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GVC exporter performance during the COVID-19 pandemic: the role of supply bottlenecks

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Abstract

This paper provides an analysis of the impact of the COVID-19 pandemic on exporting firms, focusing on the role of supply bottlenecks. Based on monthly transaction-level data for the universe of French exporters over the period January 2020-December 2021, we find that participation in global value chains increased firms' vulnerability to the COVID-19 shock, in terms of both export performance and probability of survival in the export market, the negative impact of supply disruptions being higher for relatively more downstream firms. At the same time, the results suggest that exporting firms benefited from sourcing of core inputs from different countries, supporting the hypothesis that diversification in global value chains fosters supply-chain resilience.

Keywords: Pandemic, Shock Transmission, Global Value Chains, Diversification, Upstreamness

JEL Codes: D22, F14, F61

Non-technical summary

This paper quantifies the causal impact of the COVID-19 pandemic and the ensuing disruptions to Global Value Chains (GVCs) on exporters' activities. Specifically, it compares the export performance of the firms involved in GVCs - i.e. that both import and export - and simple exporters during the pandemic.

We use monthly data at the firm-product-partner country level for the universe of French exporters during the period January 2018-December 2021. The monthly frequency of the data gives us a detailed picture of the trend in obstacles to GVC firms in obtaining a timely supply of foreign imported inputs.

We employ difference-in-differences and event-study methods to distinguish various phases since the outbreak of the pandemic. The first phase was characterised by lockdowns, in France and abroad, between February and April 2020. During this period, exports among GVC and non-GVC firms alike dropped abruptly, mainly as a result of a contraction in global demand. However, we find that GVC firms performed significantly worse than simple exporters (-4% exports compared to exporters only, ceteris paribus) as GVC firms also had to contend with a global negative supply shock. The second phase (May to August 2020) was characterised by the reopening of economies across the world. For both GVC and non-GVC firms, this period recorded some level of export recovery, though much less so for GVC firms. In the third phase, from September 2020 to December 2021, supply bottlenecks emerged and gradually intensified. While exports among non-GVC firms benefited from the pent-up demand and accumulated savings, GVC firms remained constrained due to the persistent non-availability of imported inputs. This explains the sizeable difference in the export performance between GVC and non-GVC firms (9% lower exports compared to non-GVC firms) during the supply bottleneck phase compared to the first lockdown phase. The probability of firm survival followed a similar trend to that observed for export performance.

The results also suggest that firms relatively more downstream in the value chain were hit harder, particularly during the first lockdown and the supply bottleneck phase. At the same time, sourcing key imported inputs from more than one country reduced the negative effect of the pandemic, suggesting that more diversified sourcing networks for core inputs partially shielded companies from shocks. In addition, those firms importing goods identified as creating strategic dependencies for the European Union (EU)

were more affected, while more productive firms and those with higher inventories were relatively less affected.

1 Introduction and reference literature

The COVID-19 health crisis resulted in shocks on both demand and supply, domestically and internationally. The relative intensity of these shocks varied across the different phases of the pandemic, depending on the timing and stringency of the lockdown measures adopted in different countries in response to the intensity of the contagion and its geographical spread. Contraction of production also varied and was heterogeneous across sectors, depending on whether activities could be continued remotely. On top of the domestic shock, GVC firms faced supply shocks in the source countries, resulting in shortages of intermediate inputs traded along Global Value Chains (GVC), which further constrained national production capacity and export performance. In this context, the potential for supply bottlenecks to propagate negative shocks is higher the more upstream the disruption. Thus, the COVID-19 pandemic has raised questions about whether reshoring or near-shoring would help reduce countries' vulnerability to future external shocks (Di Stefano, 2021; Javorcik, 2020), or whether diversification would be a better strategy to foster supply-chain resilience.

This paper provides an analysis of the impact of the COVID-19 pandemic on exporting firms, focusing on the role of supply bottlenecks. Based on monthly data at the firm-product-partner country level for the universe of French exporters over the period January 2018-December 2021, we identify the causal effect of supply chain linkages on exporter performance using a difference-in-differences (DiD) methodology, and on survival probability using a logit model. The effect is estimated by distinguishing three different phases of the pandemic: the first phase, between February 2020 and April 2020, when lockdowns induced an abrupt halt in a number of non-essential manufacturing and services sectors; the second phase, between May and August 2020, when there was some recovery in exports in response to the gradual lifting of restrictive measures; and the third phase, from September 2020 to the end of 2021, when disruptions to GVCs emerged and gradually intensified. For each exporting firm, the impact of supply bottlenecks is estimated by considering whether the firm was sourcing input from foreign producers and also its position in the GVC. Based on the methodology of Antràs et al. (2012), we use the latest OECD Input-Output tables to compute an indicator of upstreamness for 45 sectors. Following Chor et al. (2021), we then combine this measure of industry-level upstreamness with product-level information on firm trade flows, in order to measure each firm's position in the global supply chain. We find that participation in GVCs increased firm vulnerability during the pandemic, with the negative impact of supply disruptions more intense for firms located relatively more downstream and relying on strategic inputs.

At the same time, we show that GVC firms benefited - in terms of both export growth and probability of survival in the export market - from importing their core inputs from different countries, which supports the hypothesis that more diversified sourcing networks partially shielded companies from shocks. We contribute to the literature in three ways. First, we study the export performance and survival probability of GVC compared to non-GVC firms, during different phases of the COVID-19 crisis. Second, we estimate the causal impact of the firm's position in the supply chain. Third, we provide what, to our knowledge, is the first firm-level quantification of the impact of supply bottlenecks that occurred in 2021, when disruptions along value chains were historically high.

