Pandemic disruptions in global supply chains: evidence on trade values and prices from French firms[*]

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Abstract

This paper examines how firms responded to the disruptions caused by the global supply chain (GSC) shocks induced by the COVID-19 pandemic. Leveraging firm-level trade data from France, we analyze shifts in export and import values and prices in response to transportation bottlenecks and pandemic containment measures in partner countries. Our findings reveal that firms adapted to these shocks by temporarily scaling back trade volumes and dropping varieties. During the recovery phase, supply chain bottlenecks stoked inflation, disproportionately affecting upstream industries. Furthermore, we demonstrate that firms using industrial robots in production and those with prudent inventory management practices were more resilient to the pandemic shock.

Keywords: COVID-19, French firms, trade, supply chains disruptions, rising costs, inflationary pressures.

JEL Codes: D22; F10.

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1 Introduction

Global supply chain disruptions caused by the COVID-19 pandemic significantly destabilized international trade. In the first half of 2020, trade flows came to a standstill as containment measures were implemented worldwide. However, as economic activity began to recover, trade flows started to return to pre-pandemic levels in late 2020. Despite this recovery, global transportation networks struggled to keep pace with the surge in demand, leading to increased shipping costs and production delays. Studies by Bonadio et al. [2021], Bai et al. [2024], and Benigno et al. [2022] highlight the impact of pandemic-related global supply chain (GSC) disruptions on output losses and rising producer and consumer prices globally. Nonetheless, many questions regarding firm-level adjustments to these GSC disruptions remain unanswered.

This paper investigates the firm-level adjustments of trade flows and prices in response to the pandemic-induced GSC disruptions. We utilize granular monthly customs data from France for 2020 and 2021 to analyze the responses of exporters and importers to GSC shocks during the initial lockdowns and the subsequent recovery period. The dataset includes not only trade values measured in euros but also information on the quantities of traded goods, enabling us to track changes in unit values as a proxy for prices. The detailed nature of the data allows us to identify which firm and industry characteristics contributed to the dynamic adjustments of trade values and prices in response to the pandemic-related shock.

We integrate the trade data with indices that measure GSC pressures and the stringency of containment measures in France's partner countries. Specifically, we employ the Global Supply Chain Pressure Index (GSCPI) and the Lockdown Stringency Index (LSI) to quantify the magnitude of the shocks. The GSCPI, developed by Benigno et al. [2022], combines monthly data on transportation costs and supply bottlenecks. This index rose sharply at the onset of the pandemic when China implemented its initial lockdowns and peaked at the end of 2021 amid the global transportation crisis and escalating shipping costs. We are the first to utilize this index to examine firm responses to pandemic shocks. Additionally, we complement the GSCPI with the LSI created by Hale et al. [2021], which is a time- and country-specific index that allows us to leverage the variations in the severity of supply chain disruptions linked to mobility restrictions imposed by trade partners of French firms. Together, these indices enable us to trace the dynamic responses of firms' trade values and prices, highlighting key differences in their transmission mechanisms at various stages of the pandemic.

We first characterize the margins of aggregate trade adjustment at firm, product, and country level. We show that French exporters adjusted to the initial COVID-19 shock mainly along the subintensive margin by reducing the volume of exports and imports. About a third of the adjustment is accounted for by the subextensive margin, i.e., firms temporarily halting exports of some varieties, predominantly to low-income trade partners. Our findings suggest that firm exits and entries from exporting and importing (extensive margin) explain a small share of the overall trade collapse. However, the extensive margin played a bigger role in the recovery of trade flows, with many French firms forming new linkages with Chinese exporters.

We use the variation in timing and magnitude of GSCPI and lockdown stringency across countries to measure the effect of GSC disruptions on exports and imports of French firms. Our findings suggest pandemic-related disruptions had sizable effects on trade flows and prices. An increase in the GSC pressures of one deviation above its historical average is associated with about 21 percentage point drop in import growth and a 19 percentage point drop in export growth. Controlling for global shocks to supply chains, we also find a large association between French firms' trade flows and lockdown stringency in partner countries. Lockdown effects are strongest in the early months of the pandemic, which is consistent with the findings in Lafrogne-Joussier et al. [2023] and Bricongne et al. [2025] (refer to Appendix A.1). We show that implementing the most stringent lockdowns (e.g., as in the Philippines in April, 2020) is associated with 66 percentage point drop in exports growth and 46 percentage point drop in imports growth. In addition, we find that GSC shocks contributed to import and export price inflation. Our estimates suggest that import price inflation increased by 0.01 percentage points in response to the GSC shock while export price inflation increased by 0.005 percentage points on average. However, we find no direct evidence of inflationary pressures from lockdowns.

We rely on the local projections method to measure the dynamic effects of lockdown and GSC shocks on trade values and prices. Estimated impulse response functions are distinct in their magnitudes and shapes depending on the outcome of interest—trade values or prices—and the type of shock. Initially, trade values drop in response to a lockdown shock, swiftly recovering afterwards. Trade values drop sharply in response to the GSC shocks, while prices increase. Over time, GSC shocks are more persistent compared to the lockdown shock both with respect to trade values and especially prices. These results align closely with the timing of events in 2020 and 2021, including the onset of inflation.

Granularity of the data allows us to explore how firm, product, and industry heterogeneity contributed to firms' adjustment to GSC shocks. First, we provide novel evidence on the role of robotization as a mitigating factor in firm adjustment. Automation of production processes is associated not only with a smaller decline in trade flows but also smaller inflationary pressures, as these firms are likely to be more agile in adjusting input quality. We also find that inventory management practices also play a role in adjustment: firms with high levels of inventories saw larger declines in exports and imports. While high-inventory firms tend to amplify the shock by relying on existing stockpiles, lean inventory practices, on the other hand, expose firms to higher price inflation. Finally, we show that the inflationary pressures in the upstream industries from the GSC shocks amplify along supply chains, resulting in larger export declines in industries closest to the final consumer.

The rest of the paper is organized as follows. We first review the literature and position the contribution of this paper in the existing body of work. Section 3 describes the firm-level monthly customs dataset used highlighting its granularity and richness. Section 4 investigates the margins of trade adjustment, while Section 5 outlines the main specification used in the empirical analysis. Section 6 reports static and dynamic regression results while Section 7 explores results on product and firm heterogeneity. Section 8 concludes.

2 Contributions to the literature

This study contributes to several strands of literature. First, we contribute to the emerging literature examining the economic effects of global supply chain disruptions (Bonadio et al. [2021], Çakmaklı et al. [2021], Alessandria et al. [2023], Bai et al. [2024], and Acemoglu and Tahbaz-Salehi [2024]). Similarly to our findings, this literature shows large inflationary effects of GSC disruptions in addition to negative effects on output and trade flows. However, most of this literature is theoretical and relies on aggregate data to document supporting evidence. Our study provides micro-level evidence consistent with theoretical predictions on negative real effects and inflationary nature of GSC disruptions. In addition, we complement the existing evidence with more granular analysis on extensive and intensive margins of adjustment to GSC shocks and show the evolution of adjustment over time.

Second, our study contributes to the vast literature examining the impact of the COVID-19 pandemic on trade flows. The vast majority of existing studies use trade data at the country and product level (Cerdeiro and Komaromi [2022], Liu et al. [2022], Berthou and Stumpner [2024], Espitia et al. [2022], Aiyar et al. [2022], and Bas et al. [2023]). Similarly to Aiyar et al. [2022], Berthou and Stumpner [2024], and Liu et al. [2022], we measure the COVID-19 shock using the lockdown stringency index. However, we complement this measure with the GSCPI to gauge broader supply chain bottlenecks. We also contribute to this literature by studying the heterogeneity of responses at the firm level, which allows us to identify additional mitigating factors, including the role of automation and inventories.

Our paper is most closely related to firm-level studies that examine the effect of the COVID-19 pandemic on trade (Lafrogne-Joussier et al. [2023], Bricongne et al. [2025], and Amador et al. [2023]). Similarly to the findings in Bricongne et al. [2025] and Amador et al.

[2023], we show that large firms were also more susceptible to the shock. In line with the key conclusions Lafrogne-Joussier et al. [2023] and Bricongne et al. [2025], we also show that lockdown orders implemented by France's trade partners played a major role on French firm's trade activity in early in 2020. However, we extend their analysis by expanding the time horizon and including recovery period characterized by easing lockdown orders. In addition, we incorporate a broader measure of GSC disruptions, which allows us to study more general repercussions of the pandemic and provide complementary evidence on its inflationary effect beyond real effects. We show that lockdowns had a smaller effect on trade flows and prices after the first half of 2020 and transportation bottlenecks captured by the GSCPI played a bigger role in the recovery period.

The main contribution of this paper to the existing literature at both aggregate and firm levels is its focus on pandemic-related GSC shocks not necessarily captured by lockdown stringency measures. By incorporating the novel measure of global supply chain disruptions, we are able to investigate responses of both trade volumes and prices to these shocks. We borrow the GSCPI from Benigno et al. [2022] who, in addition to introducing the index, apply it to assess its explanatory power in the case of the US inflation. To our knowledge, our paper is the first to relate the index to changes in export and import values and prices at the firm, product, and country level.[1]

Lastly, this paper contributes to the long-standing literature investigating trade in the times of crisis. Bricongne et al. [2012] study the firm-level adjustment to the 2008 financial crisis and show that the adjustment along the intensive margin was mainly due to large firms, which represent 80 percent of their sample, reducing their flow of exports, while small firms adjusted mainly along the extensive margin. Similarly, Gopinath and Neiman [2014] study the margins of adjustment of Argentinian firms to the 2001-2002 crisis. In line with the findings of these studies, we show that the bulk of trade adjustment in response to the COVID-19 shock happened along the intensive margin.

3 Data

We use firm-level monthly customs data from France to analyze the impact of the COVID-19 pandemic on trade flows. Two firm-level datasets are available from the French customs authorities: one contains information on intra-EU trade and the other dataset contains information on extra-EU trade. Both datasets provide information on French firms' monthly

[1] Studies including Hupka [2022], Binici et al. [2022], and Finck and Tillmann [2022] also use GSCPI but focus on macroeconomic effects (predominantly inflation) at the country level. Bai et al. [2024] construct an alternative index of supply chain disruption and also focus on the evolution of macroeconomic outcomes.

imports and exports, including product identifiers, values, quantities, origin and destination countries covering January 1995 to December 2021. Products are classified based on the European CN8 nomenclature system, which is one step more detailed than the international HS6 system. We follow Bergounhon et al. [2018] to harmonize the product classification over time.[2]

Table 1: Summary statistics

	Mean	Standard deviation	Median
Exports			
Values: total change (%)	8.595	561.2	4.526
Unit values: total change (%)	1.382	61.16	0.0876
GSCPI	1.496	1.473	1.422
Lockdown stringency	0.343	0.304	0.417
World demand	6.477	42.11	1.987
VIXCLS	21.33	8.606	18.98
French LSI	0.356	0.297	0.431
French demand growth	-0.150	4.375	-0.00628
Inventory-to-sales ratio	0.168	0.115	0.145
Upstreamness	2.000	0.348	1.975
Share of firms using robots (%)	5.6		
Age	18.91	7.637	24
Size group	2.036	0.740	2
Imports			
Values: total change (%)	8.144	555.4	5.431
Unit values: total change (%)	1.418	65.12	0.317
GSCPI	1.488	1.470	1.422
Lockdown stringency	0.377	0.320	0.467
World demand	7.253	46.29	2.607
VIXCLS	21.32	8.596	19.57
French LSI	0.355	0.298	0.431
French demand growth	-0.144	4.359	-0.00628
Upstreamness	2.038	0.366	1.980
Inventory-to-sales ratio	0.150	0.0527	0.146
Share of firms using robots (%)	3.9		
Age	17.78	8.634	21
Size group	1.803	0.741	2

Notes: We calculate the mean, the standard deviation and the median values of each variable. The share of firms using robots is the share of firms that imported industrial robots in 2017-2019. All values are computed over the 2020-2021 period.

