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Trade and the COVID-19 Pandemic

Lessons from French Firms

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Trade and the COVID-19 Pandemic: Lessons from French Firms

Prepared by Mariya Brussevich, Chris Papageorgiou, Pauline Wibaux

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ABSTRACT: This paper uses granular customs data from France to investigate propagation of the COVID-19 shock along the supply chains in 2020. It quantifies the effect of the COVID-19 shock on trade adjustment and identifies mitigating and amplifying factors contributing to French firms' heterogeneous adjustment paths. Early in the pandemic, firms mainly responded to global lockdowns and spread of the virus by reducing trade volumes (intensive margin) as opposed to exiting from import and export markets (ex-tensive margin). However, adjustment along the extensive margin played a more important role in trade with developing countries. It is shown that the impact of lockdowns was stronger for final consumer goods and the trade recovery was predominantly demand-driven. More automated, inventory-intensive, older, and medium-sized firms were more insulated from the shock, whereas firms' reliance on air transportation for shipping goods amplified the shock. Trade bans and promotion measures implemented by governments in response to the pandemic had little impact on aggregate trade flows.

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WORKING PAPERS

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Prepared by Mariya Brussevich, Chris Papageorgiou, and Pauline Wibaux[1]

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1 Introduction

As the COVID-19 virus spread rapidly and lockdown orders were imposed across the globe, trade flows came to a halt. In April 2020, the value of France's total exports declined by 78% and imports declined by 70% in year-on-year terms. The trade collapse raised questions about fragility of global value chains (GVCs) and pandemic-induced deglobalization. However, concerns about survival of GVCs subsided when global trade flows returned to their pre-pandemic levels by the end of 2020. Fueled by economic recovery in advanced economies and shifts in consumption patterns away from contact-intensive service industries, demand for manufactured goods has rebounded quickly. Nevertheless, many questions about the margins of trade adjustment and firm-level factors that contributed to collapse and the subsequent rebound of international trade remain unanswered.

This paper focuses on the economic damage caused by the pandemic in addition to its colossal human costs. It investigates how French firms adjusted to the COVID-19 shock, using granular monthly customs data from 2020. Our analysis focuses on the first year of the pandemic, capturing the initial shock and subsequent recovery.[1] The paper first decomposes international trade adjustment into extensive and intensive margins. It then examines how French firms' exports and imports responded to the spread of the virus and lockdowns imposed in the trade partner countries and how the shock propagated along GVCs. Granularity of the data allows to pin down which firm and industry characteristics contributed to firms' adjustment to the COVID-19 shock. We examine the following mechanisms contributing to heterogeneous impact of the COVID-19 pandemic on firms: location of industries along the supply chains or level of industry upstreamness, inventory management practices, automation of production processes, firms' age and size, as well as the mode of transportation used for shipping the goods. In addition, the paper examines whether pandemic-related trade and economic policies implemented by France's trade partners had an impact on French exports and imports.

Our data include detailed information on French firms' monthly exports and imports by a narrowly defined product category, country of destination or origin, and mode of transportation. In addition to trade values measured in euros, the data contain information on quantities of traded goods, which allows us to track changes in unit values—a proxy for prices. Moreover, information on France's trade partners allows us to gauge the effect of the pandemic across the world. Given that granular trade data are often not available in a timely manner for many countries especially in the developing world, our analysis is able to shine the light on how French trade partners adjusted to the pandemic shock. Thus, our analysis focuses on the heterogeneity of trade adjustment across countries by income groups—advanced and emerging markets as well as low-income countries.

We characterize the mechanics of aggregate trade adjustment at firm, product, and country level. Our findings suggest that firm exits and entries from export and import markets (extensive margin) explain a small share of the overall trade collapse. However, the extensive margin played a bigger role in changes in trade with developing countries, with many French firms halting imports from low-income trade partners and, on the other hand, forming new linkages with Chinese exporters. Among continuing exporters and importers, French exporters predominantly adjusted the value of goods traded with their partners in advanced and emerging market economies (sub-intensive margin). At the same time, firms temporarily halted exports of some products to low-income trade partners (sub-extensive margin), which explained most of the change in exports of French firms to these countries in 2020. Overall, margins of trade adjustment varied substantially

[1] French customs data from 2021 were not available at the time of writing and thus the paper does not capture the pandemic developments after December 2020.

across country groups, with developing trade partners exhibiting higher levels of volatility in trade linkages.

We use variation in timing and stringency of lockdowns as well as the number of the COVID-19 related deaths across countries to identify the effect of the pandemic on French firms' exports and imports and to disentangle demand and supply forces driving the trade adjustment. First, our findings suggest that French firms substantially reduced both exports and imports in response to the shock, with lockdowns being the main transmission mechanism. Implementing the most stringent lockdowns (e.g., as in the Philippines in April of 2020) is associated with 19 percentage point drop in exports and almost 8 percentage point drop in imports. Trade with low-income countries was less responsive to lockdown stringency, however, given later timing of the virus spread and limited enforcement of lockdown orders in these countries. Second, the shock was short-lived, with the effect of lockdowns dissipating quickly in the third quarter of 2020. Third, we find that trade values decreased in response to the shock primarily due to the adjustments in volumes, with slower passthrough to prices. Fourth, when taking a closer look at the firms integrated in GVCs, we find that the COVID-19 shock propagated quickly along the supply chains. Goods further down the supply chains, i.e., closest to the final consumer, were most impacted by the COVID-19 shock, with intermediate goods relatively more insulated. Together, these findings suggest that demand forces explained most of the initial trade collapse and subsequent recovery in 2020.

We further explore how firm heterogeneity determined the size of the adjustment. First, we show that inventory management practices and automation of production processes played a role. Firms in more inventory-intensive industries weathered the shock better and the most inventory-intensive firms tended to stockpile imported inputs. We proxy automation of production processes by firm-level imports of industrial robots in recent years. Based on this measure of automation, we find that robotization mitigated the impact of the shock on both exports and imports. Second, we find that older and medium-sized firms fared better during the pandemic, with younger, smaller and larger firms' trade flows being more negatively impacted. Third, firms relying on air transportation to transport their goods were also more hit by the COVID-19 shock, suggesting that COVID-19 containment policies initially brought larger disruptions to air transportation compared to road and maritime transportation.

Finally, we examine the effect of two distinct sets of policies on trade adjustment in France. First, we estimate the impact of trade promotion measures and trade bans implemented by many countries. Our findings suggest that the overall impact of these policies was limited, with an exception of trade with low-income countries, where import and export bans dampened trade. Second, we evaluate the effect of economic support policies, including cash transfers to households and stimulus spending, on demand for French exports and supply of imports to France. On both sides, we find no significant impact of these policies.

Overall, the first year of the pandemic demonstrated a remarkable level of resilience of global supply chains. Our results support the view that deglobalization of trade following the COVID-19 shock is unlikely. Antràs (2020) posits that adjustment to the pandemic shock along the intensive margin, as observed in the case of French firms, signals that comprehensive and permanent realignment of supply chains in response to the pandemic shock is unlikely, all else being equal. While some argue that the lockdown shock followed by demand-driven recovery is unlikely to bring radical changes to how firms source and sell their products, we could see adjustments in other firms' practices. The findings on French firms' adjustment to the pandemic shock highlighted the role of automation as a mitigating factor, suggesting that the pandemic is likely to accelerate this trend. Inventory management practices also played a role in firms' ability to weather the shock, with smoother adjustment in more inventory-intensive industries.

This paper contributes to the growing literature examining the impact of the COVID-19 pandemic on

trade and GVCs. Lafrogne-Joussier, Martin, and Mejean (2021) and Bricongne, Carluccio, Fontagné, Gaulier, and Stumpner (2021) are the two closest studies in that they examine the impact of the COVID-19 shock on French firms. Lafrogne-Joussier, Martin, and Mejean (2021) focus on the impact of the lockdown put in place in January 2020 by the Chinese government on the trade activity of French firms. They find that French firms relying heavily on inputs imported from China were most impacted, causing sizable disruptions in GVCs. Bricongne, Carluccio, Fontagné, Gaulier, and Stumpner (2021) find that the largest French firms were disproportionately affected by the pandemic shock. The paper focuses on French firms' exports in 2020 and explores factors contributing to under-performance of the largest firms, including heterogeneous elasticities of firms to demand shocks by size. Relative to these papers, we examine both the initial trade collapse and the recovery period for the entirety of 2020. We also go beyond quantifying the impact of the pandemic on French firms and examine cross-country heterogeneity in French trade partners' response to the COVID-19 shock.

Our study contributes to the broader literature examining the effect of the COVID-19 pandemic on aggregate trade flows. Most of these studies use bilateral trade data at the country level. First, Liu, Ornelas, and Shi (2021) use data on Chinese exports to investigate the impact of foreign trading partners' lockdown policies designed to contain the pandemic and the number of the COVID-19 deaths. Their results suggest a large heterogeneity in the trade responses, with the dampening effects of the pandemic being mitigated for capital goods and in sectors with a high "work-from-home" share and high contract intensity. Similarly, using bilateral trade data from about 30 countries, Berthou and Stumpner (2021) and Espitia, Mattoo, Rocha, Ruta, and Winkler (2021) find that lockdowns had a dampening effect on bilateral trade flows and document substantial heterogeneity of lockdown effects across sectors. Cerdeiro and Komaromi (2020) use a high-frequency dataset on seaborne world trade to quantify the effect of supply spillovers from the COVID-19 lockdowns. Relying on geography-induced cargo delivery lags, they are able to disentangle the supply and demand channels of the COVID-19 trade collapse. Our paper follows a similar identification strategy to Liu, Ornelas, and Shi (2021) and Berthou and Stumpner (2021), with the COVID-19 shock being captured by the lockdown stringency index and the number of COVID-19 deaths. However, we further extend the analysis by examining the heterogeneity of the response at the firm level, allowing us to identify additional mitigating factors like firm age and size.

