markup^{2018}	-0.356	-0.524	-0.537	-0.540*
	(0.362)	(0.352)	(0.350)	(0.324)
HH Infl Exp × Markup^{2018} × 2020	0.067	0.113	0.302	0.095
	(0.425)	(0.347)	(0.392)	(0.299)
HH Infl Exp × Markup^{2018} × 2021	-0.451	-0.258	-0.139	-0.245
	(0.475)	(0.570)	(0.461)	(0.493)
HH Infl Exp × Markup^{2018} × 2022	1.494**	1.541**	1.381**	1.455**
	(0.671)	(0.704)	(0.631)	(0.599)
Markup^{2018}	97.121***	99.516***	99.755***	100.050***
	(7.601)	(7.278)	(7.282)	(7.041)
Fixed effects				
Industry-country-time	✓	✓	✓	✓
Observations	11,724	11,724	11,724	11,724
R-squared	0.707	0.707	0.707	0.707

Table B.8: Household inflation expectations and firm markups: Income split. This table presents estimation results from Specification (9) separately for different respondent income ranges. The dependent variable is a firm's markup, which we estimate following De Loecker et al. (2020). *Material* measures the share of firms that indicate that their production is constrained by supply-chain problems at the industry-country level. *HH Infl Exp* measures the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months. $Markup^{2018}$ measures a firm's markup in the fiscal year 2018. The analysis includes all firms in Compustat for which markups can be estimated. All specifications include industry-country-quarter fixed effects. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Markup	(2) Markup	(3) Markup
Education	Primary	Secondary	Further
Material × Markup^{2018}	-0.323**	-0.332**	-0.330**
	(0.141)	(0.145)	(0.146)
Material × Markup^{2018} × 2020	0.124	0.100	0.149
	(0.177)	(0.183)	(0.184)
Material × Markup^{2018} × 2021	0.517**	0.496**	0.490**
	(0.200)	(0.206)	(0.204)
Material × Markup^{2018} × 2022	0.443**	0.510**	0.518**
	(0.216)	(0.221)	(0.226)
HH Infl Exp × Markup^{2018}	-0.592	-0.524	-0.509
	(0.427)	(0.360)	(0.390)
HH Infl Exp × Markup^{2018} × 2020	0.295	0.414	0.052
	(0.447)	(0.402)	(0.376)
HH Infl Exp × Markup^{2018} × 2021	-0.120	-0.105	-0.380
	(0.608)	(0.566)	(0.506)
HH Infl Exp × Markup^{2018} × 2022	1.687**	1.558**	1.440**
	(0.775)	(0.717)	(0.648)
Markup^{2018}	100.813***	99.552***	99.362***
	(8.494)	(7.511)	(8.186)
Fixed effects			
Industry-country-time	✓	✓	✓
Observations	11,724	11,724	11,724
R-squared	0.707	0.707	0.707

Table B.9: Household inflation expectations and firm markups: Education split. This table presents estimation results from Specification (9) separately for different respondent education groups. The dependent variable is a firm's markup, which we estimate following De Loecker et al. (2020). *Material* measures the share of firms that indicate that their production is constrained by supply-chain problems at the industry-country level. *HH Infl Exp* measures the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months. $Markup^{2018}$ measures a firm's markup in the fiscal year 2018. The analysis includes all firms in Compustat for which markups can be estimated. All specifications include industry-country-quarter fixed effects. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Markup	(2) Markup
Gender	Male	Female
Material × $Markup^{2018}$	-0.331**	-0.327**
	(0.135)	(0.146)
Material × $Markup^{2018}$ x 2020	0.136	0.123
	(0.189)	(0.184)
Material × $Markup^{2018}$ × 2021	0.512***	0.486**
	(0.196)	(0.205)
Material × $Markup^{2018}$ × 2022	0.479**	0.531**
	(0.211)	(0.228)
HH Infl Exp × $Markup^{2018}$	-0.587	-0.542
	(0.368)	(0.385)
HH Infl Exp × $Markup^{2018}$ 2020	0.303	0.232
	(0.367)	(0.436)
HH Infl Exp × $Markup^{2018}$ × 2021	-0.405	-0.073
	(0.487)	(0.591)
HH Infl Exp × $Markup^{2018}$ × 2022	1.462*	1.665***
	(0.756)	(0.637)
$Markup^{2018}$	101.043***	99.287***
	(7.771)	(7.576)
Fixed effects		
Industry-country-time	✓	✓
Observations	11,724	11,724
R-squared	0.707	0.707