The French government imposed several lockdowns since 2020 to respond to the pandemic, the more stringent being the first one, implemented on March 17th up to May 11th.

[2] Bergounhon et al. [2018] provides the steps to clean French customs data and harmonize them over time along the product dimension following a uniform CPA classification.

We thus focus on the period from January 2018 to December 2021, to study the pandemic impact on trade flows, considering the years 2018 and 2019 as a benchmark. Our main variable of interest, the Global Supply Chain Pressure Index (GSCPI) computed by Benigno et al. [2022], captures the effect of supply chain bottlenecks on international trade that are not necessarily caused by local pandemic conditions. This monthly index is based on the following components: the Baltic Dry Index (BDI), the Harpex index, airfreight cost indices from the U.S. Bureau of Labor Statistics, as well as supply chain-related indicators from Purchasing Managers' Index (PMI) surveys of manufacturing firms from China, the euro area, Japan, South Korea, Taiwan, the United Kingdom, and the United States. The Oxford COVID-19 Government Response Tracker (OxCGRT), compiled by Hale et al. [2021], provides a large number of COVID-related indicators. From this, we use the Lockdown Stringency Index (LSI) to capture the intensity of the pandemic shock among French trade partners, as well as the French Lockdown Stringency Index to control for local pandemic impact.

The performance of French importing and exporting firms may also be impacted by variation in global demand, which was deeply affected by the pandemic over the period. We thus include the year-on-year change of world imports, excluding French imports. We use the UN Comtrade data to compute the growth in imports at the product level. We also control for variation in French demand, proxied by the monthly GDP growth of the French economy OECD [2024]. In addition, we control for the level of demand uncertainty, by including the monthly average level of Chicago Board Options Exchange's Volatility Index (VIXCLS), which captures market volatility.

To investigate differential responses of firms to the pandemic-related shocks, we also utilize information on industry-level characteristics. First, we use a measure of inventory intensity. Industry-level inventory intensity variable is constructed from the firm balance sheet data from 2019 collected by the French National Statistics Insitute (FARE).[3] Finally, we apply the methodology for constructing the upstreamness index from Antràs et al. [2012] using French input-output tables from the OECD [2018]. Table 1 presents summary statistics of the main variables.

4 Three trade margins of adjustment

We measure the relative contribution of firms' adjustment along extensive and intensive margins to the aggregate changes in French exports and imports. To study the margins of

[3] We are grateful to Isabelle Mejean for sharing industry-level information on inventories and sales of French firms.

trade adjustment to the COVID-19 shock in France, we use a strategy similar to Gopinath and Neiman [2014].[4] Entry and exit of firms from export and import markets capture adjustment along the extensive margin. Changes in trade values and in the variety mix of import and export baskets capture adjustments along the subintensive and subextensive margins. A variety is defined as a combination of an imported or exported CN8 product and country of origin or destination. To that end, we can decompose the aggregate year-on-year changes in monthly trade flows, denoted by v_t, as:

$$\begin{aligned}\frac{\Delta v_t}{v_{t-1}} = & \underbrace{\left(\sum_{j \in \Phi_{i,t-1} \cap \Phi_{i,t}} \frac{v_{j,t} - v_{j,t-1}}{v_{t-1}} \right)}_{\text{Subintensive margin}} + \underbrace{\left(\sum_{j \in \Phi_{i,t}, j \notin \Phi_{i,t-1}} \frac{v_{j,t}}{v_{t-1}} - \sum_{j \in \Phi_{i,t-1}, j \notin \Phi_{i,t}} \frac{v_{j,t-1}}{v_{t-1}} \right)}_{\text{Subextensive margin}} \\ & + \underbrace{\left(\sum_{i \in \Psi_t, i \notin \Psi_{t-1}} \frac{v_{i,t}}{v_{t-1}} - \sum_{i \in \Psi_{t-1}, i \notin \Psi_t} \frac{v_{i,t-1}}{v_{t-1}} \right)}_{\text{Extensive margin}}\end{aligned} \tag{1}$$

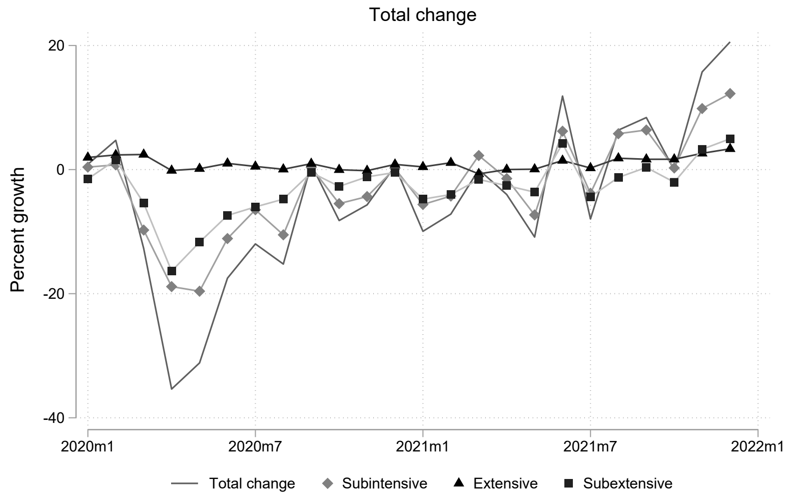
where j denotes a firm $\times$ variety combination, and i denotes a firm. Ψ_t is the set of all importing or exporting firms in period t. $\Phi_{i,t}$ is the set of all varieties in period t of firms exporting or importing in both periods $t-1$ and t or continuing firms. The first term captures the subintensive margin, where continuing firms adjust the value of imported or exported variety. The second term captures the subextensive margin, where continuing firms add or drop varieties from or to their export and import baskets. The last term—the extensive margin—captures firms' exit from or entry to exporting or importing.

Figures 1 and 2 plot the three margins of adjustment over 2020m1-2021m12, for French exporting and importing firms respectively.[5] Considering the peak of the trade shock in the first half of 2020, the extensive margin played a small role in trade adjustment, as both exporting and importing firms adjusted primarily along the subintensive margin. Exporting firms also halted sales of some varieties, a behavior reflected by the large adjustment along the subextensive margin. The adjustment dynamics along the subextensive and subintensive margins are similar for importing firms, with the subintensive margin accounting for almost two thirds of the drop in aggregate imports and exports in the second quarter of 2020. The data for the second half of 2020 and early 2021 suggest that both imports and exports were still declining relative to 2018 and 2019. In the second half of 2021, however, both

[4] Gopinath and Neiman [2014] study mechanics of trade adjustments during the 2000-2002 currency crisis using customs data from Argentina.

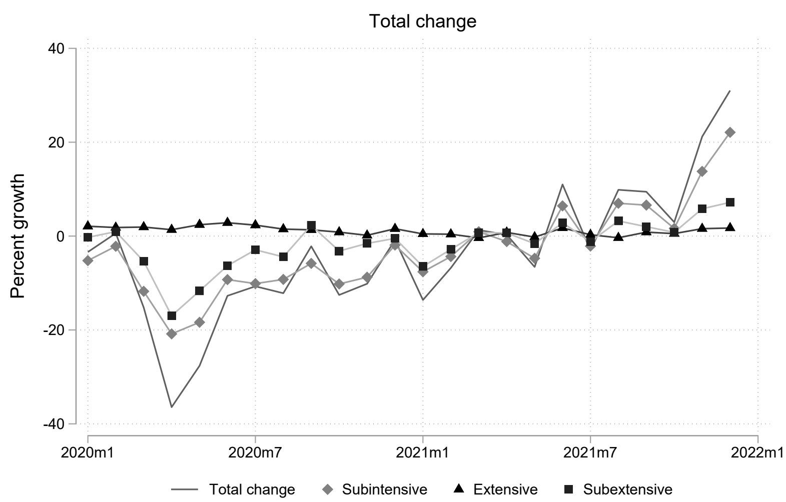
[5] To avoid computing trade flow changes in 2021 relative to 2020, we compute year-on-two-year changes, so that changes are computed over 2018-2020 and 2019-2021.

Figure 1: Trade margins: exports



Notes: We decompose total change in export flows into three trade margins over 2020m1-2021m12: subintensive, extensive and subextensive as defined in Equation 1. Monthly changes are computed as year-on-2 years, comparing 2020 to 2018, and 2021 to 2019.

Figure 2: Trade margins: imports



Notes: We decompose total change in import flows into three trade margins over 2020m1-2021m12: subintensive, extensive and subextensive as defined in Equation 1. Monthly changes are computed in year-on-2 years terms, comparing 2020 to 2018, and 2021 to 2019.

exports and imports begin a steady ascent with growth rates peaking in December 2021. This rise in trade flows is accompanied by major supply chain bottlenecks as evidenced by the skyrocketing GSCPI, which reached its highest historical value of about 4.3 in December

2021.[6] Subintensive and subextensive margins account for most of the expansion in both exports and imports, while firm entry into exporting or importing played a smaller role. This finding suggests that the COVID-19 shock is transitory in nature.[7]

Table 2: Contribution of margins to changes in trade flows by trading partner

	Percent total	Share subintensive	Share subextensive	Share extensive
Exports				
AE	-34.56	0.74	0.24	0.02
EM excl. China	-39.73	0.43	0.57	-0.004
China	-27.92	1.02	-0.01	-0.01
LIDC	-34.48	0.10	0.89	0.01
Imports				
AE	-28.97	0.87	0.13	0.005
EM excl. China	-41.54	0.80	0.14	0.06
China	21.02	-0.32	0.36	0.96
LIDC	-39.41	0.65	0.05	0.30

Notes: We calculate year-on-year percent changes in exports and imports between 2020Q2 and 2019Q2 for each group. The contributions of three margins add to one.

We perform the decomposition in Equation 1 for three country groups categorized by countries' income per capita levels—advanced economies (AE), emerging markets (EM), and low-income and developing countries (LIDC)—and China separately. Table 2 summarizes the contribution of each margin to the total change in exports and imports between 2019Q2 and 2020Q2, focusing on the quarter including the first wave of lockdowns outside of China. The top panel shows that adjustment along the subintensive margin accounted only for 1 percent of total drop of exports to LIDCs in the second quarter of 2020, while it accounted for the majority of the decline in exports to AEs. The subextensive margin played a major role in explaining the changes in exports to developing countries, accounting for 57 percent in EMs and 89 percent in LIDCs.