This paper also relates to a number of studies on the role of GVCs in the impact of the COVID-19 pandemic on trade flows across countries. Bonadio, Huo, Levchenko, and Pandalai-Nayar (2021) and Çakmaklı, Demiralp, Kalemli-Özcan, Yeşiltaş, and Yıldırım (2021) develop general equilibrium models of trade to quantify these effects and understand the implications of the pandemic on the future of GVCs and identify optimal policies in the aftermath of the shock. Bonadio, Huo, Levchenko, and Pandalai-Nayar (2021) show that GVCs play an important role in the transmission of pandemic-related labor supply shocks across countries. However, they show that the economic impact of the pandemic would have been substantially larger in the absence of global trade. Çakmaklı, Demiralp, Kalemli-Özcan, Yeşiltaş, and Yıldırım (2021) consider the role of global vaccination rates on transmission of the COVID-19 shock across countries through GVCs. They demonstrate that even if advanced economies achieve full vaccination rates, they can still bear significant costs of the pandemic-related supply chain disruptions in developing countries, where vaccination rates remain low. Our findings are consistent with the theoretical predictions of these papers: we show that lockdown shocks quickly propagated along the supply chains.

Finally, this paper contributes to the long-standing literature investigating trade in the times of crisis. Bricongne, Fontagné, Gaulier, Taglioni, and Vicard (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% of their sample, reducing their flow of exports, while small firms adjusted mainly along the extensive margin. Similarly, Gopinath and Neiman (2014) studies 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 happened along the intensive margin.

The rest of the paper is organized as follows. Section 2 describes the data used in the analysis. Section 3 investigates the margins of trade adjustment. Section 4 outlines the main specification. Section 5 describes the main results and Section 6 concludes.

2 Data

We use firm-level monthly customs data from France to analyze the impact of the COVID-19 pandemic on trade flows. Two French 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 imports and exports, including product identifiers, values, quantities, origin/destination countries, from January 1995 to December 2020. Products are classified based on the European CN8 nomenclature system, which is broadly equivalent to the international HS8 nomenclature system. We harmonize the product classification over time and follow Bergounhon, Lenoir, and Mejean (2018).[2]

The French government imposed several lockdowns during the year 2020 to respond to the pandemic, the more stringent being the first one, implemented on March 17th up to May 11th. We thus focus on the period from January 2019 to December 2020, to study the pandemic impact on trade flows, considering the year 2019 as a benchmark. The Oxford Covid-19 Government Response Tracker (OxCGRT), compiled by Hale, Angrist, Goldszmidt, Kira, Petherick, Phillips, Webster, Cameron-Blake, Hallas, Majumdar, and Tatlow (2021), provides a large number of Covid-related indicators. From this, we use the lockdown stringency index and the number of COVID-19 deaths in foreign economies, to capture the intensity of the shock in these economies. In addition, we use their economic support index to further account for governments' interventions. Countries all over the world also put in place COVID-19 trade policies, either to restrict exports of strategic products produced locally, or to facilitate imports of other products, namely medical and pharmaceutical goods. We collect these data from the WTO website.[3] Finally, we apply the methodology for constructing the upstreamness index from Antràs, Chor, Fally, and Hillberry (2012) and use French input-output tables from OECD (2018). Table 1 presents summary statistics of the main variables by country group.

3 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 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

[2]Bergounhon, Lenoir, and Mejean (2018) provides the different steps to clean French customs data, and harmonize them over time along the product dimension following a uniform CPA classification.

[3]https://www.wto.org/english/tratop_e/covid19_e/trade_related_goods_measure_e.htm

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

Table 1: Summary statistics by country group

	AE	EM (excl. China)	China	LIDC
Exports				
Total change	-27.58	-57.55	-51.11	-38.35
	(537.96)	(642.51)	(727.33)	(734.05)
Lockdown stringency	0.50	0.51	0.69	0.43
	(0.237)	(0.276)	(0.15)	(0.258)
COVID-19 deaths	3.11	2.23	0.34	0.035
	(8.04)	(5.19)	(0.74)	(0.11)
Upstreamness	1.98	2.02	2.01	2.01
	(0.364)	(0.340)	(0.33)	(0.321)
Inventory-to-sales ratio	0.16	0.15	0.20	0.16
	(0.11)	(0.08)	(0.16)	(0.11)
Share of firms using robots	8.40	11.43	17.46	13.30
Imports				
Total change	-30.96	-28	-20.63	-15.43
	(568.10)	(579.77)	(573.82)	(552.2)
Lockdown stringency	0.51	0.53	0.68	0.53
	(0.24)	(0.27)	(0.16)	(0.26)
COVID-19 deaths	4.92	3.64	0.34	0.17
	(10.88)	(7.16)	(0.75)	(0.36)
Upstreamness	2.1	1.91	1.98	1.72
	(0.38)	(0.36)	(0.35)	(0.30)
Inventory-to-sales ratio	0.14	0.15	0.16	0.17
	(0.05)	(0.05)	(0.04)	(0.05)
Share of firms using robots	8.25	11.08	9.13	17.79

Notes: We calculate the mean value (and the standard deviation in parenthesis) of each variable by country group. The share of firms using robots is the share of firms doing business with a country in the area using robots in the production process. All values are computed over 2020.

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 sub-intensive and sub-extensive 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:

$$\frac{\Delta v_t}{v_{t-1}} = \underbrace{\left(\sum_{j \in \Phi_{t-1} \cap \Phi_t} \frac{v_{j,t} - v_{j,t-1}}{v_{j,t-1}} \right)}_{\text{Sub-intensive margin}} + \underbrace{\left(\sum_{j \in \Phi_t, j \notin \Phi_{t-1}} \frac{v_{j,t}}{v_{t-1}} - \sum_{j \in \Phi_{t-1}, j \notin \Phi_t} \frac{v_{j,t-1}}{v_{t-1}} \right)}_{\text{Sub-extensive margin}} + \underbrace{\left(\sum_{i \in \Psi_t, i \notin \Psi_{t-1}} \frac{v_{i,t}}{v_{t-1}} - \sum_{i \in \Psi_{t-1}, i \notin \Psi_t} \frac{v_{i,t-1}}{v_{t-1}} \right)}_{\text{Extensive margin}} \tag{1}$$

where j denotes a firm $\times$ variety combination, and i denotes a firm. Φ_t is the set of all firm $\times$ variety combinations in period t and Ψ_t is the set of all importing or exporting firms in period t. The first term captures the sub-intensive margin, where continuing firms adjust the value of imported or exported variety. The second term captures the sub-extensive 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.

Figure 1: Trade margins - Exports

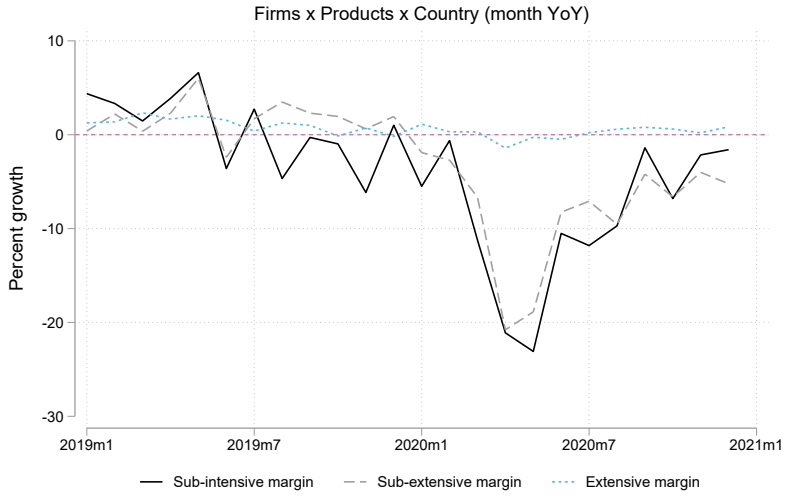
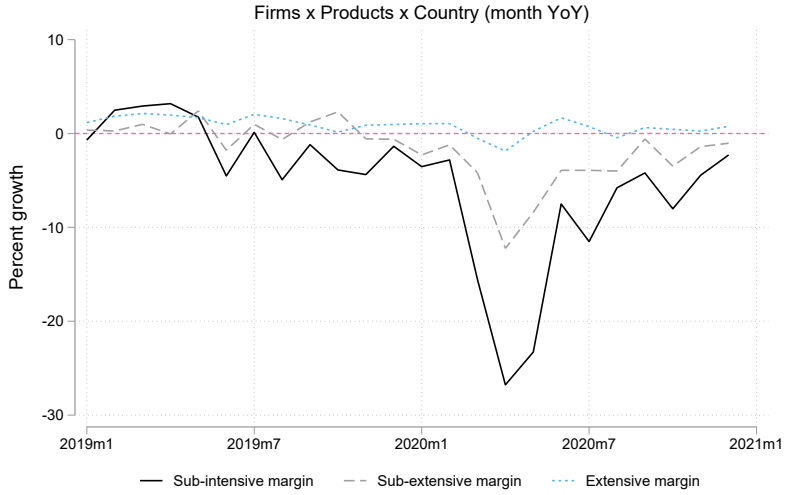