Our paper relates to the existing literature on the role of globalisation – via trade in final and intermediate goods - in propagating the economic impact of the pandemic (Bonadio et al., 2021; Eppinger et al., 2020; Kohlscheen et al., 2020; Sforza and Steininger, 2020). Several studies highlight the effect of supply value chain trade in amplifying the economic contagion (Baldwin and Freeman, 2020; Baldwin and Tomura, 2020). Espitia et al. (2022) estimate a difference-in-differences specification to identify the impact of the shock to domestic supply, foreign demand, and competitor countries, on bilateral export growth. They examine 28 countries at the sectoral level, over the period February-June 2020 and find that GVC participation buffered the fall in exports driven by the contraction of domestic supply. They also find that disruptions to industrial production in source countries - captured by an upstream shock variable measuring the exporting country's dependence on imported inputs - negatively affected export growth during the first phase of the pandemic, up to April 2020. Meinen et al. (2021) use monthly data on the four largest euro area countries for the first phase of the pandemic (March-April 2020). They find that the interplay between the stringency of government containment measures, the sectoral structure and trade linkages helps to explain the regional within-country heterogeneity of the labour market impact of the COVID-19 shock. They show, in particular, that regions that relied on intermediate goods sourced from foreign regions heavily impacted by the pandemic were relatively more affected due, possibly, to disruptions to intra-EU supply chains.

The availability of detailed micro data for the universe of French firms has resulted in numerous investigations of the heterogeneity of firm exposure to the pandemic, depending on the extent and nature of their involvement in international trade. Di Giovanni et al. (2020) show that only a small number of large firms source inputs from abroad; however, since they account for a large share of aggregate economic activity, the relatively higher vulnerability of these types of firms to external shocks has sig-

nificant macroeconomic implications. Bricongne et al. (2022) confirm the predominant role played by a few large incumbent exporters in driving the trade collapse recorded in April/May 2020, a pattern observed in a number of countries during the 2008 financial crisis (Bricongne et al., 2012; Bugamelli et al., 2019; De Lucio et al., 2011). Based on transaction-level import and export data, Lafrogne-Joussier et al. (2022) use the early lockdown in China as a natural experiment to quantify the causal impact of supply value chain disruptions on exports and domestic sales. In particular, firms sourcing their inputs from China experienced a drop in exports of up to 15% in April 2020, compared to GVC firms importing inputs from countries other than China, largely due to a temporary reduction in the number of products shipped or a temporary exit from specific destination markets. Their results show, also, that geographically diversified input sourcing does not mitigate the reduction in exports induced by China's lockdown. Rather than following the approach taken by Lafrogne-Joussier et al. (2022), our paper looks into differences in performance between exporters only and those sourcing inputs from the rest of the world, rather than between exporters importing or not from a specific source country (such as China). Moreover, the longer time coverage of our data (up to December 2021) allows us to compare two-way traders with non-importing exporters not only in the earliest phases of the pandemic but also later on, when firms faced increasingly severe supply disruptions. Lastly, we provide novelty by tailoring the diversification measure proposed by Lafrogne-Joussier et al. (2022) to core imports, and find evidence that diversifying source countries of key inputs did provide exporters with some protection from the crisis.

The paper is structured as follows: Section 2 presents the dataset and some descriptive statistics. The identification strategy, as well as the analysis of the effect of GVC participation on exporter performance, is presented in Section 3. The impact of firm position along the value chain and the role of diversification within the GVC are discussed in Sections 4 and 5, respectively. Section 6 concludes.

2 Dataset and descriptive analysis

Our analysis is based on transaction-level data from customs, for the universe of exporters in France. Specifically, for each firm, detailed information is provided on nominal import and export flow values[1], by product (at the 6-digit level of the Harmonised System (HS) Classification) and by partner country, at monthly frequency between January 2018 and December 2021. To account for additional firm characteristics in the pre-crisis period, such as productivity, size and stock of inventories, we merge these

[1] Since we do not have information on the price of each individual product, it is not possible to deflate the variable to obtain real exports. Therefore, in this paper we refer to nominal trade.

data with annual firm-level balance sheet data produced by the French National Institute of Statistics and Economic Studies (INSEE).

We define GVC firms as exporting firms that imported intermediate inputs at least once in the six months before the COVID-19 crisis (i.e. between July and December 2019). Restricting GVC participation to the pre-crisis period is required to avoid endogeneity linked to the non-availability of certain products during the pandemic[2]. Due to our definition of GVC firms, by construction, the majority of new entrants fall into the non-GVC group, which would provide a misleading picture (see Figure A1 in the appendix, which shows the generally high contribution of the firms' extensive margin to non-GVC aggregate export growth, especially as from the second half of 2020). For this reason, we restrict the sample for analysis to continuous exporters, which avoids misallocation of new exporters. In particular, we define continuous exporters as firms that exported every month in the pre-crisis period. Table 1 shows that, in 2019, continuous exporters represent 25% of exporting firms, but account for 97% of aggregate exports.

Table 1: Number and export value per type of firms in the year 2019

		Number of firms (% of total)	Nominal exports in billion € (% of total)	Firm median nominal exports in thousands €	Firm median number of employees	Firm median nominal revenues in thousands €
Continuous	All	25,801 (25%)	474 (97%)	1,505	24	9,610
	GVC	20,516 (20%)	457 (93%)	1,858	45	19,188
	non-GVC	5,285 (5%)	18 (4%)	772	13	5,155
Occasional	All	76,182 (75%)	15 (3%)	12	3	1,083
	GVC	29,688 (29%)	10 (2%)	18	11	4,725
	non-GVC	46,494 (46%)	5 (1%)	10	3	1,036

Source: Direction générale des douanes et droits indirects, INSEE and authors' own calculations.
Note: Firms are defined according to their status in the six months before the crisis (July-December 2019). Continuous exporters are firms that exported every month in the pre-crisis period, while occasional exporters are firms that experienced at least one interruption in their export flows. GVC firms are defined as exporting firms that imported at least once in the pre-crisis period, while non-GVC exporters are firms that did not import over the same period.