As shown in the bottom panel of Table 2, the subintensive margin played a major role in total variation of imports, accounting for at least two-thirds of imports for all country groups, except for trade with China which stands out in French firms' import patterns in 2020. Adjustment in imports from China along the extensive margin explains almost all of the observed change suggesting that many firms previously not importing from China began

[6]Data on GSCPI is available since September, 1997. For reference, GSCPI value in December 2019 was about zero.

[7]Similarly, using firm-to-firm sales data from an Indian state, Khanna et al. [2022] show that supplier separation rates along the subextensive margin increased sharply following lockdowns. We also find that intensive margin accounted for the majority of trade adjustment during the Great Trade Collapse (GTC) of 2009 (these results are available upon request).

doing so in the second quarter of 2020. This is consistent with the earlier onset of the virus spread in China: by the time the rest of the world was entering into first lockdown, China has adapted its supply chains and recommenced production. Trade margin plots by country group in Appendix Figures A1 and A2 further show that Chinese imports rebounded swiftly in the first half of 2020, while imports from all other countries took longer to recover.

5 Econometric Specification

Static specification. The empirical strategy relies on the time variation of the GSCPI to measure the effect of disruptions in the GSC during the pandemic. We also rely on the variation in the magnitude and timing of the COVID-19 shock, measured by the stringency of lockdowns imposed by French firms' international trade partners. Lockdown stringency captures the severity of the pandemic and associated containment policies. Given that the analysis is performed from the vantage point of French firms, domestic pandemic containment policies, conditional on the industry, are assumed to apply to all French firms uniformly.

We first estimate the average effects of global supply chain pressures and partner countries' lockdown policies on firm- and product-level monthly exports and imports as follows:

$$y_{i,p,c,t} = \beta_0 + \beta_1 \mathrm{GSCPI}_t + \beta_2 \mathrm{LSI}_{c,t} + \gamma X_t + \sigma D_{p,t} + \alpha_{i,p,c} + \epsilon_{i,p,c,t}. \tag{2}$$

GSCPI_t denotes the monthly Global Supply Chain Pressure Index. The Lockdown Stringency Index, denoted by $\mathrm{LSI}_{c,t}$, is a monthly average of the country-specific daily index.[8] X_t contains time-varying controls: monthly lockdown stringency index in France capturing domestic pandemic conditions, monthly change in French demand proxied by GDP growth, and a monthly average level of Chicago Board Options Exchange's Volatility Index (VIXCLS) measuring global market volatility. $D_{p,t}$ denotes year-on-year changes in world demand at the product level proxied by monthly import demand by France's trade partners $\alpha_{i,p,c}$ denotes firm-product-country fixed effects and $\epsilon_{i,p,c,t}$ is an error term.

$y_{i,p,c,t}$ is a mid-point year-on-year growth rate of trade flows between firm i and country c of product p in month t:

$$y_{i,p,c,t} = \frac{\mathrm{Y}_{i,p,c,t} - \mathrm{Y}_{i,p,c,t-12}}{\frac{1}{2}\left(\mathrm{Y}_{i,p,c,t} + \mathrm{Y}_{i,p,c,t-12}\right)}, \tag{3}$$

where $\mathrm{Y}_{i,p,c,t}$ denotes export or import values. There are advantages of measuring growth

[8] We also consider alternative sets of fixed effects and show the results in Appendix Table A1, although this prevents us from estimating the impact of GSC pressures on trade flows.

in trade using the mid-point growth formula. One, the mid-point growth measure allows to account for seasonality effects. Two, given that entries and exits of firms from international trade are more frequent in product and country-level monthly data, the formula accounts for the adjustment of trade values along the extensive margin.

In addition to trade flows, we examine the effect of the GSC and lockdown shocks on import and export prices. This allows us to test whether the changes in trade values are driven by changes in prices as opposed to changes in the volumes of traded goods. While French customs data only contain information on quantities and not on prices, we compute unit values as a proxy for prices by dividing the values by the corresponding units of a traded good. We compute the mid-point growth in unit values for continuing varieties and use it as a dependent variable in Equation 2. We thus focus on responses in unit values for adjustments along the intensive margin only.

We also examine the heterogeneity in the magnitude of the pandemic shock across various firm, product, and country characteristics. Since many of the characteristics that we consider in Section 7 are time-invariant, we interact the main variables of interest—GSCPI and LSI—with these characteristics.

Dynamic specification. In addition to estimating the average responses of trade flows and prices to the pandemic shocks, we are interested in tracing the path of these responses over time. This allows us to examine the potential response lags and speed of adjustment. To measure the dynamic effect of the shocks on French trade flows, we rely on the local projections methodology developed by Jordà [2005]. To estimate impulse response functions (IRFs) of the lockdown and GSC shocks for traded values and prices, we use the following linear model:

$$
\begin{aligned}
y_{i,p,c,t+f} = {} & \beta_0^f + \beta_1^f \mathrm{GSCPI}_t + \beta_2^f \mathrm{LSI}_{c,t} + \sum_{l=1}^{L} \sigma_l^f \mathrm{GSCPI}_{t-l} + \sum_{l=1}^{L} \kappa_l^f \mathrm{LSI}_{c,t-l} + \sum_{l=0}^{L} \phi_l^f y_{i,p,c,t-l} \\
& + \gamma X_t + \sigma D_{p,t} + \alpha_{i,p,c}^f + \epsilon_{i,p,c,t+f} \quad \text{for } f = 1, \cdots, F.
\end{aligned} \tag{4}
$$

Similarly to the static regression, $y_{i,p,c,t+f}$ denotes a change in export or import values or prices. We include lags of the dependent variable as well as the two shocks of interest, GSCPI_t and $\mathrm{LSI}_{c,t}$ and their corresponding lags. The rest of the variables are defined analogously to the static specification. We estimate Equation 4 via OLS for each period f separately and back out Newey and West [1987] standard errors. The estimated β_1^f and β_2^f for $f = 1, \cdots, F$ reflect the response of trade variables to changes in the GSCPI or the change in lockdown stringency imposed in trade partner countries up to F months out.

Our objective is to measure the effect of GSC and lockdown shocks over the entire path, including anticipation effects of subsequent shocks. As shown in De Chaisemartin and d'Haultfoeuille [2024], GSC and lockdown shocks are likely to be serially correlated in the dynamic specification. The resulting IRFs based on the local projections method thus account for the non-zero probability of subsequent shocks Jordà [2023] and do not consider the effect of the initial shock in isolation.

Potential sources of bias. Our primary parameters of interest in Equation 2 are β_1 and β_2, which capture the effect of global supply chain disruptions and pandemic containment policies in partner countries on French firms' import and export values and prices. First, we rely on time variation in GSCPI to capture disruptions in global supply chains. Changes in GSCPI, however, could be correlated with changes in global demand. To deal with these confounding factors, we control for world demand conditions captured by the year-on-year changes in total imports of French trade partners at the product level and the monthly average VIXCLS. We also control for pandemic-related shocks to French consumers' demand by including the monthly lockdown stringency index for France as a control.

Second, lockdown stringency index varies across French firms' trade partners and time. Firm-country-product fixed effects control for any time-invariant differences in firm characteristics and product-specific trade flows between French firms and partner countries explained by standard gravity factors (geographical and cultural characteristics of trade partners, trade agreements and other trade barriers). However, inclusion of the GSCPI in the regression precludes the use of time fixed effects. Our estimates can thus suffer from bias stemming from time-varying changes in trade partner-specific demand and supply not explained by global supply chain disruptions, global demand conditions, and lockdowns. We thus perform a battery of robustness checks including firm-time and firm-product-time fixed effects. Results reported in Appendix Table A1 show that country-specific shocks not explained by lockdown intensity could indeed be a source of bias. These findings also suggest that lockdown timing and stringency levels are likely to be correlated among French trade partners.

Finally, it is important to point out that all unit value regressions include only continuing firms and varieties. While this allows us to consistently compute price changes for narrowly defined varieties, it introduces selection bias. It is possible that only the most productive relationships survive the shocks while those with prohibitive price hikes are terminated. The resulting coefficient, in this case, are likely to be biased downwards, understating the inflationary pressure of GSC and lockdown shocks.

6 Baseline results

In this section, we discuss baseline static and dynamic estimates for responses of trade values and prices to GSC and lockdown shocks.

6.1 Static results

Table 3 reports static results based on the specification in Equation 2 for trade values and prices. The first column shows the average effect of GSCPI and lockdown stringency on French firms' exports growth. The estimated effect of GSCPI on aggregate export growth is negative and statistically significant, suggesting that disruptions in the logistics networks impeded the flow of French exports to other countries. One standard deviation increase in the GSCPI above its historical average is associated with almost 19 percentage point decline in exports growth. Likewise, the coefficient on LSI is also negative. An increase of one standard deviation in the monthly LSI (about 0.3 on a scale from 0 to 1) is associated with about 20 percentage point drop in aggregate exports growth, when the GSC pressures, world demand conditions, growth of French aggregate demand, and lockdowns in France are controlled for. Implementing the most stringent lockdowns (e.g., as in the Philippines in April of 2020) implies a drop in exports of almost 66 percent.[9]

Column 3 of Table 3 shows the estimates for French imports. GSC pressures are a larger contributor to trade slowdown experienced by French importers: a standard deviation increase in the GSCPI is associated with 21 percentage point drop in import growth. On the other hand, the effect of lockdowns is considerably smaller and only marginally statistically significant in the case of import growth—one standard deviation increase in the stringency of lockdowns in countries exporting to France is associated with about 14 percent decline in the value of goods imported by French firms. These results are consistent with the real effects of pandemic shocks predicted by theoretical models in Bonadio et al. [2021] and Çakmaklı et al. [2021].

To evaluate the inflationary effects of GSC and lockdown shocks, we consider changes in unit values at the firm-product-country level. We isolate continuing firms and varieties, thus only capturing trade adjustments along the intensive margin. Results in Columns 2 and 4 of Table 3 show that GSC shocks exerted inflationary pressure on export and import prices. Stricter lockdowns in partner countries have no statistically significant effect on prices, when GSC bottlenecks and world demand conditions are controlled for. The inflationary effect

[9] We cluster at the country and month level in our baseline specification in line with the level of variation of the key variable of interest–GSCPI. Clustering at the country level provides similar results, with smaller standard errors.

Table 3: Average static results

	(1) export values	(2) export unit values	(3) import values	(4) import unit values
GSCPI	-18.828***	0.005***	-20.968***	0.010***
	(2.831)	(0.001)	(2.971)	(0.002)
LSI	-66.575***	-0.000	-45.849***	-0.003
	(17.050)	(0.007)	(16.289)	(0.009)
World demand	0.068	0.000***	0.117***	0.000***
	(0.042)	(0.000)	(0.041)	(0.000)
French LSI	8.891	-0.001	-15.241	-0.015
	(32.042)	(0.009)	(33.415)	(0.013)
VIXCLS	2.169**	-0.001***	2.653***	-0.001**
	(0.834)	(0.000)	(0.836)	(0.000)
French demand	2.323**	-0.000	2.766***	-0.000
	(0.936)	(0.000)	(0.930)	(0.000)
Constant	21.524*	0.025***	17.752	0.021***
	(11.324)	(0.006)	(12.089)	(0.007)
Observations	24,523,161	8,062,220	30,112,298	9,701,676
R-squared	0.282	0.152	0.280	0.155

Notes: Dependent variable is a mid-point yoy growth in trade flows or unit values. Robust standard errors clustered by country and month are in parentheses. All regressions include firm-country-product fixed effects.
*** p<0.01, ** p<0.05, * p<0.1

of GSC shocks thus dominates: a standard deviation increase in GSCPI corresponds to a 0.005 percentage point increase in export price growth and 0.01 percentage point increase in import price growth.