Figure 2: Trade margins - Imports

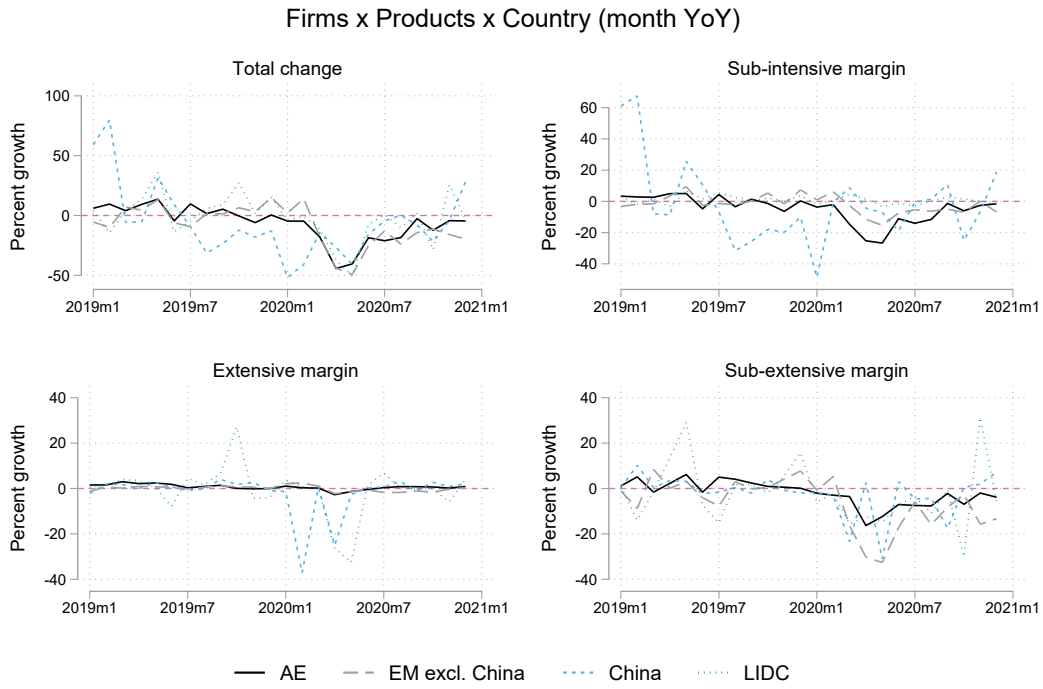


Figures 1 and 2 plot the three margins of adjustment over 2019m1-2020m12, for French exporting and importing firms respectively. Considering the peak of the trade shock in the first-half of 2020, the extensive margin played a small role in trade adjustment, as both exporting and importing firms adjusted primarily along the sub-intensive margin.[5] However, exporting firms also stopped exporting some products to some destinations, a behavior reflected by the large adjustment along the sub-extensive margin. The role of adjustment along the sub-extensive margin is smaller for importing firms, with the sub-intensive margin accounting for almost 90 percent of the drop in aggregate imports in the second quarter of 2020. The data

[5]This finding suggests that the COVID-19 shock is transitory. We also find that intensive margin accounted for the majority of trade adjustment during the Great Trade Collapse (GTC) of 2009.

for the second half of 2020 indicate that trade flows largely recovered in the second half of 2020. Nevertheless, by December 2020, both imports and exports were still declining relative to 2019.

Figure 3: Trade margins by income group - Exports



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. The results in Figures 3 and 4 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. In Figure 4, 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 imported from China for the first time during this period. Changes along the sub-intensive margin also suggest that many firms switched to Chinese imports away from existing trade partners, and especially so from other EMs.

Exports to China dropped earlier, given that the pandemic originated in China (Figure 3). 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 sub-extensive margin also played a more prominent role in exports to developing countries, including China, compared to the AEs. Unlike Figure 4, however, Figure 3 shows more consistent patterns of trade adjustment across country groups.

Table 2 summarizes the contribution of each margin to the total change in exports and imports between 2019Q2 and 2020Q2, focusing on the quarter covering the first lockdown. The top panel shows that adjustment along the sub-intensive margin accounted only for 1 percent of total drop of exports to LIDCs

Figure 4: Trade margins by income group - Imports

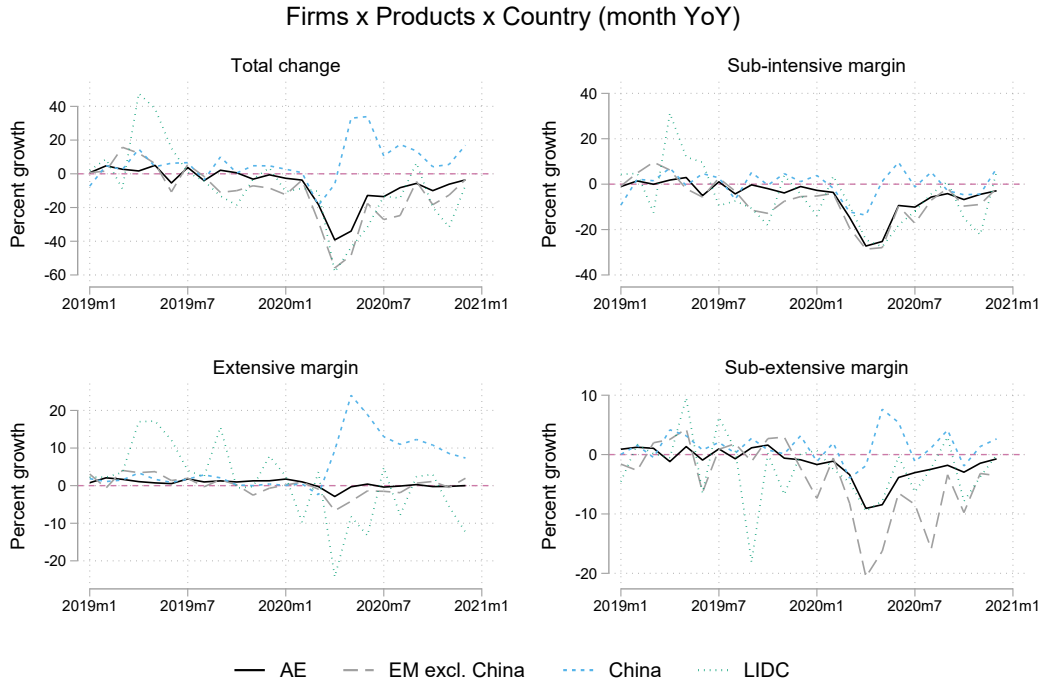


Table 2: Contribution of margins to changes in trade flows by trading partner

	Percent total	Share sub-intensive	Share sub-extensive	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	0.01	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.

in the second quarter of 2020, while it accounted for the majority of the decline in exports to AEs. The sub-extensive 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, the sub-intensive 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. This implies that many firms previously not importing from China began doing so in the second quarter of 2020. This is consistent with the earlier onset of the virus spread in China and subsequent recovery, while the rest of the world was dealing with the rapid spread of the virus and stringent lockdown orders.

4 Econometric Specification

The empirical strategy relies on the variation in the magnitude and timing of the COVID-19 shock, measured by the number of the COVID-19 deaths and stringency of lockdowns imposed by French firms' international trade partners. Whereas deaths counts capture the direct effect of the pandemic severity on trade flows, lockdown stringency captures the indirect effect of the pandemic through containment policies.

We estimate the effect of partner countries' COVID-19 death toll and lockdown policies on firm- and product-level monthly exports and imports as follows:[6]

$$y_{ipct} = \beta_1 \text{Stringency}_{ct} + \beta_2 \text{Deaths}_{ct} + \alpha_i + \gamma_{pc} + \tau_t + \epsilon_{ipct}. \tag{2}$$

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

$$y_{ipct} = \frac{\text{flow}_{ipct} - \text{flow}_{ipc(t-12)}}{\frac{1}{2}\left(\text{flow}_{ipct} + \text{flow}_{ipc(t-12)}\right)}. \tag{3}$$

There are advantages of measuring growth in trade using the mid-point growth formula.[7] 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 along the extensive margin.

The lockdown stringency measure is a monthly average of the country-specific daily index. Deaths_{ct} denotes the monthly change in the number of COVID-19 deaths per 1,000 people in a country c. Both measures are from the Oxford COVID-19 Government Response Tracker (Hale, Angrist, Goldszmidt, Kira, Petherick, Phillips, Webster, Cameron-Blake, Hallas, Majumdar, and Tatlow, 2021). α_i denotes firm fixed effects, γ_{pc} denotes product-country fixed effects, τ_t is a month-year fixed effects and ϵ_{ipct} is an error term.

In addition, we examine the heterogeneity in the magnitude of the COVID-19 shock across various firm, product, and country characteristics. Since many of the characteristics that we consider in Sections 5.3-5.6 are time-invariant, we interact the main variables of interest—lockdown stringency and COVID-19 deaths—with these characteristics.

5 Results

5.1 Baseline

Column 1 in Table 3 contains the baseline results based on the specification in Equation 2. In addition, we posit that the effect of the COVID-19 shock can vary by countries' development level. For instance, countries' level of integration in GVCs and product composition of their trade baskets can determine the magnitude of the COVID-19 shock on trade flows. While some of these time-invariant characteristics would be absorbed by country-product fixed effects, differences in effects of lockdown stringency and COVID-19 deaths can provide insights on the shock transmission channels. Columns 2-4 contain results by country group—AEs, EMs and LIDCs.

[6] Our estimation framework is similar to Liu, Ornelas, and Shi (2021), who examine the effect of lockdowns on country-specific Chinese exports. We examine both imports and exports at the firm level and use mid-point growth of trade flows to account for changes in trade flows along the extensive margin.

[7] We perform a robustness check where we replace the mid-point growth measure by the year-on-year log difference in trade flows. The baseline results discussed below are robust to this definition of import and export growth.

Top panel of Table 3 shows the effect of lockdown stringency on French firms' exports. The results suggest that, on average, in 2020, an increase of one standard deviation in the monthly lockdown stringency index (about .25 on a scale from 0 to 1) is associated with about 4.8 percentage point drop in aggregate exports. Implementing the most stringent lockdowns (e.g., as in the Philippines in April of 2020) implies a drop in exports of 19 percentage points, when controlling for the number of COVID-19 deaths. This effect is both economically and statistically significant and is predominantly driven by AEs and EMs, as suggested by the results in Columns 2-4. The effect of lockdowns on exports to LIDCs is not statistically significant, which could in part be due to LIDCs' limited participation in GVCs and lower effectiveness of lockdown orders. Spread of the COVID-19 virus was faster in AEs and EMs in 2020 and thus containment measures in those countries tended to be more wide-reaching and more stringent. In addition, higher rates of labor market informality in LIDCs may imply more limited enforcement and compliance.