To analyse the probability of firm survival, our sample was further restricted, due to constraints related to EU Customs Union reporting rules. One of the issues in studying the extensive margin using customs data is that for dispatches within the EU not exceeding a specified threshold, firms are not required to declare to the French customs either the destination country or the type of products being

[2]It should be noted that our definition of GVC firms has two limitations: first, it does not include firms at the very top of the value chain (which would be classified as an exporter only and, therefore, would be assigned to the control group); second, it does not include firms that obtain their inputs from other French firms that also belong to the GVC. Our data do not allow us to identify these two types of firms.

shipped. In 2011, this threshold was fixed at €460,000 per year. More specifically, starting from January, and for the entire year if the threshold was exceeded in the previous year, or from the month when the €460,000 threshold was reached (cumulatively from January) and until the following reporting year, firms are obliged to compile an intra-community trade statistics (Intrastat) declaration of the destinations of their export flows by product, from the first euro. To ensure that we measure firms' actual entry/exit and not just an administrative induced discontinuity, among continuous exporters[3], we retain in our sample only firms that were above the threshold in 2019 or declared flows in January 2020. Table 2 shows that application of the threshold has a very limited impact on aggregate export coverage, since the analysis focuses only on continuous exporters, which are typically large exporters.

Table 2: Number and export value for continuous exporters in the year 2019 after applying the threshold

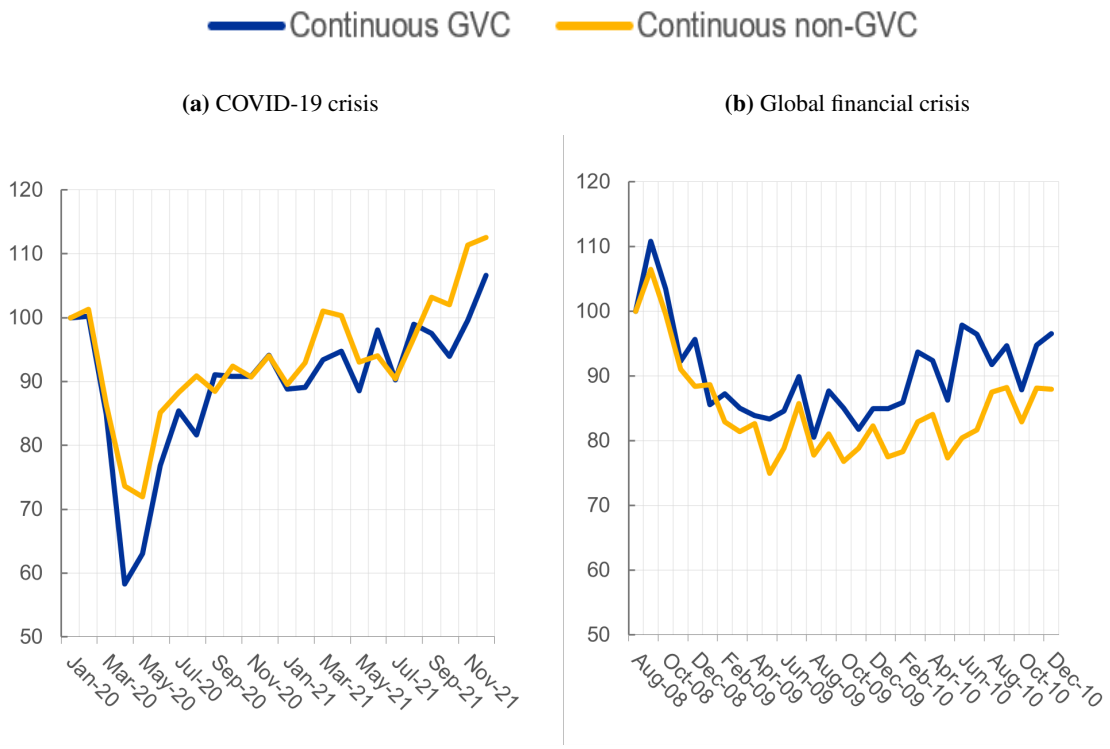
	Firm median nominal exports in thousands €	Number of firms (% of total)	Nominal exports in billion € (% of total)
non-GVC firms	833	5,029 (5%)	18 (4%)
GVC firms	1,937	20,135 (20%)	457 (93%)

Source: Direction générale des douanes et droits indirects and authors' own calculations.
Note: Only firms that were above the €460,000 threshold in 2019 or declared export flows in January 2020 are retained. Numbers in parentheses include occasional exporters and flows below the threshold.

At the onset of the COVID-19 crisis, firms involved in global production networks in the pre-crisis period experienced the sharpest fall in exports and, after the economic reopening, recovered at a slower pace than non-GVC exporters (Figure 1 below, left panel). In April 2020, continuous GVC exporters recorded export volumes 42% lower than in January 2020. For continuous non-GVC firms, the lowest point was reached in May 2020, when exports were 28% lower than in January 2020. The two groups diverged further when the restrictions were lifted in the summer of 2020 and when the recovery took shape over the following year; by March 2021, the non-GVC group had reached their January 2020 levels and by September 2021 had surpassed them, while it took until December 2021 for GVC firms to overtake their January 2020 levels. This was due, most likely, to the disruptions to supplies from other countries.

[3]Being a continuous exporter between July and December 2019 does not necessarily mean that the firm was above the threshold in 2019. It might have declared trade flows in 2019 because it was above the threshold in 2018.