Table B.10: Household inflation expectations and firm markups: Gender split. This table presents estimation results from Specification (9) separately for male and female respondents. The dependent variable is a firm's markup, which we estimate following De Loecker et al. (2020). *Material* measures the share of firms that indicate that their production is constrained by supply-chain problems at the industry-country level. *HH Infl Exp* measures the share of households in a country-quarter that believe consumer prices will increase more rapidly over the next 12 months. $Markup^{2018}$ measures a firm's markup in the fiscal year 2018. The analysis includes all firms in Compustat for which markups can be estimated. All specifications include industry-country-quarter fixed effects. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

C Additional Figures

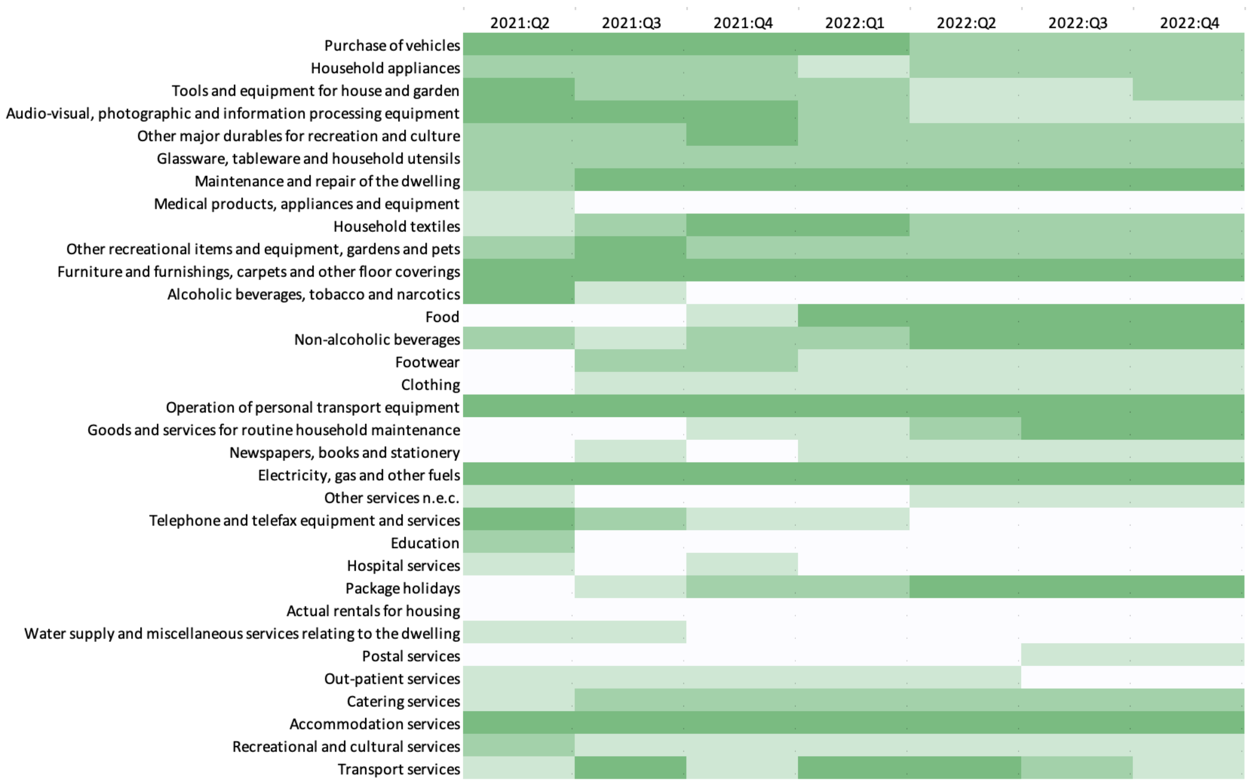