Table 3: Baseline Results

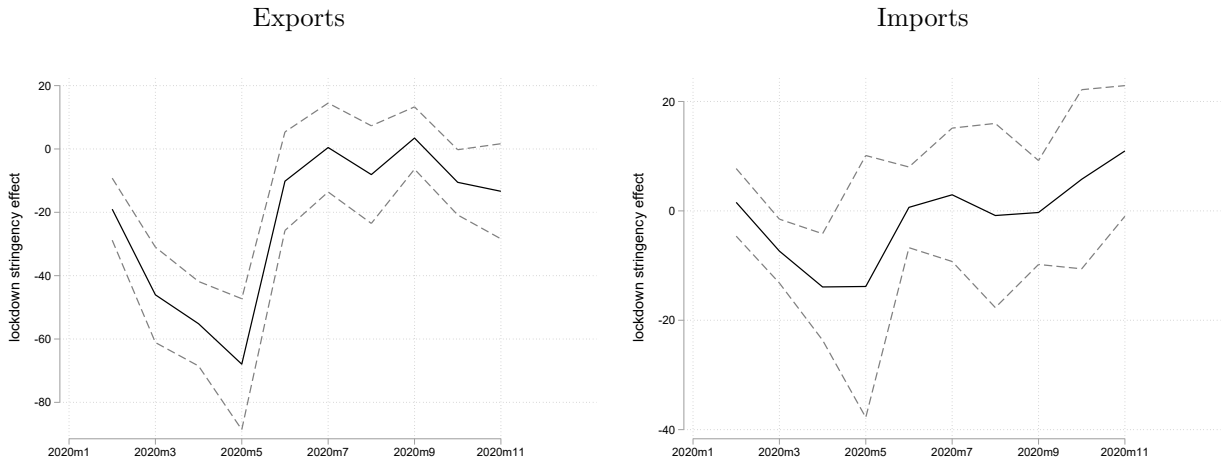
	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-19.391***	-13.423**	-24.047***	-18.624
	(4.161)	(5.441)	(8.565)	(12.483)
COVID-19 deaths	-0.170**	-0.184**	0.104	-17.659*
	(0.082)	(0.075)	(0.213)	(9.630)
Observations	13412558	9968879	2918718	463977
Imports				
lockdown stringency	-7.843**	-8.916	-14.203***	7.455
	(3.559)	(6.193)	(3.933)	(7.435)
COVID-19 deaths	-0.015	-0.078**	0.120	-6.727*
	(0.037)	(0.032)	(0.104)	(3.550)
Observations	16975634	11713020	4738066	494784

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

The effect of new COVID-19 deaths on aggregate exports is negative and statistically significant, suggesting that the severity of the virus spread and the associated death toll significantly reduced the demand for French exports. One standard deviation increase in the number of monthly new deaths due to COVID-19 (about 7 in the entire sample of countries) is associated with 1.2 percentage point decline in exports. This effect is statistically significant at the 5 percent significance level in the aggregate regression but, economically, it is considerably smaller compared to the effect of lockdowns. This result suggests that lockdown policies were the primary driver of the demand shock. In addition, it could also capture the measurement error in new deaths. While deaths are considered a more reliable indicator of severity of the pandemic in a given country compared to the confirmed cases, the effect of COVID-19 related deaths is limited in the case of EMs, suggesting that the main channel of transmission of the COVID-19 shock in these countries was government-imposed lockdown orders.[8]

[8]True number of cases is likely to exceed the number of confirmed cases, given that many cases are not reported, especially in cases where symptoms are mild or absent altogether. Despite being a more telling measure of the virus severity in a given

Figure 5: 3-months rolling average effect of lockdowns on trade flows



Note: Dependent variable is a mid-point yoy growth in trade flows. Dashed lines indicate 95 percent confidence intervals. All regressions control for monthly new COVID-19 deaths per 1,000 and include firm, country-product, and time fixed effects.

The bottom panel of Table 3 shows the baseline results for French imports. The effect of lockdowns is considerably smaller for imports compared to exports—one standard deviation increase in the stringency of lockdowns in countries exporting to France is associated with about 1.9 percentage point decline in the value of goods imported by French firms. Implementing the most stringent lockdown implies a drop in imports of almost 8 percentage points. This effect, however, is stronger for EMs, where one standard deviation increase in lockdown stringency in EMs is associated with 3.8 percentage point drop in imports from these countries. In Appendix A, we show that this result is mainly driven by imports from China. The coefficient on the lockdown stringency index and new deaths in the case of imports are not significant both in economic and statistical terms for the entire sample of countries. The impact of COVID-19 deaths on imports from AEs is small economically. For LIDCs, the coefficient is sizable but only weakly statistically significant. Similarly to the export results, lockdowns appear to be the main transmission channel of the COVID-19 shock.

Differences in estimated effects of lockdowns and COVID-19 deaths on exports and imports in Table 3 suggest that demand shocks in French firms' trading partner countries tend to dominate the supply shocks. It is important to note, however, that the results on both exports and imports simultaneously capture supply and demand shocks. We must thus assume that supply shocks experienced by French exporters did not vary by destination of French exports and that supply shocks in a given country uniformly affected French importers trading with that country. Based on these assumptions, our conclusion is predominantly based on the difference in the coefficients, with the coefficients in the imports regressions being considerably smaller. Evidence on the upstreamness of sectors most impacted by lockdowns provided in Section 5.3 further corroborates this hypothesis.

How lasting are the effects of lockdowns and COVID-19 deaths on trade flows? We explore the dynamic effect of the COVID-19 shock on trade flows. To that end, we estimate the baseline specification in Equation 2 for three-month rolling windows for both export and import flows. Figure 5 plots the coefficients on the lockdown stringency index from the resulting regressions for exports and imports.[9] The effect of lockdowns

countries, COVID-19 related deaths may still not be fully accurate. Karlinsky and Kobak (2021) show large discrepancies between reported COVID-19 death and excess mortality estimates.

[9]We omit the results on new COVID-19 deaths since the coefficients are not significant, both economically and statistically. However, these are available upon request.

dissipates quickly for both exports and imports. The initial impact of lockdowns on exports is considerably larger compared to imports, making the recovery path sharper. Towards the end of 2020, the coefficients on lockdown stringency for imports, in fact turns positive, albeit with rather wide confidence intervals.

5.2 Unit values

We test whether the changes in trade values are driven by changes in prices versus changes in quantities of traded goods. While French customs data only contain information on quantities and not on prices, we construct 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 average unit values for continuing products and use it as a dependent variable in Equation 2 instead of the change in trade values.

Table 4: Unit values

	(1) Export Unit Values	(2) Import Unit Values
lockdown stringency	-0.800	0.581*
	(0.635)	(0.339)
COVID-19 deaths	-0.035***	-0.025***
	(0.011)	(0.008)
Observations	4696074	5548822

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

The results presented in Table 4 suggest that, in aggregate, the COVID-19 shock had limited impact on average unit values in 2020. We do find, however, a small negative effect of rising COVID-19 deaths in countries trading with French firms on unit values. However, coefficients on both the new deaths and the lockdown stringency index are economically small and, in the case of the stringency index, not statistically significant.

5.3 COVID-19 shock propagation via supply chains

This section provides evidence on the propagation of the COVID-19 shock along GVCs and differential impact of the shock on goods at different levels of upstreamness.

We limit the sample of firms to those that simultaneously export and import. This type of firms is generally considered to be integrated in GVCs, given that at least a part of their intermediate goods suppliers and final goods buyers are located abroad. For this sample of firms, in addition to our two variables of interest—lockdown index and COVID-19 deaths—we relate their contemporaneous exports to lagged imports. This allows us to understand how pandemic-related delays in imports of intermediate goods affected production and subsequent exports of final products. These results are presented in the top panel of Table 5. These results suggest that 10 percentage point drop in the value of imports in the previous period is associated with almost 0.7 percentage point drop in exports in the current period. This effect is stronger for firms trading with AEs and EMs and is more than 50 percent lower for firms exporting to LIDCs.

In addition to relating exports to lagged import growth, we explore the relationship between contemporaneous imports and future exports. This allows us to investigate whether firms, in anticipation of lower

Table 5: Shock propagation in supply chains

	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lagged import growth	6.989***	7.127***	7.283***	3.186***
	(0.321)	(0.350)	(0.607)	(0.810)
lockdown stringency	-19.103***	-13.167**	-23.234**	-21.044
	(4.359)	(5.584)	(8.807)	(12.656)
COVID-19 deaths	-0.205**	-0.221**	0.092	-17.488*
	(0.090)	(0.084)	(0.219)	(9.515)
Observations	12208088	9089129	2686982	382947
Imports				
lead export growth	2.647***	2.464***	3.041***	4.320***
	(0.134)	(0.149)	(0.288)	(0.996)
lockdown stringency	-9.717***	-9.670	-15.793***	-1.339
	(3.537)	(6.312)	(4.399)	(5.420)
COVID-19 deaths	-0.034	-0.115*	0.156	-0.177
	(0.065)	(0.066)	(0.148)	(2.613)
Observations	10254488	7273360	2714302	256294

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

demand for their exports in the future, scale back on imports of intermediate goods in the current period. To test this hypothesis, we add a lead of exports to the baseline specification. Compared to the relationship between exports and lagged import changes, the coefficient on the lead export growth in the bottom panel of Table 5 is considerably smaller, albeit positive and statistically significant. A 10 percentage point drop in the value of future exports is associated with about 0.26 percentage point decrease in imports. This evidence suggests that shocks propagate along supply chains and firms adjust their export supply and demand for imported intermediates in response to upstream and downstream shocks.