Figure 1: Export performance over time by GVC status
(Total export, baseline = 100)



(a) COVID-19 crisis

Source: Direction générale des douanes et droits indirects and authors' own calculations.
Notes: GVC firms imported at least once during the six months before the crisis. Non-GVC firms did not import in any of the six months before the crisis. Baseline month of January 2020.

(b) Global financial crisis

Source: Direction générale des douanes et droits indirects and authors' own calculations.
Note: GVC firms imported at least once during the six months before the crisis. Non-GVC firms did not import in any of the six months before the crisis. Baseline month of August 2008.

Interestingly, during the 2008 global financial crisis, the situation was reversed (Figure 1, right panel), with GVC firms displaying a more subdued reaction to the crisis than their non-GVC counterparts. Continuous GVC exporters recorded much more contained reductions (19% in August 2009 compared to August 2008) than similar continuous non-GVC exporters, which, at their lowest point (May 2009), had lost a quarter of their August 2008 value. Compared to the COVID-19 crisis, the 2008 trade collapse was less sizeable and less abrupt, although, for both types of firms, more persistent, suggesting that whether supply value chain trade is mainly a source of vulnerability or a source of resilience ultimately depends on the nature of the shock.

3 Impact of GVC participation on export performance

3.1 GVC participation and the intensive margin

The empirical approach aims to investigate how different dimensions of GVC involvement shaped firms' performance throughout the pandemic.

This section estimates the effect of being involved in a GVC on firm-level exports, using a difference-in-differences specification with fixed effects. As mentioned earlier, our treatment group is continuous exporters that imported at least once between July and December 2019; the control group is the remaining exporting firms, i.e. those that did not import over that period. The first lockdown in France started in March 2020. However, it is possible that some French firms' business partners might have already been affected by the COVID-19 before that date since certain Chinese provinces were in lockdown as early as January 2020. Since sea freight from China to France takes around six weeks, our treatment starts in February 2020 and continues to December 2021, the end of our time horizon. The pre-treatment phase is January 2018 to January 2020. The specification is as follows:

$$ln\,export_{it} = \beta\, GVC_i \times COVID19_t + FE_i + FE_t + \varepsilon_{it} \tag{1}$$

where $ln\,export_{it}$ is the logarithm of firm i's export value at time t (where t takes monthly frequency), GVC_i is a dummy variable that takes the value 1 if firm i is involved in the GVC in the pre-crisis period, $COVID19_t$ is a dummy variable that takes the value 1 for the period February 2020-December 2021, and FE_i and FE_t are respectively firm fixed and time fixed effects. The results of equation 1 are presented in Table 3 column 1.

Table 3 column 1 shows evidence of a negative and significant effect of GVC participation during COVID-19: on average, two-way traders exported 7.7% less than similar firms that are simple exporters. Although both GVC and non-GVC exporters were affected negatively by the pandemic through the domestic lockdown and lower global demand, GVC exporters faced one additional channel of shock transmission via disruptions in supply linked to international lockdowns. Time fixed effects allow us to control for common shocks, overall inflation, and also for seasonality[4]. Firm fixed effects allow us to control notably for the size of the firms, Table 1 showing that GVC firms' exports are on average six times

[4]The restricted selection of firms that continuously exported between July and December 2019 also limits the risk of dealing with firms that export only in specific months (for example in the agriculture sector).

Table 3: Difference-in-differences, effect of GVC involvement

ln export$_{it}$	(1) Main	(2) No carry-along trade	(3) Imported intermediate goods only	(4) 3-month continuous exporter	(5) 6-month continuous importer for GVC	(6) Control for sectoral demand	(7) Control for international demand
GVC$_i$ × COVID19$_t$	-0.0768***	-0.118***	-0.0778**	-0.0643***	-0.0685***	-0.0318***	-0.0353***
	(0.00967)	(0.0142)	(0.00980)	(0.00847)	(0.00994)	(0.00907)	(0.00710)
Constant	11.67***	10.55***	11.72***	11.35***	11.80***	10.88***	9.528***
	(0.00364)	(0.00418)	(0.00362)	(0.00297)	(0.00359)	(0.00454)	(0.00294)
Observations	1,156,272	657,060	1,058,108	1,344,392	967,802	1,110,047	8,832,483
R-squared	0.823	0.691	0.827	0.816	0.837	0.415	0.415
Firm FE	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	NO	NO
Time-sector FE	NO	NO	NO	NO	NO	YES	NO
Time-destination FE	NO	NO	NO	NO	NO	NO	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only continuous exporters in the immediate six months before the crisis are retained. GVC_i is a dummy equal to 1 if the firm imported at least once in the six months immediately before the crisis. Pre-treatment period is January 2018 to January 2020. COVID-19 (treatment period) is February 2020 to December 2021. In column 3 the intermediate goods are those whose HS code matches with products classified as such (code "*INT*") in the BEC (Broad Economic Categories) classification. In contrast to the firm-time estimates in columns 1-6, column 7 is estimated at the firm-time-country level (the dependent variable is $ln\,export_{itc}$, the logarithm of the value of firm i's exports at time t in country c).

larger than non-GVC firms. Indeed, GVC status correlates with size, and Bricongne et al. (2022) show that large exporters react particularly strongly to common shocks. We therefore perform an additional robustness check: on top of firm fixed effect, Figure A2 and Table A1 in the appendix measures the export performances of GVC firms during the pandemic by size decile. There is no significant difference between the deciles, suggesting that the significant coefficient measured in column 1 does not reflect the larger size of GVC exporters compared to non-GVC firms.