In Appendix A.1, we perform a series of robustness checks. In line with the existing literature Bricongne et al. [2025], we expand our sample period to include the pre-pandemic year—2019—as well as month fixed effects. Variation of GSCPI at the monthly level precludes us from including this variable into specifications with monthly fixed effects and thus we focus on the estimated effects of the LSI. In Tables A1-A3, we include firm-product-month and product-country fixed effects in Columns 1 and 2, firm-month and product-country fixed effects in Columns 3 and 4, and firm-month, product-month and country fixed effects in Columns 5 and 6 (consistent with the specification in Bricongne et al. [2025]). Comparing the results in Table A2 where the sample period covers 2019 to 2020m6 to Table A3 where the sample period extends to end-2021 we conclude that the effect of lockdowns is strongest earlier in the pandemic. Comparing both sets of results to those in Table A1 with our baseline period 2020-2021, we conclude that the binary nature of lockdowns (0 in 2019 versus non-zero stringency level in 2020-2021) serves as the crux of identification when time fixed effects are included in the specification. This also highlights the large degree of correlation between lockdowns across French trade partners. Overall, these robustness exercises highlight the time-varying effect of LSI as well as the importance of imposition of a lockdown in a partner country rather than the magnitude of its stringency.

Our findings suggest that, controlling for variation in lockdown policies among trade partner countries of French firms, the effect of GSC bottlenecks is sizeable on both export and import flows. Imports decline more in response to the GSC shocks compared to exports of French firms. Import prices are also more susceptible to inflationary pressure from GSC shocks compared to export prices. These differences in observed price inflation of imports and exports are consistent with bigger bottlenecks in inbound shipments to the euro area and bigger delays in delivery times for shipments originating from Asia, as documented in Bai et al. [2024]. These results, however, provide little information about the dynamics of trade adjustment to shocks, which we address in the following section.

6.2 Dynamic results

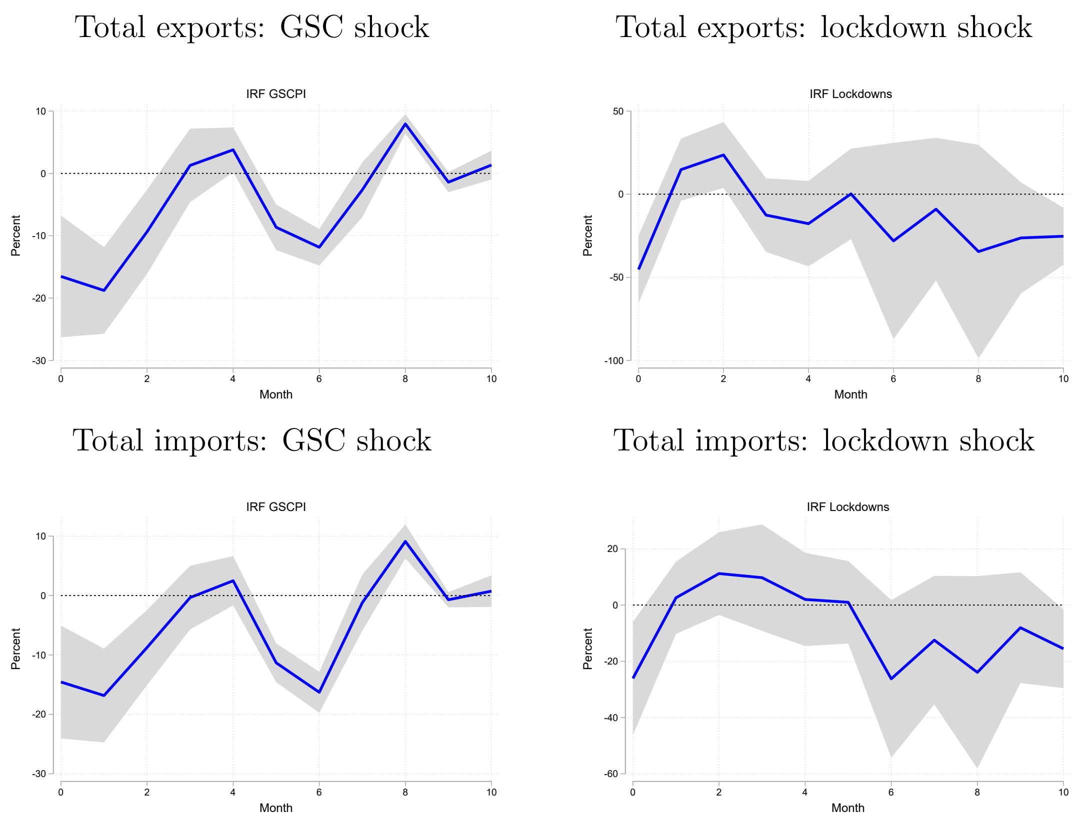
How lasting are the effects of the COVID-19 lockdowns and GSC shocks on trade flows? In this section we explore the dynamic effect of the COVID-19 shock on trade values and prices and construct IRFs based on the specification in Equation 4. Figures 3 and 4 plot the coefficients on GSCPI and LSI for French export and import values and unit values.

The first two panels of Figure 3 compare the dynamics of export and import values in response to GSC and lockdown shocks. The magnitude of the GSC shock is smaller but the subsequent recovery is more sluggish compared to an isolated lockdown shock. The initial impact of lockdowns on both types of trade flows is considerably larger compared to the GSC shock, making the recovery path sharper with a strong rebound within 6 months. Exports drop by 50 percent and imports drop by about 25 percent immediately after lockdown imposition. However, the initial drop in trade flows is partially compensated for by the increase in trade growth within the following 6 months. Exports and imports decline by about 15 percent in response to the GSC shock but the effect is longer-lasting. In net terms, trade flows are lower by the end of our estimation window, which is consistent with the cumulative static results discussed above.[10]

Trade prices in Figure 4 follow a different path compared to trade values, and this path depends on the type of the shock. Export and import unit values increase in response to the GSC shock and continue rising sharply in the following four months. This reflects inflationary pressures coming from production disruptions and logistical bottlenecks that take time to

[10] Quantity results provide broadly similar IRFs to those of total trade values. The magnitude of coefficients is much smaller as we only focus on the intensive margin in this case, that is firms that continue exporting or importing despite the shock. These results are available upon request.

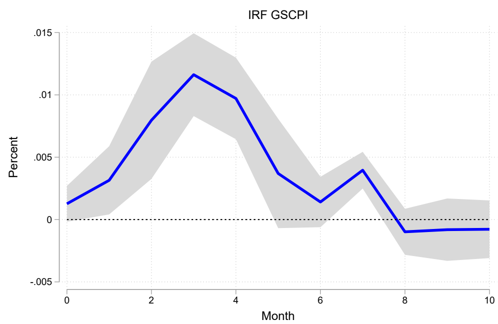
Figure 3: Impulse response functions for exports and imports



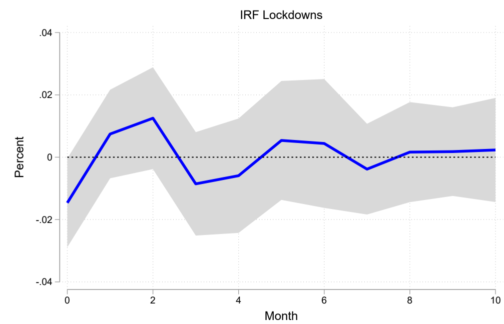
Notes: Dependent variable is a mid-point yoy growth in total trade value. All specifications include lags of the dependent variable, the two shocks of interest (Global Supply Chain Pressure Index and Lockdown Stringency Index) and their lags, as well as firm-country-product fixed effects and controls (World demand, French LSI, VIXCLS, French demand). The blue line plots the coefficient on either of the shocks, and the grey area plots the 95% confidence interval.

Figure 4: Impulse response functions for export and import unit values

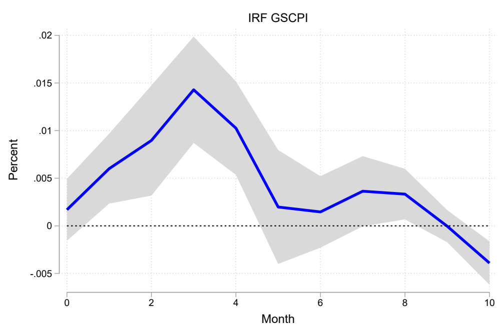
Export unit values: GSC shock



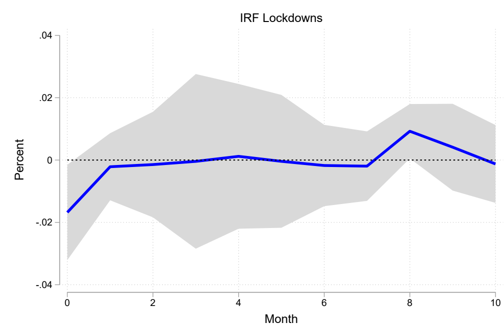
Export unit values: lockdown shock



Import unit values: GSC shock



Import unit values: lockdown shock



Notes: Dependent variable is a mid-point yoy growth in unit values. All specifications include lags of the dependent variable, the two shocks of interest (Global Supply Chain Pressure Index and Lockdown Stringency Index) and their lags, as well as firm-country-product fixed effects and controls (World demand, French LSI, VIXCLS, French demand). The blue line plots the coefficient on either of the shocks, and the grey area plots the 95% confidence interval.

clear. The cumulative effect is long-lasting as we do not observe a decline in prices in our window of 10 months.

Contrary to the GSC shocks, we see a deflationary effect in the first month of lockdown imposition but it is short-lived and dissipates in the following period. This initial deflationary effect could be linked to lower demand due to limited consumer mobility during lockdowns. However, net lockdown effect on import and export prices is not statistically different from zero in the following months.

7 Firm and product heterogeneity

This section focuses on heterogeneous responses of firms to GSC and lockdown shocks. We investigate whether robot use and differences in inventory management practices helped mitigate or amplified the effect of the shocks. We also study propagation of shocks along the supply chains by evaluating differential responses of firms depending on the level of upstreamness. To evaluate these potential sources of heterogeneity, we construct corresponding categorical variables capturing firm, product, and industry heterogeneity and interact them with the key variables of interest—GSCPI and LSI—in Equation 2.