We further explore the mechanisms of shock propagation along GVCs by using a measure of product upstreamness at the industry level. The measure of upstreamness proposed by Antràs, Chor, Fally, and Hillberry (2012) captures the average distance of an industry from its final use, implying that the closer the industry is to the final consumer, the lower the value of the index is.[10] We apply the algorithm developed by these authors to the case of French input-output table from 2015 (OECD, 2018). The resulting measure is continuous and ranges from about 1.4 to 3.1 and with an average value at about 2 for exporting and importing firms as shown in Table 1.

We interact both the stringency index and the number of deaths with the upstreamness index and report the resulting coefficients in Table 6. Positive coefficients on interaction terms suggest that products further away from the final consumer (more upstream) were more insulated from the COVID-19 shock. These results are particularly consistent for the interaction between lockdown stringency and upstreamness indices across countries, suggesting that the decrease in consumer demand was the driving force behind the initial

[10]In addition, we use Broad Economic Categories classification of goods to devide them into capital, intermediate, and consumer goods. Consistent with the rest of the results in this section, we find that intermediate and capital goods were more insulated from the pandemic shock than consumer goods. These results are available upon request.

Table 6: Upstreamness in supply chains

	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-49.594***	-44.360***	-63.159***	-17.474
	(7.451)	(9.236)	(10.050)	(21.233)
lockdown stringency × upstreamness	15.018***	15.542***	19.316***	-0.545
	(2.729)	(3.008)	(3.853)	(8.206)
COVID-19 deaths	-0.817*	-0.953	0.781**	-102.819**
	(0.490)	(0.594)	(0.315)	(41.020)
COVID-19 deaths × upstreamness	0.327	0.390	-0.337**	42.077**
	(0.215)	(0.271)	(0.136)	(19.886)
Observations	13154338	9767952	2875927	450628
Imports				
lockdown stringency	-35.106***	-28.843**	-50.321***	-25.492*
	(7.098)	(11.011)	(6.994)	(13.488)
lockdown stringency × upstreamness	13.636***	9.659***	18.860***	19.062**
	(2.633)	(3.312)	(2.842)	(8.646)
COVID-19 deaths	-0.029	-0.288	1.025***	23.533***
	(0.292)	(0.391)	(0.199)	(6.590)
COVID-19 deaths × upstreamness	0.004	0.102	-0.473***	-18.221***
	(0.136)	(0.180)	(0.130)	(4.077)
Observations	16694396	11483601	4691449	489678

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

collapse in trade volumes. More upstream industries were relatively more insulated, potentially due to slower passthrough of the shock to intermediate goods trade. This mechanism operates for exports and imports across all country groups, with an exception of exports to LIDCs. The coefficient on the interaction term between lockdown stringency and product upstreamness in the latter case is neither statistically nor economically significant, which could in part be due to the later arrival of the virus to LIDCs and less stringent lockdowns. Nevertheless, the coefficient on the interaction between COVID-19 deaths and upstreamness index is positive for LIDCs, suggesting that the effect of the pandemic on more upstream products was indeed smaller for all country groups.

The results on the interaction between COVID-19 deaths and upstreamness measure are less conclusive. In the aggregate and for AEs, the interaction terms are not statistically significant, suggesting that there was no differential impact of COVID-19 deaths on trade by the level of good's position along the GVCs. However, we do find that the COVID-19 shock, as measured by its death toll, played an important role in the decline of more upstream imports from developing countries, including EMs and LIDCs, and exports for EMs. As discussed above, this result could be driven by the timing of the virus spread, with developing countries seeing higher cases and deaths counts later in 2020, with a larger impact on their exports of intermediates and corresponding consequences for GVCs.

5.4 Heterogeneous effects: inventory intensity and automation

In this section, we investigate the mitigating factors of the pandemic shock, including firms' inventory management practices and the level of automation. To that end, we interact both the lockdown stringency index and the number of COVID-19 deaths with an industry-level inventory intensity measure (Table 7) and a firm-level indicator for industrial robot use (Table 8). We posit that firms with higher stocks of inventories were able to better weather supply disruptions associated with the spread of the virus and lockdown policies. Similarly, we expect that firms using robots in production were better equipped to respond to labor shortages associated with the pandemic.

Table 7: Inventory intensity

	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-24.898***	-17.711***	-33.141***	-25.446*
	(4.743)	(6.174)	(9.207)	(13.525)
lockdown stringency × inventory intensity	22.428***	17.896***	35.891***	28.505
	(4.640)	(5.261)	(7.765)	(18.998)
COVID-19 deaths	-0.247**	-0.276**	0.021	-20.299
	(0.119)	(0.117)	(0.297)	(12.620)
COVID-19 deaths × inventory intensity	0.218	0.272	0.220	7.087
	(0.164)	(0.193)	(0.344)	(31.571)
Observations	13289612	9860461	2907873	461479
Imports				
lockdown stringency	-15.980	-0.145	2.629	44.139***
	(4.100)	(5.302)	(4.297)	(13.571)
lockdown stringency × inventory intensity	33.486***	36.110***	33.852***	33.814*
	(4.227)	(5.457)	(5.590)	(17.888)
COVID-19 deaths	-0.063	-0.115**	0.154	-14.813***
	(0.042)	(0.049)	(0.192)	(1.944)
COVID-19 deaths × inventory intensity	0.213***	0.168*	-0.131	35.860**
	(0.078)	(0.090)	(0.434)	(13.836)
Observations	16886395	11646500	4719524	491037

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

We find support for our first hypothesis in Table 7. We use industry-level medians of inventories-to-sales ratio to capture the impact of inventory intensity.[11] Firm-level data on inventory holdings and sales from balance sheets administered by the French National Statistical Institute are aggregated at the 3-digit French Classification of Activities (NAF) level. In our main specification, we use median levels of inventories-to-sales ratios. The results suggest that exports and imports of firms located in more inventory-intensive industries were more insulated from the pandemic shock. The coefficient on the interaction between lockdown stringency and inventory intensity is particularly sizable. Interestingly, our results suggest that firms in the most inventory-intensive industries (with a ratio of inventories-to-sales ratio at about 0.83) increased their imports during the pandemic. Some anecdotal evidence suggests that stockpiling behavior in some industries

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

led to shortages and shipping delays later in the pandemic.

Our findings on the role of inventory intensity in import adjustment are consistent with Lafrogne-Joussier, Martin, and Mejean (2021). However, Alessandria, Kaboski, and Midrigan (2010), Bems, Johnson, and Yi (2013), and Gopinath and Neiman (2014) show that, during previous crises (e.g., Global Financial Crisis in the US and Argentinian crisis in early 2000s), inventory intensity tended to amplify the trade collapse, since inventory-intensive firms tended to exhaust their inventories in the face of demand uncertainty. Overall, the evidence on the role of inventories as a mitigating factor should be interpreted with caution.[12]

Table 8: Robotization

	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-23.608***	-18.449***	-27.988***	-12.765
	(4.267)	(5.564)	(8.666)	(12.104)
lockdown stringency × robots	9.541***	11.961***	8.713***	-14.444**
	(1.578)	(2.030)	(2.228)	(5.477)
COVID-19 deaths	-0.192**	-0.206**	0.127	-22.208**
	(0.095)	(0.088)	(0.214)	(10.749)
COVID-19 deaths × robots	0.061	0.071	-0.070	10.355
	(0.048)	(0.053)	(0.091)	(14.495)
Observations	13412558	9968879	2918718	463977
Imports				
lockdown stringency	-12.584***	-13.231**	-20.321***	3.401
	(3.689)	(6.404)	(4.220)	(7.633)
lockdown stringency × robots	11.757***	10.034***	16.864***	17.056***
	(1.606)	(1.760)	(2.403)	(3.728)
COVID-19 deaths	-0.042	-0.116**	0.189*	-4.773
	(0.047)	(0.043)	(0.113)	(4.122)
COVID-19 deaths × robots	0.044	0.073**	-0.208***	-8.305***
	(0.027)	(0.035)	(0.050)	(2.578)
Observations	16975634	11713020	4738066	494784

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

In Table 8, we investigate whether automation of production processes served as a mitigating factor in the impact of the COVID-19 shock on firms' exports and imports. 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. The resulting measure is a binary indicator. If a firm imported industrial robots between 2017 and 2020, we assign it a value of one for using industrial robots in production. If a firm did not import robots during this period, we assign a value zero. About 7 percent of firms exporting to AEs and around 11 percents of firms exporting to EMs and LIDCs use industrial robots in production (Table 1). On the import size these shares range from 8 percent for firms importing from AEs and close to 18 percents importing from LIDCs.

[12]We tested other measures of inventory intensity, including an industry average ratio of inventories to sales and a ratio of aggregate inventories to aggregate sales for each industry. We find that the results based on the median measure are not robust to other measures of inventory intensity. These results are available upon request.

Coefficients on the interaction between lockdown stringency and robots indicator in the top panel of Table 8 are positive for all country groups, with an exception of LIDCs. This evidence suggests that firms using industrial robots in production were less impacted by lockdowns, when it came to exports to AEs and EMs. Robots, however, did not serve as a mitigating factor for exports to LIDCs.

On the import side (lower panel of Table 8), automation of production was associated with higher imports from all country group, as measured by the coefficient on the interaction between lockdown stringency and robots indicator. Evidence on the interaction between COVID-19 deaths and robots is less conclusive, with negative coefficients in imports from EMs and LIDCs. However, on net, imports of firms using industrial robots in production declined significantly less.