Figure C.1: Inflation propagation across industries. This figure shows the propagation of inflation across industries and time. The x-axis shows dates characterized by inflation (2021:Q1 onward). The y-axis shows industries ranked by supply-chain issues, namely industries that experienced the worse supply-chain issues on top and industries that experienced less supply-chain issues at the bottom. Colors are based on the quartiles of "abnormal inflation" in each quarter. Abnormal inflation at time t in industry j is defined as the difference between inflation in $\{jt\}$ and the mean inflation observed in j in 2019:Q1-2020:Q2.

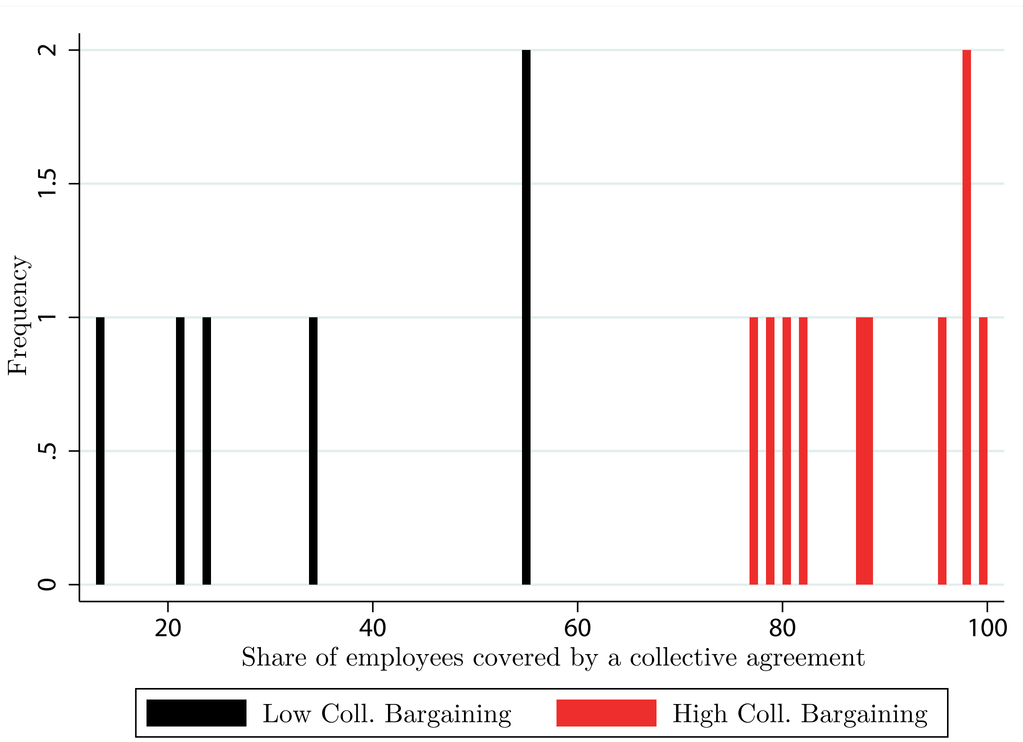

Figure C.2: Share of employees covered by a collective agreement. This figure shows the distribution of the adjusted collective bargaining coverage rate from the OECD/AIAS ICTWSS database for our sample countries. This coverage rate is defined as the number of employees covered by a collective agreement 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).