7.1 Robotization

Table 4: Robotization

	(1) export values	(2) export unit values	(3) import values	(4) import unit values
GSCPI × Robots	-13.961***	0.004***	-14.142***	0.006***
	(2.203)	(0.001)	(2.171)	(0.002)
GSCPI × No robots	-15.483***	0.006***	-18.002***	0.013***
	(2.646)	(0.001)	(2.476)	(0.002)
LSI × Robots	-7.035	0.003	-10.315	-0.005
	(22.263)	(0.009)	(18.083)	(0.009)
LSI × No robots	-8.388	0.009	-12.902	-0.014
	(23.114)	(0.009)	(19.364)	(0.010)
Controls	Yes	Yes	Yes	Yes
Observations	15,064,003	7,130,071	18,276,227	8,592,211
R-squared	0.295	0.151	0.286	0.154
Test GSCPI	0.0684	0.150	0.000940	2.14e-05
Test LSI	0.681	0.278	0.319	0.167

Notes: Dependent variable is a mid-point yoy growth in trade flows or unit values. Robust standard errors clustered by country and month are in parentheses. All regressions include firm-country-product fixed effects and controls (World demand, French LSI, VIXCLS, French demand). We test the statistical difference of the estimates of *Robots* and *No robots* when interacted with GSCPI and LSI. The p-value of each test is reported in the bottom panel of the table.
*** p<0.01, ** p<0.05, * p<0.1

In this section, we investigate whether automation of production processes helped French firms' mitigate GSC and lockdown shocks. Comin et al. [2022] shows that adoption of sophisticated technologies increases resilience of firms during the pandemic. The direct effect of these technologies on firms' resilience operates through firm's ability to deal with labor shortages and absorb higher transaction costs with customers and suppliers. Cost-saving technologies may boost firms' ability to absorb input price shocks thus ensuring continuity of supplier and buyer relationships. Indirectly, pre-shock level of technology sophistication may be indicative of firm's readiness to adopt new technologies in response to shocks.

We capture the degree of automation by firms' use of industrial robots in production and expect that firms using robots are better equipped to respond to labor shortages and optimize production times. This, in turn, could increase the degree of firm resilience to external shocks such as lockdown orders and transportation bottlenecks. Since there is no direct measure of industrial robot use in production for French firms, we construct a proxy based on the information about firms' imports of industrial robots similarly to Acemoglu et al. [2020]. The resulting measure is a binary indicator. If a firm imported industrial robots between 2017 and 2019, we assign it a value of one for using industrial robots in production. Otherwise, the value is zero. Based on our measure, Table 1 shows that about 6 percent of exporters and 4 percent of importers adopted industrial robots prior to the pandemic.[11]

Table 4 shows the coefficients on interactions between the indicator for robot use and two shock variables: GSCPI and LSI. The coefficients on the interaction between GSCPI and robot usage in Columns 1 and 3 suggest that adoption of robots helped firms better shield their exports and imports from the GSC shocks. While both types of firms experience a decline in export and import flows, this decline is larger for firms not using robots in production. These differences are statistically significant at the 1% level for imports and 10% level for exports. Moreover, this finding matches the theoretical predictions in Comin et al. [2022].

Coefficients on the interactions between GSCPI and robot use in Column 4 of Table 4 suggest that firms using robots in production faced lower inflation of input prices. In fact, import unit value growth is twice larger for firms with no robots. These findings are in line with Koren and Tenreyro [2013] who show that firms with more diversified stock of technologies are better able to weather external shocks by adjusting the composition of inputs, e.g., lowering the quality of material inputs in the event of shortages or price spikes.

Finally, coefficients on the interaction between the indicators for robot use and lockdown stringency show little difference between firms with and without robots, when including firm-product-country fixed effects and controls for demand conditions and lockdown stringency in France.

7.2 Shock propagation via supply chains

To document evidence on the propagation of shocks along GSC, we use a measure of upstreamness at the industry level. The measure of upstreamness captures an average distance of an industry from its final use, with lower values of the index indicating that the product is closer to the final consumer along the supply chain. We apply the algorithm developed by Antràs et al. [2012] to the case of French input-output table containing 38 industries from 2015 OECD [2018] to construct the upstreamness index. The resulting measure is continuous with an average and median values of about 2 for exporting and importing firms as shown in

[11] This share of robot adoption is slightly higher compared to about one percent documented in Acemoglu et al. [2020] possibly due to our sample limited to French firms actively involved in international and a later time period.

Table 5: Upstreamness

	(1) export values	(2) export unit values	(3) import values	(4) import unit values
GSCPI × Downstream	-16.637***	0.002	-18.255***	0.003
	(2.966)	(0.001)	(2.770)	(0.002)
GSCPI × Middle	-13.223***	0.005***	-15.213***	0.009***
	(2.166)	(0.001)	(2.152)	(0.002)
GSCPI × Upstream	-14.640***	0.009***	-16.439***	0.019***
	(2.454)	(0.001)	(2.301)	(0.003)
LSI × Downstream	0.059	0.031***	-6.668	0.022**
	(21.365)	(0.009)	(19.092)	(0.008)
LSI × Middle	-6.830	-0.005	-9.017	-0.014*
	(20.134)	(0.008)	(17.467)	(0.008)
LSI × Upstream	-12.028	-0.003	-13.356	-0.029**
	(20.676)	(0.009)	(18.358)	(0.011)
Controls	Yes	Yes	Yes	Yes
Observations	15,064,003	7,130,071	18,276,227	8,592,211
R-squared	0.295	0.151	0.286	0.154
Test GSCPI	0.0800	7.39e-05	0.130	6.49e-05
Test LSI	0.0549	1.56e-06	0.266	6.87e-05

Notes: Dependent variable is a mid-point yoy growth in trade flows. Robust standard errors clustered by country and month are in parentheses. All regressions include firm-country-product fixed effects and controls (World demand, French LSI, VIXCLS, French demand). We test the statistical difference of the estimates of *Downstream* and *Upstream* when interacted with GSCPI and LSI. The p-value of each test is reported in the bottom panel of the table. *** p<0.01, ** p<0.05, * p<0.1

Table 1. For ease of interpretation, we divide industries into three categories, depending on their position along the supply chain captured by the index: upstream (industries furthest removed from the final consumer or the top quartile of the distribution), downstream (industries closest to the final consumer or the bottom quartile of the distribution), and middle (two middle quartiles).

We interact GSCPI and LSI with the upstreamness measure and report the resulting coefficients in Table 5. Coefficients on the interaction terms with GSCPI in Columns 1 and 3 show that products in downstream industries experienced a larger decline in total values in response to the GSC shocks. Exports from upstream and downstream industries, however, fell slightly less than from downstream industries. This result is likely to be driven by higher inflationary pressure stemming from the GSC shocks on more upstream products, as evidenced by the interaction coefficients in Columns 2 and 4. Higher inflationary pressures in the upstream industries, however, appear to propagate to the downstream industries where exports see a larger decline.

The estimates on the LSI interactions in Columns 2 and 4, show that lockdowns were of an inflationary nature in the downstream industries. However, imports from upstream industries saw a decline in prices. Reduced domestic demand and excess inventories in exporting countries could be associated with lower component prices during lockdown periods. This result is also consistent with high volatility in commodity prices during the early months of the pandemic Bourghelle et al. [2021] and prior to the outset of transportation bottlenecks.

7.3 Inventory Intensity

Several studies, including Alessandria et al. [2010], Bems et al. [2013], Gopinath and Neiman [2014], and Lafrogne-Joussier et al. [2023] show that inventory management practices are one of the key factors in firms' adjustment to demand and supply shocks. The first three studies show that, during previous crises (e.g., Global Financial Crisis in the US and Argentinian crisis in the early 2000s), inventory intensity amplified the trade collapse, since inventory-intensive firms tended to exhaust their inventories in the face of demand uncertainty. Lafrogne-Joussier et al. [2023] show that, during the COVID-19 pandemic, high inventory intensity helped firms insulate themselves from the supply shocks associated with early lockdowns in China.

Table 6: Inventory intensity

	(1) export values	(2) export unit values	(3) import values	(4) import unit values
GSCPI × Low	-13.413***	0.007***	-15.411***	0.012***
	(2.136)	(0.001)	(2.222)	(0.002)
GSCPI × Medium	-14.934***	0.006***	-16.530***	0.010***
	(2.525)	(0.001)	(2.333)	(0.002)
GSCPI × High	-14.853***	0.001	-16.851***	0.007***
	(2.584)	(0.001)	(2.377)	(0.002)
LSI × Low	-9.642	-0.018**	-9.967	-0.019**
	(20.208)	(0.008)	(17.714)	(0.009)
LSI × Medium	-6.974	0.008	-11.685	-0.007
	(20.401)	(0.008)	(18.038)	(0.009)
LSI × High	-0.448	0.026***	-5.641	-0.001
	(20.606)	(0.009)	(18.173)	(0.008)
Controls	Yes	Yes	Yes	Yes
Observations	15,064,003	7,130,071	18,276,227	8,592,211
R-squared	0.295	0.151	0.286	0.154
Test GSCPI	0.0800	1.45e-06	0.0618	0.00283
Test LSI	0.0123	0	0.123	0.00331

Notes: Dependent variable is a mid-point yoy growth in trade flows. Robust standard errors clustered by country and month are in parentheses. All regressions include firm-country-product fixed effects and controls (World demand, French LSI, VIXCLS, French demand). We test the statistical difference of the estimates of *Low* and *High* when interacted with GSCPI and LSI. The p-value of each test is reported in the bottom panel of the table.
*** p<0.01, ** p<0.05, * p<0.1

We test the existing predictions in the literature and further extend them by adding evidence on the price responses of firms with differential inventory-to-sales ratios. Our measure of inventory intensity is based on the firm-level balance sheet data, as described in Section 3. Firm-level data on inventory holdings and sales are aggregated at the 3-digit French Classification of Activities (NAF) level. We use industry-level medians of inventories-to-sales ratios to divide all firms into high (top quartile of industries' median inventories-to-sales distribution), low (bottom quartile), and middle (two middle quartiles) inventory intensity groups. We interact both the GSCPI and LSI with the resulting inventory intensity measure.

In Table 6, we find support for the hypotheses posited in the literature. Our findings in Columns 1 and 3 suggest that the GSC shock is amplified in medium- and high-inventory firms. These firms see larger decline in both exports and imports. The amplification effect of high-inventory firms is consistent with the theoretical predictions in Alessandria et al. [2010] and existing empirical findings. However, these differences between firms based on the level of inventory holdings is only statistically significant at the 10% level and are likely to be driven by price effects in Columns 2 and 4. Namely, firms with low inventory holdings experienced larger price hikes both on import and export sides. This finding suggests that lean inventory management practices disproportionately exposed these firms to GSC disruptions. On the other hand, firms with larger inventory stocks were more insulated from import price hikes (Column 4) and only partially passing higher input prices to their buyers (Column 2).

Coefficients on inventory interactions with LSI in Columns 1 and 3 of Table 6 show no statistically significant impact of lockdowns on total export or import values of firms with low, high or medium levels of inventories. However, results in Columns 2 and 4 show that low-inventory firms saw lower prices of imported input and exports when their trade partners entered into lockdowns compared to firms with higher inventory stocks. This difference could be explained by stronger adjustment to lockdown shocks along the extensive margin by low-inventory firms. This evidence corroborates the findings in Lafrogne-Joussier et al. [2023] showing that inventories served as a buffer during lockdowns.