5.5 Heterogeneous effects: firm characteristics

Table 9: Firm age

	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-22.367***	-18.934***	-25.030**	-23.802
	(4.351)	(5.623)	(9.757)	(18.311)
lockdown stringency × age	0.154	0.301**	0.054	0.251
	(0.111)	(0.135)	(0.174)	(0.544)
COVID-19 deaths	-0.278***	-0.250***	-0.197	-45.860
	(0.079)	(0.065)	(0.287)	(28.406)
COVID-19 deaths × age	0.006**	0.004	0.015	1.339
	(0.003)	(0.003)	(0.009)	(1.080)
Observations	13412558	9968879	2918718	463977
Imports				
lockdown stringency	-17.378***	-17.789***	-23.739***	-0.475
	(3.393)	(5.941)	(4.791)	(8.606)
lockdown stringency × age	0.539***	0.479***	0.568***	0.543**
	(0.073)	(0.082)	(0.169)	(0.219)
COVID-19 deaths	-0.009	-0.071	-0.070	-5.395
	(0.058)	(0.067)	(0.114)	(4.749)
COVID-19 deaths × age	-0.000	-0.000	0.011***	-0.097
	(0.002)	(0.003)	(0.004)	(0.132)
Observations	16975634	11713020	4738066	494784

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

We now investigate the mitigating factors of the pandemic shock, considering the role of firm characteristics. Specifically, we focus on the role of the age of the firm (Table 9) and the firm's size (Table 10). Existing literature on the capacity of firm in dealing 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, Haltiwanger, Jarmin, and Miranda (2013) distinguish the effect of both size and age, showing that young or small firms are the most hit in cyclical

Table 10: Firm size

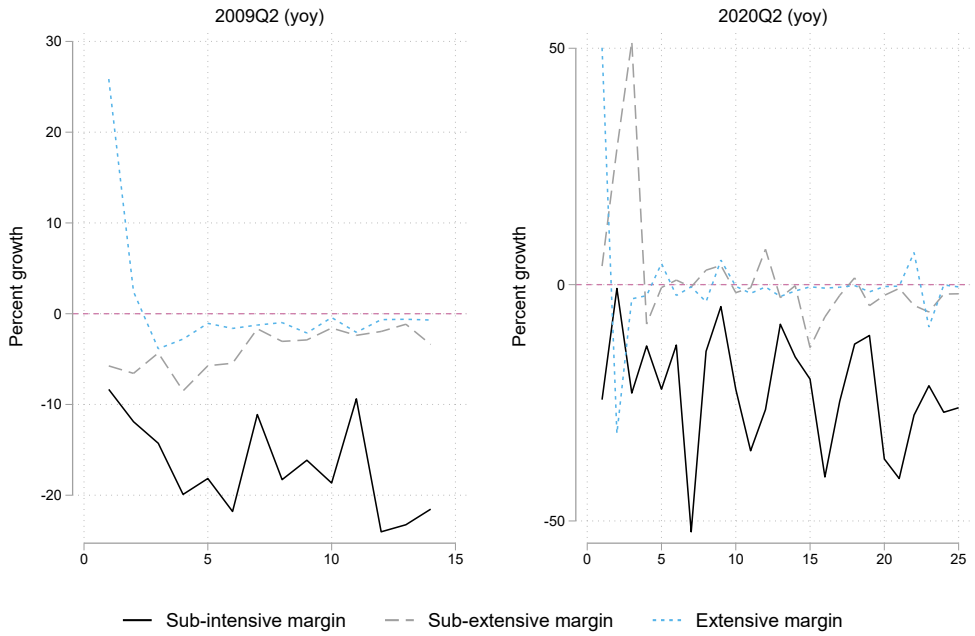
	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-22.305***	-17.479***	-27.230***	-25.838*
	(4.391)	(5.745)	(8.726)	(12.967)
lockdown stringency × medium	6.342***	6.514***	6.935***	7.857
	(1.362)	(1.489)	(2.006)	(8.272)
lockdown stringency × large	0.271	2.920	0.729	11.789*
	(2.264)	(2.786)	(2.269)	(6.868)
COVID-19 deaths	-0.165*	-0.197**	0.179	-9.349
	(0.088)	(0.086)	(0.264)	(11.744)
COVID-19 deaths × medium	-0.008	0.009	0.031	-9.229
	(0.046)	(0.049)	(0.133)	(14.854)
COVID-19 deaths × large	-0.000	0.042	-0.158	-10.354
	(0.081)	(0.098)	(0.145)	(9.754)
Observations	13412558	9968879	2918718	463977
Imports				
lockdown stringency	-16.605***	-15.769**	-26.224***	-13.231
	(3.998)	(6.398)	(5.128)	(9.994)
lockdown stringency × medium	15.092***	12.356***	19.503***	28.811***
	(1.724)	(1.549)	(3.789)	(4.319)
lockdown stringency × large	11.453***	7.746***	17.370***	32.143***
	(2.113)	(2.137)	(4.672)	(6.595)
COVID-19 deaths	-0.017	-0.115*	0.271*	-11.508**
	(0.053)	(0.063)	(0.151)	(5.157)
COVID-19 deaths × medium	0.014	0.057	-0.194**	9.266**
	(0.041)	(0.057)	(0.092)	(3.910)
COVID-19 deaths × large	0.007	0.094	-0.303***	2.284
	(0.047)	(0.069)	(0.097)	(2.751)
Observations	16975634	11713020	4738066	494784

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

downturns, especially during the GTC. We first compute the age of the firm in 2020 with respect to the first year the firm appeared in the original French customs dataset which starts in January 1995. Figures 6 and 7 plot the different margins of trade adjustment depending on the age of the firm in 2009Q2 (left graph) and 2020Q2 (right graph). No particular pattern seems to emerge from the COVID-19 crisis, aside from the sub-intensive margin dominating the trade adjustment. On the contrary, during the GTC, older firms adjusted substantially more along the sub-intensive margin and much less on the extensive margins than young firms, pointing to a learning effect. This missing trend during the COVID-19 crisis may indicate that French firms were not prepared to deal with this type of trade shock, regardless of their trade experience. This finding may also suggest a substantial effect of policy support provided by the government during the COVID-19 crisis, targeting smaller firms.

In Table 9 we present the results where we interacted both the stringency index and the number of

Figure 6: Response to shock depending on age - Imports



deaths with the age of the firm. The estimates indicate that older firms coped better with the COVID-19 shock: imports decreased significantly less in response to lockdowns in the seller's country. This is less clear for exports, although results indicate that exports dropped less in response to the number of deaths in the buyer's country when the exporting firm was older.

Second, we account for the size of the firm, which can be a significant mitigating factor. Bricongne, Fontagné, Gaulier, Taglioni, and Vicard (2012) show that larger firms dealt more easily with the shock during the GTC. To that end, we bin the sample by firms' size, where the size is proxied by the total amount of exports (or imports) in 2019Q2. Figure 8 plots the share of total trade realized by each size bin for 2019Q2 and 2020Q2. Interestingly, the largest firms are those who experienced the largest decrease in both exports and imports during the COVID-19 crisis, while this lost trade got redistributed to other firms. We then investigate trade adjustment depending on firms' size. Figures 9 and 10 provide information on the change in imports and exports along the sub-intensive, and extensive and sub-extensive margins. The largest firms reacted more along the sub-intensive 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.

Table 10 presents the results where we interact the variables of interest with three size categories: small, medium and large firms. Contrary to the standard wisdom, the interaction with our variables of interest show that large exporting firms did not do better than small firms during the crisis. Large importing firms performed better than small importing firms. Consistent with the stylized facts, it seems that the largest firms bore a large share of the cost of the shock. These results are in line with the findings of Bricongne, Carluccio, Fontagné, Gaulier, and Stumpner (2021), as they show that "export champions" are responsible for half of the slump of 2020.

Figure 7: Response to shock depending on age - Exports

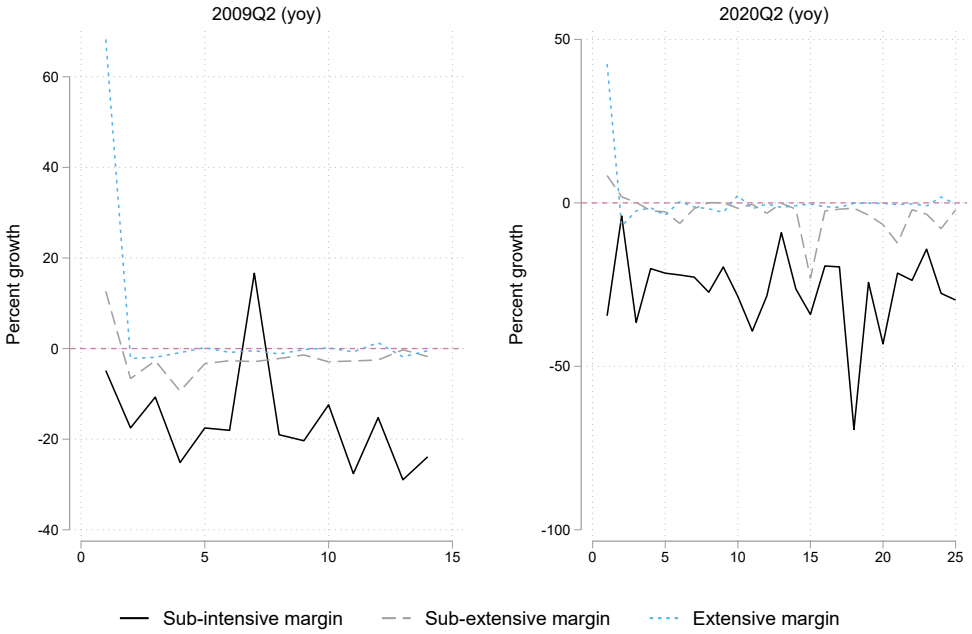
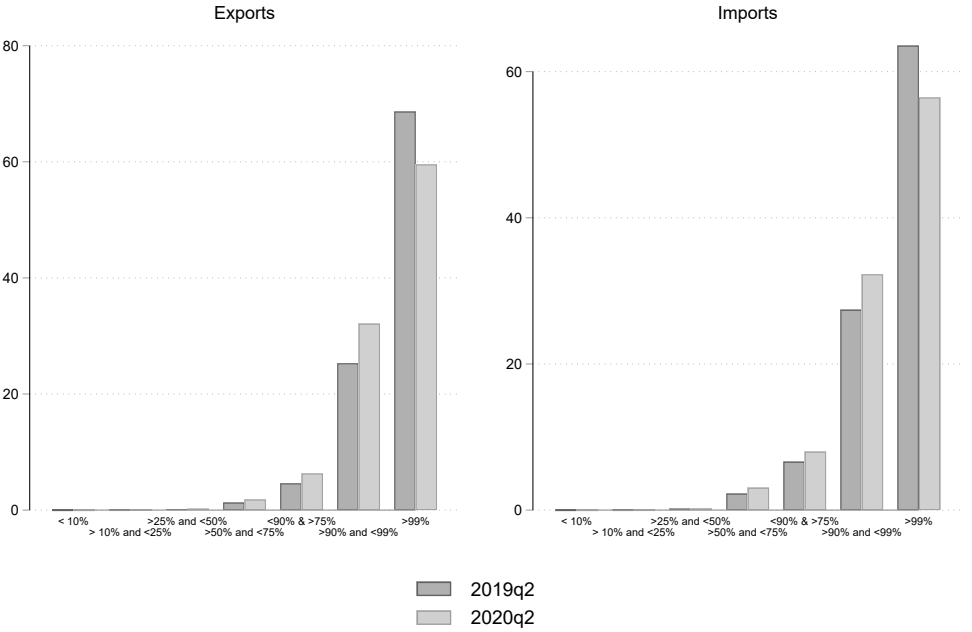