Columns 2 to 7 present the results of several robustness checks. Column 2 excludes carry-along trade, defined as flows of same HS6 products imported and re-exported by the same firm within the same six-month period, which nearly halves the number of observations. Using this specification, the effect is still negative and significant, with a larger coefficient than in the case of all trade flows. Column 3 complements column 2's analysis by reproducing the specification of column 1 but keeping only imported intermediate goods; in other words, GVC firms that were importing only final goods are dropped from the analysis. The results are stable. In column 4, continuous exporters are firms that exported only in the three (instead of six) months immediately prior to the crisis. Here, the results do not change. The results also prove robust when imposing more stringent criteria for GVC involvement, by requiring firms to have imported in each of the six months prior to the crisis rather than having imported at least once in

that period (column 5)[5]. Lastly, since GVC and non-GVC firms may differ in the countries to which they export and the sector to which they belong, columns 6 and 7 control for possible heterogeneity of demand among sectors and from destination countries. Note that the results are still negative and significant[6].

Table 4 below examines whether the impact on GVC exporters differed depending on some firms' characteristics before the pandemic, namely their inventory, productivity and foreign dependency.

Table 4: Effect of GVC involvement by firm characteristics

ln export$_{it}$	(1) Inventory	(2) Productivity	(3) Input foreign dependency
GVC$_i$×Below median characteristic$_i$×COVID19$_t$	-0.0572*** (0.00991)	-0.0843*** (0.00984)	-0.0307*** (0.0107)
GVC$_i$×Above median characteristic$_i$×COVID19$_t$	-0.0500*** (0.00947)	-0.0257*** (0.00953)	-0.0647*** (0.00915)
Constant	10.89*** (0.00432)	10.89*** (0.00431)	10.89*** (0.00432)
Observations	1,110,148	1,110,148	1,110,148
R-squared	0.807	0.807	0.807
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. The equation is: $ln\ export_{it} = \beta_1 GVC_i \times Below\ median\ characteristic_i \times COVID19_t + \beta_2 GVC_i \times (1 - Below\ median\ characteristic_i) \times COVID19_t + FE_i + FE_t + \varepsilon_{it}$ GVC_i is a dummy equal to 1 if the firm imported at least once in the six months before the crisis. $Below\ median\ characteristic_i$ takes the value 1 if the GVC firm is below the median (among GVC firms) for the characteristic tested in 2019, while $Above\ median\ characteristic_i$ is the opposite. Inventory is the total inventory stock of the GVC firm, normalised by firm size (proxied by total sales). Productivity is defined as the ratio of net value added to number of employees (full-time equivalent). Foreign dependency is calculated as the ratio of imports on total input costs in 2019.

Column 1 estimates the effect of inventories. We look at the total inventory stock value at the end of the GVC firm accounting year, normalised by the value of the firm's activity (proxied by total sales), in line with Lafrogne-Joussier et al. (2022). We observe a small, yet significant, difference in the export performances of GVC firms with high and low inventories in 2019. The results show, in particular, that GVC firms with high inventories were only slightly less affected by the pandemic than firms with low inventories. Column 2 tests the effect of productivity, defined as the ratio of net value added per employee. It shows a sizeable difference between high-productivity and low-productivity GVC firms: high- and low-productivity GVC firms record exports respectively 2.6% and 8.4% lower than similar non-GVC firms[7]. Lastly, column 3 show that GVC firms with higher foreign dependency for their inputs

[5]The control group remains unchanged; firms that exported in between one and five months out of the six are dropped from the sample.

[6]As a further robustness check, we estimate regression (1) for different dates for the start of the treatment, namely January, February and March 2020. The results are stable (see Appendix Table A2).

[7]The results hold also when considering alternative measurements of productivity, such as the share of total sales on the number of employees, or the share of total production on the number of employees. The coefficients are very similar in size.

had a lower export performance during the pandemic.

As already mentioned, in the period February 2020-December 2021 we distinguish three distinct phases: the lockdown period (February-April 2020), characterised by a sharp drop in aggregate French exports; the reopening of the economy (May-August 2020), characterised by a partial recovery in exports[8]; and the supply bottleneck period (September 2020-December 2021), characterised by a smaller, but more persistent, drop in exports. We therefore re-estimated equation 1, splitting the treatment period across these three phases. Later in this section we will use a more flexible specification allowing us to identify when exports fell disproportionately for GVC exporters. The results are presented in Table 5.

Table 5: Difference-in-differences, effect of GVC involvement by phase

ln export$_{it}$	(1) With fixed effects	(2) With treatment group and treatment period
GVC$_i$×COVID19phase1$_t$	-0.0382***	-0.0412*
	(0.0119)	(0.0221)
GVC$_i$×COVID19phase2$_t$	-0.0392***	-0.0458**
	(0.0117)	(0.0194)
GVC$_i$×COVID19phase3$_t$	-0.0944***	-0.0932***
	(0.0112)	(0.0116)
GVC$_i$		1.069***
		(0.00710)
COVID19phase1$_t$		-0.137***
		(0.0199)
COVID19phase2$_t$		-0.146***
		(0.0174)
COVID19phase3$_t$		0.0821***
		(0.0104)
Constant	11.67***	10.80***
	(0.00365)	(0.00636)
Observations	1,156,272	1,156,272
R-squared	0.823	0.034
Firm FE	YES	NO
Time FE	YES	NO

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Pre-treatment period is January 2018 to January 2020. COVID-19 (treatment period) is February to April 2020 for phase one, May to August 2020 for phase two and September 2020 to December 2021 for phase three. The equation in column 1 is: $lnexport_{it} = \beta_1 GVC_i \times COVID19phase1_t + \beta_2 GVC_i \times COVID19phase2_t + \beta_3 GVCparticipation_i \times COVID19phase3_t + FE_i + FE_t + \varepsilon_{it}$ with the dummy variables $COVID19phase1,2,3_t$.

Table 5 column 1 shows that GVC participation negatively and significantly affected export performance in all three phases. Interestingly, the impact of GVC participation did not differ significantly between the lockdown period and the following reopening of the economy (roughly a 4% decrease in

[8]The lockdown in France ended in May 2020.