8 Concluding remarks

This paper examines the adjustments of trade flows and prices in response to global supply chain shocks during 2020-2021. This period is particularly significant, encompassing the initial trade collapse due to COVID-19 containment measures and the ensuing peak of the global supply chain crisis. To analyze this, we utilize a comprehensive and granular dataset on the total values and prices of various goods imported and exported by French firms from 2018 to 2021. Notably, in April 2020, France experienced a 78% decline in total export value and a 70% decline in import value compared to the previous year.

We show that French firms adjusted their exports and imports both along the subintensive and subextensive margins in response to the initial wave of lockdowns imposed by partner countries. While the lockdown shocks were for the most part transitory and had little impact on prices, the effect of subsequent GSC disruptions appeared to be longer-lasting and inflationary in nature. In 2021, as consumer demand began to recover, firms faced major GSC disruptions, associated with production bottlenecks and rising shipping costs. Our findings show that these disruptions, captured by the GSCPI, exerted large inflationary pressures, with sharp and persistent increases in export and import prices.

We also show that responses to GSC and lockdown shocks varied across firm and industry characteristics including their location along the supply chain, level of automation, and inventory management practices. To that end, we provide evidence of larger inflationary pressures from the GSC shocks in upstream industries which resulted in declinining exports of Frenh firms in downstream industries. Use of industrial robots and prudent inventory practices tend to mitigate the impact of GSC shocks on trade volumes and prices.

Our findings provide fresh insights into firm-level trade dynamics following a significant shock. A key takeaway from the study is that, despite the notable diversity in firms' responses to such shocks, they generally display surprising resilience and agility in adapting to new circumstances, even when the necessary adjustments are substantial and costly. This study indicates that further investigation into this topic is warranted, potentially leading to the development of a theory on firm dynamics in disequilibrium scenarios.

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A Appendix

A.1 Robustness checks

We run additional robustness tests, where we include time fixed effects. We consider three different sets of fixed effects: (i) firm-product-time and product-country, (ii) firm-time and product-country, (iii) firm-time, product-time and country. These fixed effects allow to control for various firm-time and product-time variables. Because inclusion of time fixed effects absorbs variation in GSCPI and most of our control variables, we focus only on the LSI variable to capture pandemic disruptions. The last specification is similar to the one presented in Bricongne et al. [2025]. Their baseline specification includes both the pre-pandemic and the pandemic period (from January 2019 to June 2020) and thus focuses on the effect of LSI earlier in the pandemic. They find a negative and significant impact of lockdown stringency on both French exports and imports over 2019-2020m6.

Table A1 presents the results for our baseline period (2020-2021) based on specifications with time fixed effects. We estimate several specifications for trade values and unit values, including our baseline set of fixed effects (firm-country-product) and time fixed effects, as well as firm-product-time and product-country fixed effects (Columns 1 and 2), firm-time and product-country fixed effects (Column 3 and 4), and firm-time, product-time and country fixed effects (Columns 5 and 6). During this period, coefficients on lockdown stringency index are never statistically significant. We then repeat the same exercise considering the same time period (2019-2020m6) as in Bricongne et al. [2025] in Table A2. Similar to their findings, we show negative and statistically significant coefficient estimates on the LSI of similar magnitude. This suggests that this estimate captures both the switch between the pre-pandemic and the pandemic period (from no lockdown in 2019 to lockdowns in 2020) and the earlier timing of the lockdown effects. For consistency, we run the same exercise over the complete time period of 2019-2021. The results presented in Table A3 suggest that the effect of lockdowns remains statistically significant for exports, albeit of a smaller magnitude compared to the estimates in Table A2. We conclude that inclusion of pre-pandemic data for 2019 thus impacts the estimation of the effect of lockdowns on trade volumes. In addition, LSI impact is strongest in the earlier months of the pandemic and dissipates over time, as demand recovers.

A.2 Trade partner heterogeneity

Margins decomposition by country group. We perform the decomposition in Equation 1 for three country groups categorized by countries' incomes per capita—advanced

Table A1: Average static effects: robustness checks - 2020-2021

	(1) Total values	(2) Unit values	(3) Total values	(4) Unit values	(5) Total values	(6) Unit values
Exports						
LSI	-8.406	-0.003	-8.590	-0.004	-8.835	-0.004
	(9.257)	(0.007)	(8.835)	(0.006)	(8.678)	(0.006)
Constant	6.942	0.016***	7.308	0.016***	7.429*	0.016***
	(4.766)	(0.004)	(4.518)	(0.003)	(4.436)	(0.003)
Observations	20,818,795	6,831,424	25,415,408	8,207,943	25,459,895	8,228,576
R-squared	0.435	0.285	0.244	0.087	0.251	0.082
FE	fpt-pc	fpt-pc	ft-pc	ft-pc	ft-pt-c	ft-pt-c
Cluster	c	c	c	c	c	c
Imports						
LSI	5.532	0.009*	5.095	0.014**	5.316	0.014***
	(6.898)	(0.005)	(6.939)	(0.006)	(6.894)	(0.005)
Constant	-1.688	0.008***	-0.639	0.007**	-0.746	0.007***
	(3.832)	(0.003)	(3.910)	(0.003)	(3.884)	(0.003)
Observations	16,372,371	4,927,679	31,428,359	9,818,248	31,455,656	9,822,167
R-squared	0.502	0.362	0.264	0.101	0.272	0.101
FE	fpt-pc	fpt-pc	ft-pc	ft-pc	ft-pt-c	ft-pt-c
Cluster	c	c	c	c	c	c

Notes: Dependent variable is a mid-point yoy growth in trade flows or unit values. Robust standard errors clustered by country are in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A2: Average static effects: robustness checks - 2019-2020m6

	(1) Total values	(2) Unit values	(3) Total values	(4) Unit values	(5) Total values	(6) Unit values
Exports						
LSI	-29.667***	-0.006	-27.219***	-0.004	-29.218***	-0.002
	(5.680)	(0.007)	(6.058)	(0.006)	(6.040)	(0.005)
Constant	2.083**	0.007***	1.749**	0.006***	2.024**	0.006***
	(0.802)	(0.001)	(0.852)	(0.001)	(0.849)	(0.001)
Observations	15,189,403	5,367,783	18,500,245	6,462,533	18,549,607	6,484,647
R-squared	0.427	0.290	0.213	0.090	0.213	0.078
FE	fpt-pc	fpt-pc	ft-pc	ft-pc	ft-pt-c	ft-pt-c
Cluster	c	c	c	c	c	c
Imports						
LSI	-2.698*	-0.006	-3.701**	-0.004	-7.093***	-0.006
	(1.535)	(0.006)	(1.673)	(0.004)	(1.519)	(0.004)
Constant	-1.989***	0.005***	-2.213***	0.006***	-1.686***	0.006***
	(0.233)	(0.001)	(0.260)	(0.001)	(0.236)	(0.001)
Observations	12,029,354	3,867,771	23,152,905	7,669,205	23,181,561	7,674,456
R-squared	0.480	0.367	0.230	0.103	0.233	0.098
FE	fpt-pc	fpt-pc	ft-pc	ft-pc	ft-pt-c	ft-pt-c
Cluster	c	c	c	c	c	c

Notes: Dependent variable is a mid-point yoy growth in trade flows or unit values. Robust standard errors clustered by country are in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A3: Average static effects: robustness checks - 2019-2021

	(1) Total values	(2) Unit values	(3) Total values	(4) Unit values	(5) Total values	(6) Unit values
Exports						
LSI	-8.758***	-0.001	-8.122***	-0.001	-10.157***	-0.000
	(3.158)	(0.006)	(3.033)	(0.006)	(2.792)	(0.006)
Constant	6.484***	0.013***	6.423***	0.013***	7.124***	0.012***
	(1.091)	(0.002)	(1.041)	(0.002)	(0.958)	(0.002)
Observations	31,066,730	10,526,885	37,892,837	12,641,623	37,925,996	12,658,779
R-squared	0.421	0.279	0.209	0.080	0.231	0.080
FE	fpt-pc	fpt-pc	ft-pc	ft-pc	ft-pt-c	ft-pt-c
Cluster	c	c	c	c	c	c
Imports						
LSI	5.546	0.007**	5.820	0.011***	3.307	0.010***
	(3.867)	(0.003)	(4.213)	(0.003)	(4.034)	(0.003)
Constant	0.104	0.008***	0.618	0.009***	1.576	0.009***
	(1.438)	(0.001)	(1.589)	(0.001)	(1.521)	(0.001)
Observations	24,471,970	7,572,862	46,983,913	15,057,318	47,005,590	15,058,740
R-squared	0.484	0.359	0.233	0.097	0.252	0.100
FE	fpt-pc	fpt-pc	ft-pc	ft-pc	ft-pt-c	ft-pt-c
Cluster	c	c	c	c	c	c

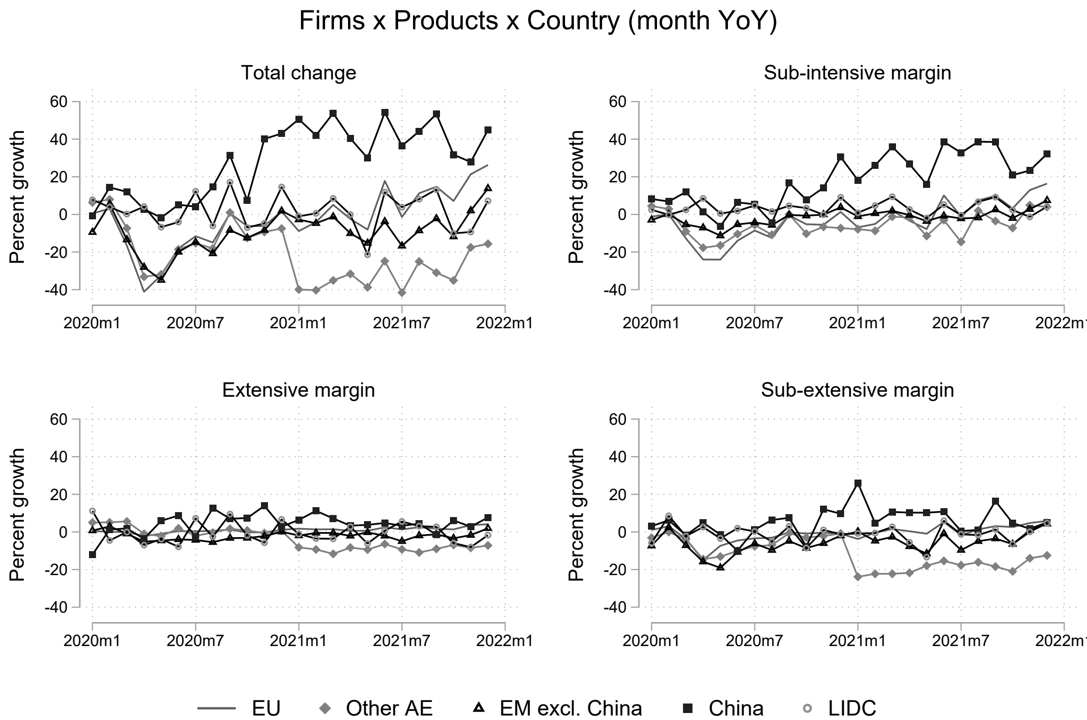
Notes: Dependent variable is a mid-point yoy growth in trade flows or unit values. Robust standard errors clustered by country are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

economies (AE), emerging markets (EM), and low-income and developing countries (LIDC)—and China separately. The results in Figures A1 and A2 suggest that both exporters and importers adjusted predominantly along the intensive margin by reducing the value of exported or imported varieties in response to the COVID-19 shock across most countries. Nevertheless, there is considerable heterogeneity in the timing of adjustment and contribution of different margins across country groups.