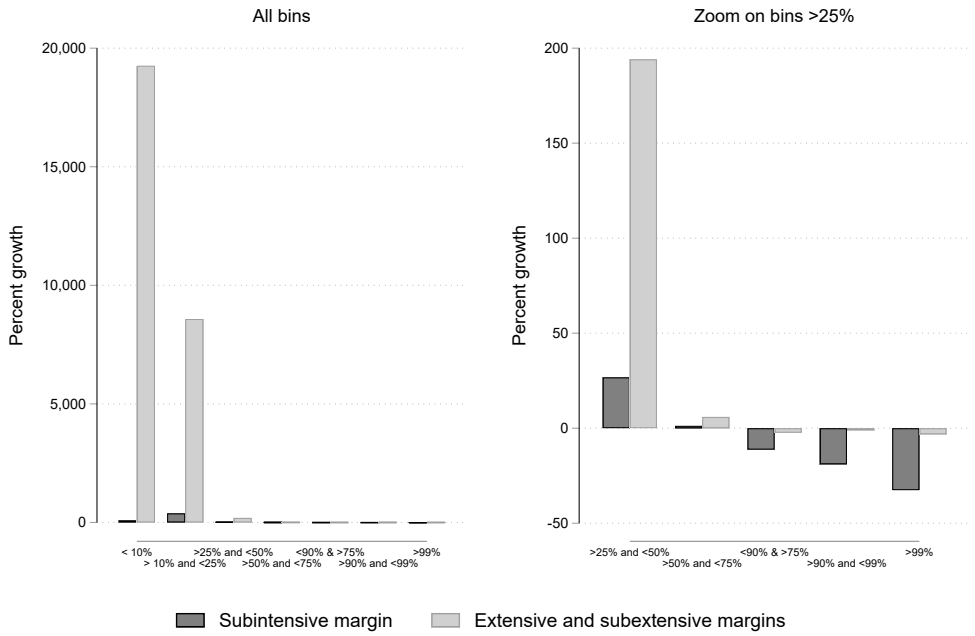
Figure 8: Share of trade per size bin



5.6 Heterogeneous effects: transportation mode

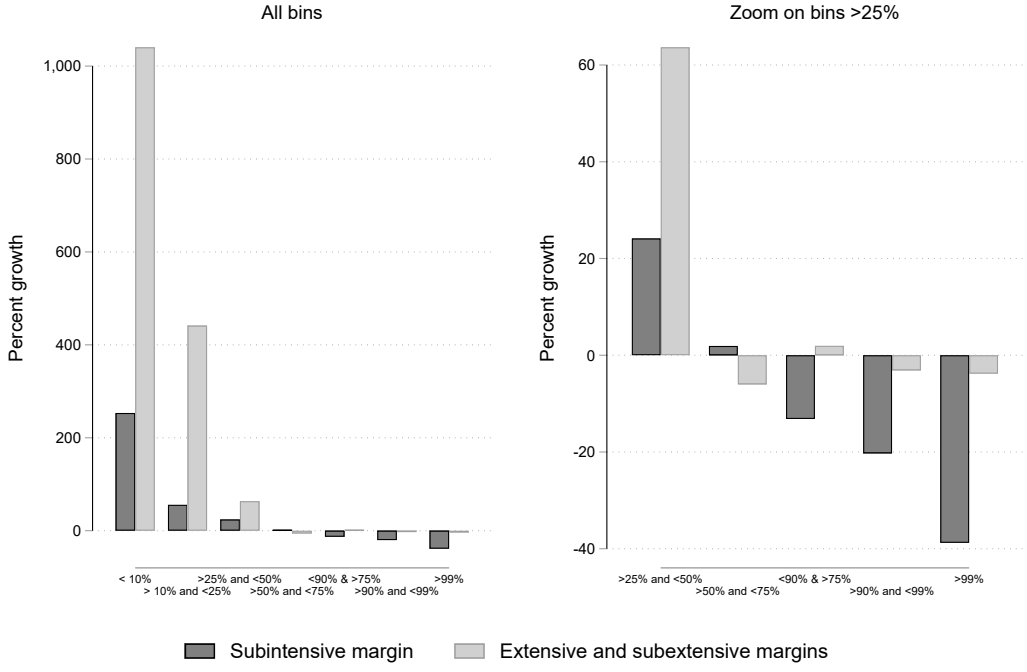
The transport sector was severely hit during the pandemic due to closing borders and national lockdowns. Some countries took special measures to help trade keep moving. For example, the European Union recom-

Figure 9: 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.

Figure 10: 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 11: Transportation mode

	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-14.260***	0.752	-16.457*	-7.783
	(4.717)	(7.127)	(9.259)	(13.118)
road	1.610	9.866***	5.952	3.758
	(2.315)	(2.971)	(3.682)	(9.423)
air	5.335**	13.182***	3.632	-7.689**
	(2.426)	(3.168)	(3.375)	(3.748)
lockdown stringency × road	-3.369	-14.173**	-8.201	-56.359***
	(3.791)	(5.828)	(5.000)	(16.845)
lockdown stringency × air	-17.356***	-20.955***	-18.653***	-22.077***
	(3.357)	(5.533)	(5.022)	(7.261)
COVID-19 deaths	-0.076	-0.060	-0.090	-23.245
	(0.069)	(0.048)	(0.213)	(17.811)
COVID-19 deaths × road	-0.341**	-0.340**	0.097	15.266
	(0.155)	(0.148)	(0.297)	(21.271)
COVID-19 deaths × air	0.059	-0.053	0.363**	11.113
	(0.076)	(0.044)	(0.178)	(20.217)
Observations	12960257	9578895	2866676	456121
Imports				
lockdown stringency	-1.161	-3.540	-6.643	46.662***
	(7.889)	(9.574)	(8.224)	(11.616)
road	0.830	2.940	-1.603	4.483
	(2.920)	(3.035)	(4.110)	(7.800)
air	10.546***	10.299***	11.307**	27.409***
	(3.072)	(2.630)	(5.573)	(6.055)
lockdown stringency × road	-6.838	-4.455	-9.101	-37.094***
	(6.765)	(5.880)	(8.433)	(8.546)
lockdown stringency × air	-17.612***	-18.825***	-16.777**	-76.264***
	(3.859)	(4.728)	(6.904)	(10.662)
COVID-19 deaths	-0.030	-0.060	0.039	-33.222***
	(0.036)	(0.049)	(0.137)	(2.691)
COVID-19 deaths × road	0.084	0.005	0.230**	28.795***
	(0.059)	(0.061)	(0.106)	(3.235)
COVID-19 deaths × air	0.028	0.059	0.012	40.445***
	(0.074)	(0.058)	(0.367)	(4.879)
Observations	16342753	11333260	4517726	463057

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

mended its member states to facilitate the use of passenger aircraft for cargo-only operations and to apply flexibly night curfews at airports for essential air cargo operations. Similarly, China accelerated the release of cargo to 45 minutes by implementing special counters and green lanes to provide 24/7 clearance at critical

ports across the country. However, these restrictions were passed on to firms relying on commercial shipping.

The French customs data provide information on the transportation mode used to sell or buy the good. We consider three main modes of transportation: maritime, road and air transports. We use this information and interact the variables capturing the pandemic shock (lockdown stringency index and number of COVID-19 deaths) to study whether French firms were more or less impacted depending on the transportation mode used. Specifically, in Table 11 we interact the stringency index and the number of new deaths with dummies equal to one when the products (sold or bought) are transported by air or road. The results indicate that both exports and imports of air-transported products decreased significantly more than sea or road-transported products, amplifying the impact of the COVID-19 shock on French trade. LIDCs stand out as road-transported products also experienced large drop in both French exports and imports to and from these countries. Despite important congestion issues which had a larger impact on trade during the recovery period in 2021, maritime-transported imports were more resilient to the shock in 2020.