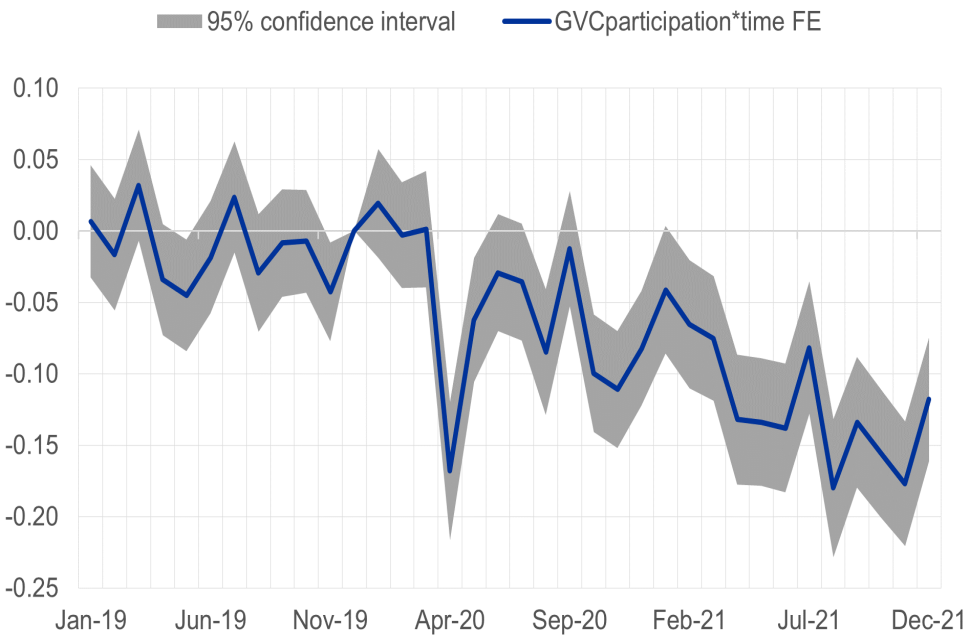
exports). However, from September 2020, the effect was twice as big. Indeed, while all the firms were affected during the first two phases of the pandemic, only GVC firms were affected by supply bottlenecks in the third phase. While the domestic economy has recovered somewhat and firms and individuals learnt to adapt during the second wave of the contagion in France (starting in September 2020), the international market was unable to satisfy the resulting high demand, leading to shortages of raw materials and intermediate goods, and extended delivery times. Column 2 shows that in February-April and May-August 2020, pure exporters recorded roughly a 14% fall in exports compared to the pre-crisis, followed by a boost of 8% in the period September 2020-December 2021. Meanwhile, exporters that had been operating within GVCs before the crisis suffered an additional set-back; notably, they did not benefit from the increase starting in September, as the coefficients of $GVCi \times COVID19phase3_t$ and $COVID19phase3_t$ cancel each other out.

It could be argued that the results presented in Table 5 are due to the arbitrary boundaries used to delimit each phase. To address this, we employ an event-study design, providing monthly profiles estimated over the full time horizon:

$$ln\,export_{it} = \sum_{j=-12}^{24} \beta_j COVID19_{jt} \times GVC_i + FE_i + FE_t + \varepsilon_{it} \tag{2}$$

Equation 2 is of course closely related to equation 1; the variables are the same as in equation 1, except that in equation 2, the GVC dummy is interacted with a dummy for each month between January 2019 and December 2021 (excluding December 2019, which is our reference point). This allows us to identify the exact month when the GVC effect began and to check for the presence of a potential pre-trend.

Figure 2: Event study, effect of GVC participation
(Coefficients and 95% confidence intervals)



Note: GVC_i is equal to 1 if the firm imported at least once in the six months immediately before the crisis. Reference point is December 2019. Appendix Table A3 presents the corresponding results.

The results presented in Figure 2 show the emergence, in April and May 2020, of the first negative and significant effect of being part of a GVC during COVID-19; it becomes insignificant in June and July, but then regains significance in August 2020, with a coefficient that is increasing over time. There is no pre-trend before the pandemic, which is reassuring in terms of the comparability between our treatment and control groups. The negative effect of GVC involvement being significant only in April, while the Chinese lockdown started in January, might be explained by the time it takes for a cargo ship to travel from China to France (six weeks). This delayed the propagation of the shock and the negative effect on the stocks of intermediate inputs among GVC firms, allowing them to continue production for a short time. The supply bottleneck is persistent over time with GVC firms significantly affected in every month since October 2020.

The difference observed in Figure 2 in export performance between GVC and non-GVC firms between September 2020 and December 2021 can be interpreted as a firm-level based measure of supply disruptions. Indeed, the trend is very similar to that of other indicators normally used to monitor bottlenecks (e.g. supply delivery time, shipping costs, equipment shortages, input prices), as shown in Figure A3 in

the appendix. To test for this hypothesis more formally, we run regression 1 by phase, controlling for other indicators of bottlenecks.