Exports to China dropped earlier, given that the pandemic originated in China (Figure A1). While the extensive margin played a limited role in export adjustment to AEs and EMs, many firms seized exports to China and LIDCs in the first half of 2020. The subextensive margin also played a more prominent role in exports to developing countries, including China, compared to the AEs. In 2021, however, exports to China expanded significantly, mainly along the subintensive margin. Similarly to Figure A2, Figure A1 shows that exports to non-EU advanced economies, including the US, were falling throughout 2021 along both extensive and subextensive margins.

In Figure A2, the patterns of import adjustment are distinct for China. We find that Chinese imports rebounded swiftly in the first half of 2020, while imports from all other countries took longer to recover. Adjustment in Chinese imports along the extensive margin accounts for almost half of import growth during this period, suggesting that many firms

Figure A1: Trade margins by income group: exports

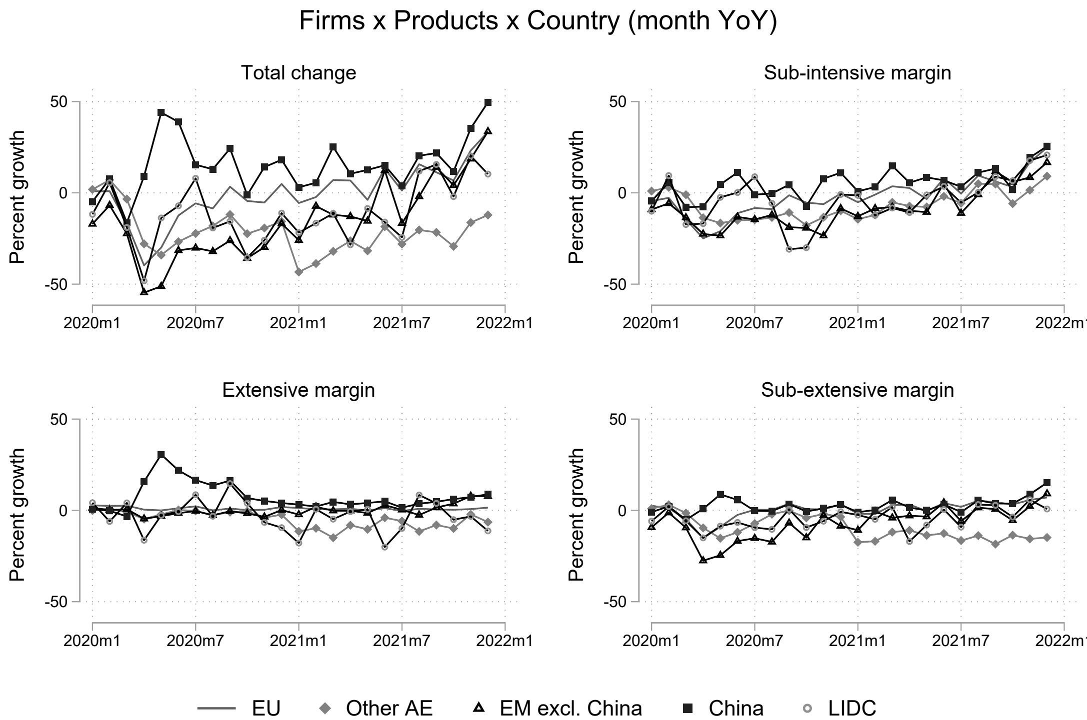


Notes: We decompose changes in export flows into three trade margins (subintensive, extensive, and subextensive as defined in Equation 1) over 2020m1-2021m12 for each country group: European Union, other advanced economies, emerging market economies excluding China, China, and low-income and developing countries. The changes are computed in year-on-2 year terms, comparing 2020 to 2018, and 2021 to 2019.

imported from China for the first time during this period. Changes along the subintensive margin also suggest that many firms switched to Chinese imports away from existing trade partners, and especially so from other EMs. By the end of 2021, imports from all income groups were recovering, with the exception of non-EU advanced economies, which continued underperforming relative to the pre-pandemic period.

Responses to GSC and lockdown shocks by country group. We posit that the effect of GSC and lockdown shocks can vary by countries' levels of income. For instance, countries' level of integration in GSC and product composition of their trade baskets, which are in turn correlated to the level of economic development, can determine the magnitude of the shock on trade flows. While some of these time-invariant characteristics would be absorbed by firm-country-product fixed effects, there can still be differences in the shock transmission channels across countries. Table A4 reports the results by country group for advanced economies (AEs), emerging market economies (EMs), and low-income developing

Figure A2: Trade margins by income group: imports



Notes: We decompose changes in import flows into three trade margins (subintensive, extensive, and subextensive as defined in Equation 1) over 2020m1-2021m12 for each country group: European Union, other advanced economies, emerging market economies excluding China, China, and low-income and developing countries. The changes are computed in year-on-2 year terms, comparing 2020 to 2018, and 2021 to 2019.

countries (LIDCs).

Results in Columns 1 and 3 of Table A4 suggest that impact of GSC shock on export and import flows is of similar magnitude in AEs and EMs. The effect of GSC disruptions dominates in the case of LIDCs while lockdowns do not have explanatory power. The average effect of LSI documented in Table 3 is mainly driven by AEs. This country difference could be in part due to faster spread of the COVID-19 virus and thus more stringent containment measures implemented in AEs and EMs in 2020. In addition, higher rates of labor market informality in LIDCs may imply more limited enforcement and compliance with lockdown orders.

The aggregate effect of GSC shocks on prices is both economically and statistically significant and is predominantly driven by AEs and EMs, as suggested by the results in Columns 2-4. Particularly, French firms hiked up export prices to EMs in response to the GSC disruptions while the effects for import prices are similar for AEs and EMs. In LIDCs, effects of GSCPI on both export and import prices are not statistically significant. Thus, in the case

Table A4: Average static results: country group

	(1) Export values	(2) Export unit values	(3) import values	(4) import unit values
Advanced economies				
GSCPI	-18.512***	0.004***	-20.633***	0.010***
	(3.030)	(0.001)	(3.067)	(0.002)
LSI	-85.643***	0.002	-63.725***	-0.013
	(22.965)	(0.008)	(22.415)	(0.011)
World demand	0.078*	0.000***	0.099**	0.000***
	(0.039)	(0.000)	(0.040)	(0.000)
French LSI	33.948	0.000	10.639	-0.007
	(30.835)	(0.008)	(30.392)	(0.012)
VIXCLS	1.940**	-0.001***	2.308**	-0.001**
	(0.894)	(0.000)	(0.888)	(0.000)
French demand	2.326**	-0.000	2.595**	-0.000
	(0.972)	(0.000)	(0.971)	(0.000)
Constant	21.408*	0.023***	16.196	0.027***
	(11.310)	(0.007)	(11.331)	(0.007)
Observations	17,839,144	6,542,960	20,469,439	6,917,487
R-squared	0.279	0.150	0.258	0.149
Emerging market economies				
GSCPI	-18.301***	0.011***	-22.407***	0.011***
	(2.743)	(0.001)	(2.926)	(0.003)
LSI	-58.099***	-0.009	-28.046**	0.007*
	(14.581)	(0.012)	(10.294)	(0.004)
World demand	0.070	0.000*	0.141***	0.000***
	(0.056)	(0.000)	(0.033)	(0.000)
French LSI	-5.901	-0.014	-43.762	-0.029**
	(35.108)	(0.021)	(28.182)	(0.012)
VIXCLS	2.062**	-0.001***	3.229***	-0.001
	(0.769)	(0.000)	(0.667)	(0.000)
French demand	1.810*	-0.001**	3.049***	0.000
	(0.918)	(0.000)	(0.822)	(0.000)
Constant	26.480**	0.029***	15.777	0.006
	(11.248)	(0.006)	(12.051)	(0.009)
Observations	5,008,955	1,332,915	8,314,865	2,471,821
R-squared	0.251	0.157	0.286	0.169
Low-income developing countries				
GSCPI	-30.042***	-0.002	-26.391***	-0.000
	(4.842)	(0.003)	(3.560)	(0.003)
LSI	-22.172	-0.041	-34.265***	-0.017
	(24.659)	(0.026)	(11.211)	(0.013)
World demand	-0.181**	0.000	0.158**	0.000**
	(0.086)	(0.000)	(0.057)	(0.000)
French LSI	-70.137	0.067*	-45.915	0.022
	(54.686)	(0.033)	(34.744)	(0.018)
VIXCLS	4.936***	-0.003**	3.584***	-0.000
	(1.102)	(0.001)	(0.814)	(0.000)
French demand	4.273**	-0.002	3.749***	0.001*
	(1.560)	(0.002)	(0.903)	(0.001)
Constant	-4.680	0.062***	19.035	-0.004
	(22.838)	(0.018)	(12.577)	(0.006)
Observations	763,234	94,672	911,415	295,356
R-squared	0.235	0.179	0.334	0.189

Notes: Dependent variable is a mid-point yoy growth in trade values or unit values for a given country group. Robust standard errors clustered by country and month are in parentheses. All regressions include firm-country-product fixed effects and controls (World demand, French LSI, VIXCLS, French demand).
*** p<0.01, ** p<0.05, * p<0.1

of LIDCs the large response of export and import values is mainly explained by the volume adjustment.