5.7 Role of economic policies

Table 12: COVID-19 trade policies

	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-19.394***	-13.408**	-24.042***	-18.413
	(4.160)	(5.448)	(8.573)	(12.469)
COVID-19 deaths	-0.171**	-0.184**	0.103	-17.423*
	(0.082)	(0.075)	(0.216)	(9.609)
import promotion	2.769	3.767*	0.665	-11.549**
	(2.302)	(2.133)	(2.907)	(5.522)
import ban	-3.865	0.000	1.604	-38.240***
	(3.111)	(.)	(1.193)	(9.392)
Observations	13412558	9968879	2918718	463977
Imports				
lockdown stringency	-7.785**	-8.811	-14.221***	7.491
	(3.534)	(6.155)	(3.906)	(7.434)
COVID-19 deaths	-0.015	-0.078**	0.121	-6.713*
	(0.037)	(0.032)	(0.104)	(3.561)
export promotion	-2.961	-4.151	4.777	
	(2.418)	(2.479)	(3.461)	
export ban	-5.904	-0.712	-7.277	-17.951*
	(4.504)	(5.633)	(4.986)	(9.739)
Observations	16975634	11713020	4738066	494784

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

National governments put in place several policies to support domestic firms and more broadly domestic economy during the pandemic. The first type of measures put in place was trade policy, to either restrict exports or facilitate imports of strategic goods to avoid domestic shortages and also increase the availability

Table 13: Economic Support Policies

	(1) All	(2) AE	(3) EM	(4) LIDC
Exports				
lockdown stringency	-19.424***	-13.430**	-23.278***	-18.422
	(4.203)	(5.643)	(8.107)	(13.372)
COVID-19 deaths	-0.170**	-0.184**	0.088	-17.832*
	(0.082)	(0.074)	(0.208)	(9.618)
economic support index	0.003	0.001	-0.031	0.010
	(0.028)	(0.045)	(0.032)	(0.062)
Observations	13407283	9968879	2918718	459685
Imports				
lockdown stringency	-8.119**	-8.937	-13.279***	6.447
	(3.901)	(6.357)	(4.356)	(7.622)
COVID-19 deaths	-0.013	-0.077**	0.094	-6.873*
	(0.037)	(0.031)	(0.117)	(3.972)
economic support index	0.010	0.003	-0.020	0.079
	(0.023)	(0.047)	(0.021)	(0.073)
Observations	16971797	11713020	4738066	494608

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

of these goods. The WTO recorded an increasing number of trade policy measures put in place as early as January 2020, with a number of targeted products peaking in March 2020. In particular, many countries lowered their trade barriers on medical supplies, such as surgical masks, but also on agricultural and food products. Evenett, Fiorini, Fritz, Hoekman, Lukaszuk, Rocha, Ruta, Santi, and Shingal (2021) report the COVID-19 related trade measures in place in 2020 on a weekly basis, and show a large heterogeneity in the use of these measures, as some countries refrained from using them.

To study the impact of these measures on firm-level performance, we collect the data from the WTO and divide the measures into the following categories: (i) import promotion; (ii) import ban; (iii) export promotion; (iv) export ban. As expected, import-banning and export-promoting measures were rarely used. We include dummy variables for a measure implemented on the targeted product p by the foreign economy c as additional controls. Table 12 presents the results. Import-promoting and export-banning measures had little impact on aggregate when considering advanced and emerging trade partners. However, they were particularly effective in LIDCs, as both exports to and imports from these countries significantly dropped in response to their trade policy changes.

The second set of policies are economic support policies. These measures are collected by the Oxford COVID-19 Government Response Tracker (OxCGRT), and refer to several policies such as: income support from the government to households and debt relief measures. Based on these policies, they build an economic support index which we include as a control variable in our estimations. Table 13 presents the results. However, these measures do not seem to have had an impact on the economic activity of French firms during the year 2020. It is likely that most of the effect of governmental policies is already captured by our variables of interest, the lockdown stringency index and the number of deaths.

6 Concluding remarks

The COVID-19 pandemic had a strong impact on firm-level performance of advanced economies. Focusing on French firms, this study shows that the lockdown stringency of trading partners, capturing the indirect effect of governmental responses to the shock, had a larger impact than number of deaths, except for LIDCs. In response to this crisis, we find that firms adjusted mainly along the intensive margin, as they did during the GTC. However, firms trading with LIDC countries were more prone to stop exchanging with these countries. We also find that the shock propagated along the supply chains.

Studying how firm heterogeneity determined the size of the adjustment, our results allow us to pinpoint air transportation for exports and road transportation for imports as amplifying factors of the shock on firm performance. However, medium-size and older firms as well as those French firms which were trading more upstream goods, using robots in their production processes and holding higher inventories coped better with the shock. Finally, we find no evidence that economic support policies and trade policies played a significant role in mitigating the shock. Our results support the view that deglobalization of trade following the COVID-19 shock is unlikely.

This paper focuses on trade adjustment in the first year of the pandemic. However, a number pandemic-related shocks posed roadblocks to trade recovery in 2021, including the rise in shipping costs and repeated waves of the COVID-19 variants and subsequent lockdowns. For instance, while our findings show that the impact of the COVID-19 shock on export and import prices was limited in 2020, anecdotal evidence suggests that strong recovery in consumer demand and supply chains bottlenecks that emerged in 2021 contributed to the inflationary pressures. Going forward, we intend to extend the analysis using 2021 data to capture these developments and document further trade adjustment to the pandemic-related shocks.

A Role of China

To test China's role in the aggregate results, we exclude trade flows to and from China. Table A.1 contains the resulting coefficients. The results for exports remain very close to the baseline results based on the entire sample of countries in the top panel of Table 3. However, the effect of lockdown stringency on imports is close to zero and no longer statistically significant when China is excluded for the set of EM exporters (Column 2 in the bottom panel of Table A.1). This result suggests that China drives the overall effects of lockdowns in EMs on their exports to France. This is conceptually consistent with the size of the Chinese market in the total French import basket as well the results in Section 3. In addition, as shown in Table 1, the average level of lockdown stringency in China was considerably higher than in other EMs. On the other hand, the coefficient on deaths remains not statistically significant in the sample excluding China, given the relatively low COVID-19 death toll in China.

Table A.1: Baseline and EM specifications excluding trade with China

	(1) All countries excl. China	(2) EM excl. China
Exports		
lockdown stringency	-17.481***	-13.999***
	(3.998)	(4.901)
COVID-19 deaths	-0.169**	0.019
	(0.083)	(0.198)
Observations	13226267	2733439
Imports		
lockdown stringency	-9.972**	-11.130
	(4.574)	(7.539)
COVID-19 deaths	-0.011	0.122
	(0.039)	(0.104)
Observations	14578116	2347917

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

References

Alessandria, George, Joseph P Kaboski, and Virgiliu Midrigan (2010): "The great trade collapse of 2008–09: An inventory adjustment?," *IMF Economic Review*, 58(2), 254–294.

Antràs, Pol (2020): "De-globalisation? Global value chains in the post-COVID-19 age," Discussion paper, National Bureau of Economic Research.

Antràs, Pol, Davin Chor, Thibault Fally, and Russell Hillberry (2012): "Measuring the Upstreamness of Production and Trade Flows," *American Economic Review*, 102(3), 412–16.

Bems, Rudolfs, Robert C Johnson, and Kei-Mu Yi (2013): "The great trade collapse," *Annual Review of Economics*, 5(1), 375–400.

Bergounhon, Flora, Clémence Lenoir, and Isabelle Mejean (2018): "A guideline to French firm-level trade data," *Unpublished manuscript*.

Berthou, Antoine, and Sebastian Stumpner (2021): "Trade Under Lockdown," Discussion paper, Mimeo.

Bonadio, Barthélémy, Zhen Huo, Andrei A Levchenko, and Nitya Pandalai-Nayar (2021): "Global supply chains in the pandemic," *Journal of international economics*, 133, 103534.

Bricongne, Jean-Charles, Juan Carluccio, Lionel Fontagné, Guillaume Gaulier, and Sebastian Stumpner (2021): "From Macro to Micro: Heterogeneous Exporters in the Pandemic," *Unpublished manuscript*.

Bricongne, Jean-Charles, Lionel Fontagné, Guillaume Gaulier, Daria Taglioni, and Vincent Vicard (2012): "Firms and the global crisis: French exports in the turmoil," *Journal of International Economics*, 87(1), 134–146, Symposium on the Global Dimensions of the Financial Crisis.

Çakmaklı, Cem, Selva Demiralp, Şebnem Kalemli-Özcan, Sevcan Yeşiltaş, and Muhammed A Yıldırım (2021): "The economic case for global vaccinations: an epidemiological model with international production networks," Discussion paper, National Bureau of Economic Research.

Cerdeiro, Diego, and Andras Komaromi (2020): "Supply Spillovers During the Pandemic: Evidence from High-Frequency Shipping Data," *Available at SSRN 3772489*.

Espitia, Alvaro, Aaditya Mattoo, Nadia Rocha, Michele Ruta, and Deborah Winkler (2021): "Pandemic trade: COVID-19, remote work and global value chains," *The World Economy*.

Evenett, Simon, Matteo Fiorini, Johannes Fritz, Bernard Hoekman, Piotr Lukaszuk, Nadia Rocha, Michele Ruta, Filippo Santi, and Anirudh Shingal (2021): "Trade policy responses to the COVID-19 pandemic crisis: Evidence from a new data set," *The World Economy*, 45, 342–364.

Fort, Teresa C, John Haltiwanger, Ron S Jarmin, and Javier Miranda (2013): "How Firms Respond to Business Cycles: The Role of Firm Age and Firm Size," *IMF Economic Review*, 61(3), 520–559.

Gopinath, Gita, and Brent Neiman (2014): "Trade adjustment and productivity in large crises," *American Economic Review*, 104(3), 793–831.

Hale, Thomas, Noam Angrist, Rafael Goldszmidt, Beatriz Kira, Anna Petherick, Toby Phillips, Samuel Webster, Emily Cameron-Blake, Laura Hallas, Saptarshi Majumdar, and Helen Tatlow (2021): "A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker)," *Nature Human Behaviour*, 5(4), 529–538.

Karlinsky, Ariel, and Dmitry Kobak (2021): "Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset," *Elife*, 10, e69336.

Lafrogne-Joussier, Raphael, Julien Martin, and Isabelle Mejean (2021): "Supply shocks in supply chains: Evidence from the early lockdown in China," Discussion paper, Mimeo, CREST.

Liu, Xuepeng, Emanuel Ornelas, and Huimin Shi (2021): "The Trade Impact of the Covid-19 Pandemic," CESifo Working Paper Series 9109, CESifo.

OECD (2018): "Input-output Tables," *Organisation for Economic Co-operation and Development, Paris.*

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