Table 6: Controlling for bottleneck indicators

ln export$_{it}$	(1) PMI supply delivery times	(2) PMI supply delivery times, intermediate goods	(3) Equipment shortages
GVC$_i$×COVID19phase1$_t$	0.0251*	0.00739	-0.0290***
	(0.0134)	(0.0125)	(0.0112)
GVC$_i$×COVID19phase2$_t$	-0.0384***	-0.0376***	-0.0446***
	(0.0121)	(0.0139)	(0.0116)
GVC$_i$×COVID19phase3$_t$	-0.0368***	-0.0334**	-0.0629***
	(0.0133)	(0.0135)	(0.0109)
GVC$_i$×Bottlenecks$_t$×preCOVID19$_t$	-0.00341	-0.00303	-0.0104
	(0.00474)	(0.00473)	(0.0126)
GVC$_i$×Bottlenecks$_t$×COVID19phase1$_t$	-0.0551***	-0.0628***	-0.186***
	(0.00824)	(0.00948)	(0.0236)
GVC$_i$×Bottlenecks$_t$×COVID19phase2$_t$	-0.00165	0.00233	0.0167
	(0.0143)	(0.0218)	(0.0153)
GVC$_i$×Bottlenecks$_t$×COVID19phase3$_t$	-0.0251***	-0.0256***	-0.0214***
	(0.00434)	(0.00433)	(0.00315)
Constant	11.66***	11.66***	11.67***
	(0.00402)	(0.00415)	(0.00357)
Observations	1,156,272	1,156,272	1,156,272
R-squared	0.824	0.824	0.824
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Pre-treatment period is January 2018 to January 2020. COVID-19 (treatment period) is February to April 2020 for phase one, May to August 2020 for phase two and September 2020 to December 2021 for phase three. See Figure A3 in the appendix for information on bottleneck indicators.

Table 6 shows that, regardless of the bottleneck indicator chosen, the coefficient $GVC_i \times COVID19phase3_t$ corresponding to the bottleneck period remains negative and statistically significant (albeit less sizeable than in Table 5)[9]. The supply delivery times for intermediates goods control is the variable to have generated the biggest reduction in the $GVC_i * COVID19phase3_t$ coefficient. It is therefore the variable that best reflects the difference in performance between GVC and non-GVC firms.

Some components have become symbolic of these bottlenecks, such as microchips, which are used extensively by the automobile industry. Therefore, we ran the same regression as in Table 5 but by industry, to better understand the bottleneck issue (Table 7). As expected, results show that GVC firms

[9]Results for the bottleneck period (phase three) are confirmed when estimating the same regression on additional bottleneck indicators often used for monitoring purposes, namely shipping costs and PMI import prices.

in the "Motor vehicles and transport equipment" sectors were affected very negatively by supply bottlenecks[10]. This contrasts with the beginning of the pandemic, when these firms benefited from the positive effects likely associated with increased use of individual vehicles to avoid the risk of infection from using public transport[11]. More surprising are the supply bottleneck effects on other sectors such as agriculture and food. However, it is worth repeating that GVC firms are defined as firms that imported goods at least once in the six months immediately before the pandemic, which, by construction, excludes those firms at the very top of the value chains, such as those producing food commodities. Therefore, in the agriculture and food industry, GVC firms are those engaged in exporting processed food, which explains the impact of bottlenecks in their value chain.

Following the severe disruptions to European production supply chains since the start of the pandemic, the European Commission identified strategic dependencies related to specific imported inputs. It identified 137 HS6 products "*in the most sensitive ecosystems where the EU can be considered highly dependent on imports from third countries*"[12], based on three indicators[13]: concentration, measured by the Herfindahl-Hirschman Index and the market share of the extra-EU supplying countries; demand importance, calculated as the share of extra-EU imports in total EU imports; substitutability, calculated as the ratio of extra-EU imports to total EU exports. In Figure 3, GVC firms are categorised according to having imported one of the 137 strategic products at least once in the six months before the pandemic, or not. Figure 3 shows that GVC firms that imported strategic products were significantly worse off compared to GVC firms in the initial drop in April 2020, both groups being more affected than non-GVC firms. After a recovery phase between May and August, strategic products faced intensifying disruptions due to supply bottlenecks, at a higher level than non-strategic products. Appendix Table A4 shows the role of each sub-indicator (concentration, demand importance and substitutability) in explaining the previous results. Concentration matters most, followed by non-substitutability and demand importance. Benoit et al. (2021) find that these three indicators were key to understanding supply chain disruptions and had a significant impact on the price pressures accompanying disruptions.

[10]Together with textiles, where France accounts for a large share of world production, production of electrical equipment and of motor vehicles is the most fragmented internationally and, therefore, is the most exposed to foreign supply shocks (Gerschel et al., 2020). In the database, French firms in the "Motor vehicles and transport equipment" industry not part of GVC produce mostly high-quality, high-precision and tailor-made transport equipment (mostly for cars), though also bikes and aircraft engines.

[11]Eisenmann et al. (2021)

[12]European Commission (2021)

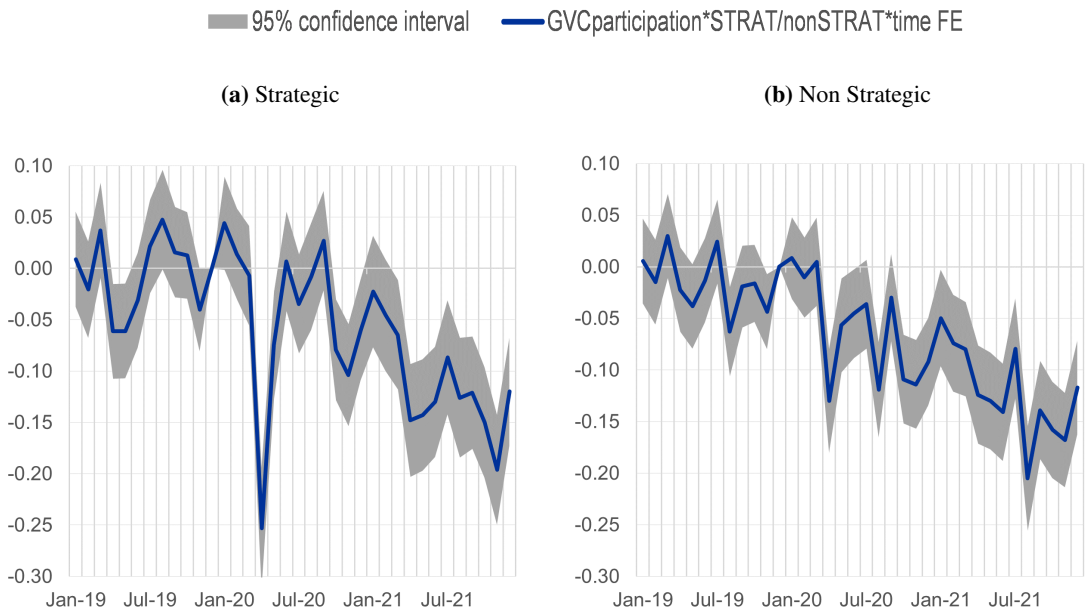
[13]The methodology is explained in detail in European Commission (2021).