A.3 Firm characteristics: age and size

Table A5: Interactions: Age

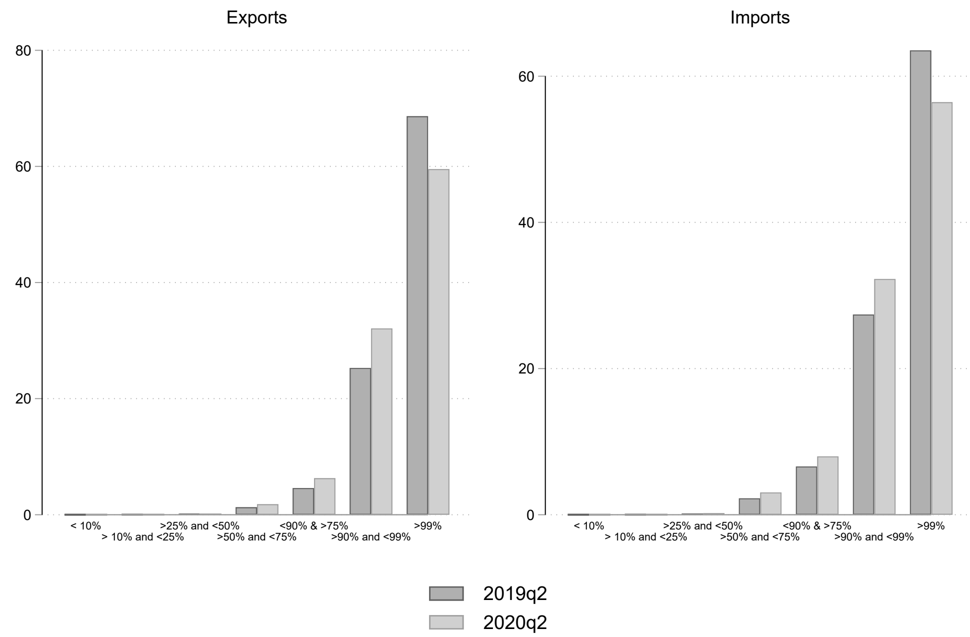
	(1) Export values	(2) Export unit values	(3) import values	(4) import unit values
GSCPI × Young	-20.360***	0.003*	-20.443***	0.005**
	(3.318)	(0.002)	(3.004)	(0.002)
GSCPI × Middle	-14.444***	0.004**	-15.469***	0.008***
	(2.485)	(0.002)	(2.390)	(0.002)
GSCPI × Old	-12.585***	0.006***	-13.149***	0.013***
	(2.212)	(0.001)	(1.986)	(0.002)
LSI × Young	-14.220	0.019*	-20.219	0.012
	(25.063)	(0.011)	(19.811)	(0.009)
LSI × Middle	-8.607	0.025**	-14.679	-0.002
	(22.511)	(0.011)	(18.484)	(0.012)
LSI × Old	-9.393	-0.006	-11.669	-0.020**
	(22.166)	(0.009)	(18.622)	(0.009)
Controls	Yes	Yes	Yes	Yes
Observations	15,064,003	7,130,071	18,276,227	8,592,211
R-squared	0.295	0.151	0.285	0.154
Test LSI	0.604	0.000316	0.297	2.22e-05
Test GSCPI	0.000174	0.0427	0.000514	7.01e-05

Notes: Dependent variable is a mid-point yoy growth in trade flows or unit values. Robust standard errors clustered by country and month are in parentheses. All regressions include firm-country-product fixed effects and controls (World demand, French LSI, VIXCLS, French demand). We test the statistical difference of the estimates of *Young* and *Old* when interacted with GSCPI and LSI. The p-value of each test is reported in the bottom panel of the table.
*** p<0.01, ** p<0.05, * p<0.1

We study whether key firm characteristics, such as the age of the firm and its size, acted as a mitigating factor for French firms when facing the pandemic shock. The existing literature on the capacity of a firm to deal with a trade shock highlights the fact that oldest firms more often survive such shocks. Theoretical models predict an "up or out" dynamic of young firms, consistent with selection and learning effects. In addition, Fort et al. [2013] distinguish the effect of both size and age, showing that young or small firms are the most hit in cyclical downturns, especially during the GTC.

We estimate Equation 2, interacting the two shock variables—GSCPI and LSI—with indicator variables to capture the differences in adjustment of young firms (less than 10 years), middle-aged firms (between 11 and 20 years) and older firms (more than 20 years). We compute the age of the firm in 2020 considering the first time a firm appeared in our dataset as the birth year of this firm. Results in Table A5 show that older firm decreased less their import and export total values compared to younger firms. However, they also saw larger import price inflation and increased their export prices significantly more than

Figure A3: Share of trade per size bin



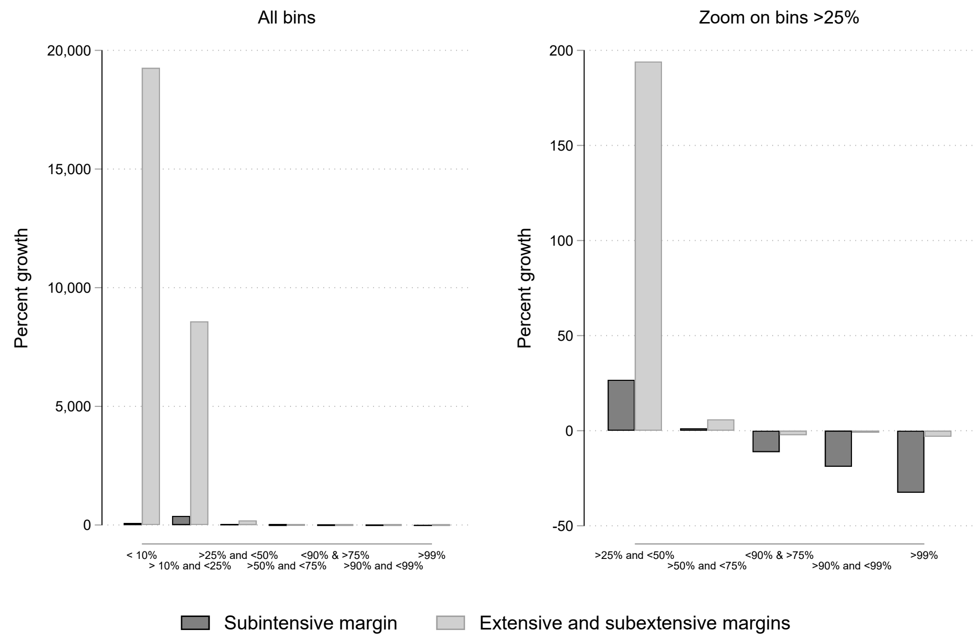
Notes: Share of total trade realized by each size bin for 2019Q2 (dark-grey bars) and 2020Q2 (light-grey bars) for both exporting and importing French firms.

younger firms. This, in part, could be attributed to a larger adjustment of younger firms along the extensive margin.

Another significant mitigating factor we account for is the size of the firm. We bin the sample by firms' size, where the size is proxied by the total amount of exports (or imports) in 2019Q2. Figure A3 plots the share of total trade realized by each size bin for 2019Q2 and 2020Q2. Interestingly, the largest firms experienced the largest decrease in both exports and imports during the COVID-19 crisis, with this lost trade being redistributed to other firms. We then investigate trade adjustment depending on firms' size. Figures A4 and A5 provide information on the change in imports and exports along the subintensive, and extensive and subextensive margins. The largest firms reacted more along the subintensive margin, reducing their imports and exports of products by up to 40 percent for the top percentile of firms, while the smallest firms started to export and import new products. This is consistent with the findings of Bricongne et al. [2025] show that "export champions" are responsible for half of the slump of 2020.

We also interact the variables of interest with dummies to account for different size categories: small, medium and large firms. We rely on total international sales to construct the firm size variable. Existing trade literature generally asserts that large firms can cope better with external shocks. For example, Bricongne et al. [2012] show that larger firms

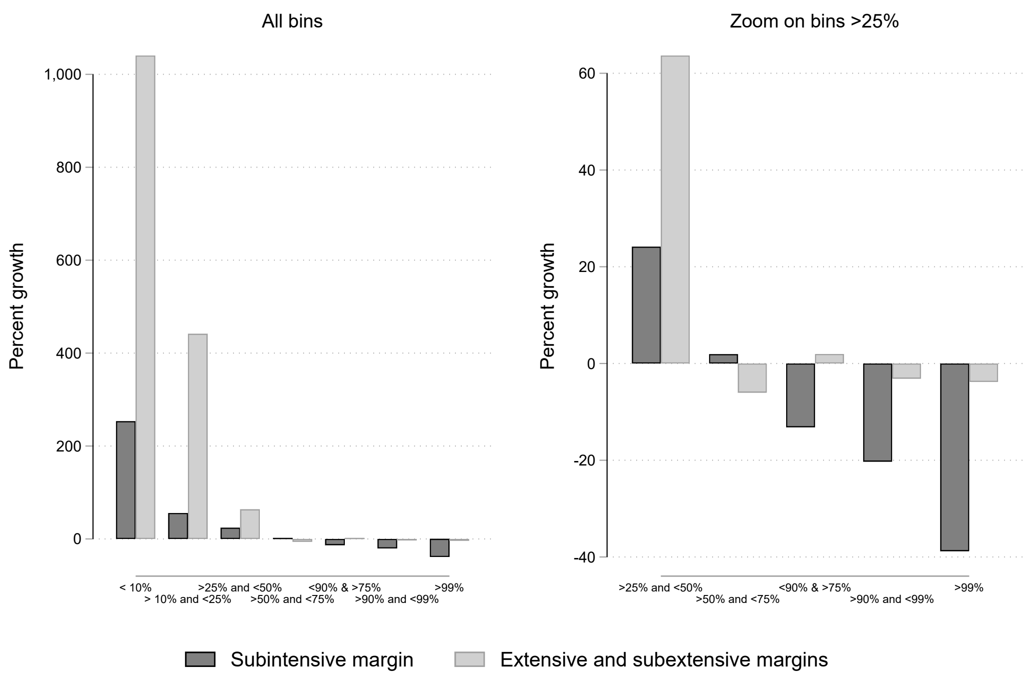
Figure A4: Import adjustment to the COVID-19 shock along size distribution



Notes: Margins are computed considering Firms x Products and using year-on-year quarterly changes.

dealt more easily with the shock during the GTC. Results in Table A6 suggest that large firms were able to cope better with GSC shocks: their export and import values decrease less than of smaller firms. Large exporters experienced smaller increase in import prices but were able to pass through higher input prices to their buyers, as evidenced by higher increases in export prices in response to the GSC shock among these firms.

Figure A5: Export adjustment to the COVID-19 shock along size distribution



Notes: Margins are computed considering Firms x Products and using year-on-year quarterly changes.

Table A6: Interactions: Size

	(1) Export values	(2) Export unit values	(3) import values	(4) import unit values
GSCPI × Small	-20.847***	0.004***	-19.135***	0.012***
	(3.041)	(0.001)	(2.566)	(0.002)
GSCPI × Medium	-14.949***	0.005***	-15.756***	0.011***
	(2.600)	(0.001)	(2.323)	(0.002)
GSCPI × Large	-11.294***	0.006***	-13.025***	0.006***
	(2.155)	(0.001)	(2.225)	(0.002)
LSI × Small	-3.445	0.008	-13.459	-0.014
	(25.565)	(0.010)	(20.369)	(0.010)
LSI × Medium	-4.715	0.013	-10.157	-0.012
	(22.730)	(0.010)	(18.391)	(0.009)
LSI × Large	-14.210	-0.003	-15.952	0.000
	(21.529)	(0.009)	(17.806)	(0.009)
Controls	Yes	Yes	Yes	Yes
Observations	15,064,003	7,130,071	18,276,227	8,592,211
R-squared	0.296	0.151	0.286	0.154
Test LSI	0.222	0.196	0.649	0.0305
Test GSCPI	1.07e-05	0.175	0.000279	1.31e-05

Notes: Dependent variable is a mid-point yoy growth in trade flows or unit values. Robust standard errors clustered by country and month are in parentheses. All regressions include firm-country-product fixed effects and controls (World demand, French LSI, VIXCLS, French demand). We test the statistical difference of the estimates of *Small* and *Large* when interacted with GSCPI and LSI. The p-value of each test is reported in the bottom panel of the table.
*** p<0.01, ** p<0.05, * p<0.1