Table 7: Difference-in-differences, effect of GVC involvement by phase and by sector

ln export$_{it}$	(1) Agriculture and food	(2) Basic metals and metal products	(3) Chemicals plastics and non-metallic mineral product	(4) Computer electronic equipment and machinery	(5) Mining and quarrying	(6) Motor vehicles and transport equipment	(7) Other services	(8) Textiles	(9) Wood and paper
GVC$_i$×COVID19phase1$_t$	0.0306	-0.00693	-0.0307	-0.00684	-0.00949	0.103**	-0.0472	-0.150***	-0.0102
	(0.0216)	(0.0422)	(0.0298)	(0.0293)	(0.0911)	(0.0448)	(0.0591)	(0.0546)	(0.0394)
GVC$_i$×COVID19phase2$_t$	-0.0219	-0.0189	-0.0334	-0.0257	-0.155*	0.0258	-0.105	-0.0268	0.0130
	(0.0219)	(0.0424)	(0.0284)	(0.0280)	(0.0854)	(0.0430)	(0.0659)	(0.0571)	(0.0394)
GVC$_i$×COVID19phase3$_t$	-0.0433**	0.0435	-0.0149	-0.00642	-0.149**	-0.132***	-0.0420	-0.130**	-0.114***
	(0.0193)	(0.0377)	(0.0257)	(0.0264)	(0.0736)	(0.0396)	(0.0562)	(0.0514)	(0.0332)
Constant	10.90***	9.264***	10.02***	10.54***	8.395***	10.42***	7.217***	9.585***	8.170***
	(0.00515)	(0.0142)	(0.00971)	(0.00967)	(0.0282)	(0.0138)	(0.0197)	(0.0198)	(0.0124)
Observations	221,226	293,991	453,467	527,138	22,283	129,504	81,772	218,239	188,701
R-squared	0.873	0.818	0.857	0.804	0.883	0.837	0.786	0.827	0.830
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Sectors are defined based on an ISIC 4 classification aggregation (see Appendix Table A5). The sectors "accommodation and food service activities", "construction", "energy", "transportation", and "wholesale and retail" are dropped due to lack of observations.

Figure 3: Event-study, strategic products
(Coefficients and 95% confidence intervals)



Note: To ease readability, the following regression is split into two graphs: $lnexport_{it} = \sum_{j=-12}^{21} \beta_j COVID_{jt} \times GVC_i \times Strategic\ product_i + \sum_{k=-12}^{21} \beta_k COVID_{kt} \times GVC_i \times (1 - Strategic\ product_i) + FE_i + FE_t + \varepsilon_{it}$. $Strategic\ product_i$ takes the value 1 if the GVC firm imported at least one of the 137 strategic products at least once in the six months immediately before the pandemic. Only continuous exporters between July and December 2019 are retained. The reference time for the event study is December 2019. Table A6 is the corresponding table.

3.2 GVC participation and exporter probability of survival

Our analysis of the intensive margin was restricted to strictly positive export flows at firm level and at monthly frequency. In this section, we investigate how GVC involvement affected probability of survival among firms in the export market. We employ a logit model to estimate the probability that a GVC firm, compared to a non-GVC firm, continues to export during the pandemic. The size of our database makes it infeasible to use time and firm fixed effects as this would require too much computational power. Instead, we use a more traditional approach and include the treatment group and the treatment period in the equation:

$$\mathbb{1}_{it} = \alpha + \beta_1 GVC_i + \beta_2 GVC_i \times COVID19_t + \beta_3 COVID19_t + \varepsilon_{it} \quad (3)$$

The dependent variable is a dummy that takes the value 1 if the firm has a positive export flow in that month. The other variables are the same as in equation 1. The results are presented in Table 8. Columns 1 and 2 show that GVC participation significantly increases the probability of exiting the export market during the pandemic, by 1.2% (column 2). Columns 3 and 4 show that this probability varied over the different phases of the pandemic, for all exporting firms in general, and for GVC firms in particular. For GVC firms, the highest probability of (at least temporary) interruptions in export flows occurred in the first and third phases, at a similar level (1.2%). Thus, the dynamics at the extensive and intensive margins differ: at the intensive margin, the lockdown and reopening phases show similar lower negative effects than during the bottleneck phase; at the extensive margin, the negative effect is similar and higher during the lockdown and bottleneck phases. At the end of end 2019, the biggest GVC firms had the highest level of inventories, even after controlling for the number of employees. The difference observed in the lockdown phase might come from there: the biggest GVC firms could continue exporting due to their stocks of imported inputs ; thus, the effect on export sales was less sizeable than on the number of firms. An analysis of the time related variables ($COVID19phase1_t$, 2 and 3) shows that the highest probability of exit for firms in general occurred between September 2020 and December 2021. This might be explained by the ending of government support schemes for businesses during that period. Lastly, as a robustness check, we estimate a probit model; the results are comparable to the results of the logit estimation (Appendix Table A7 compared with columns 2 and 4 in Table 8).

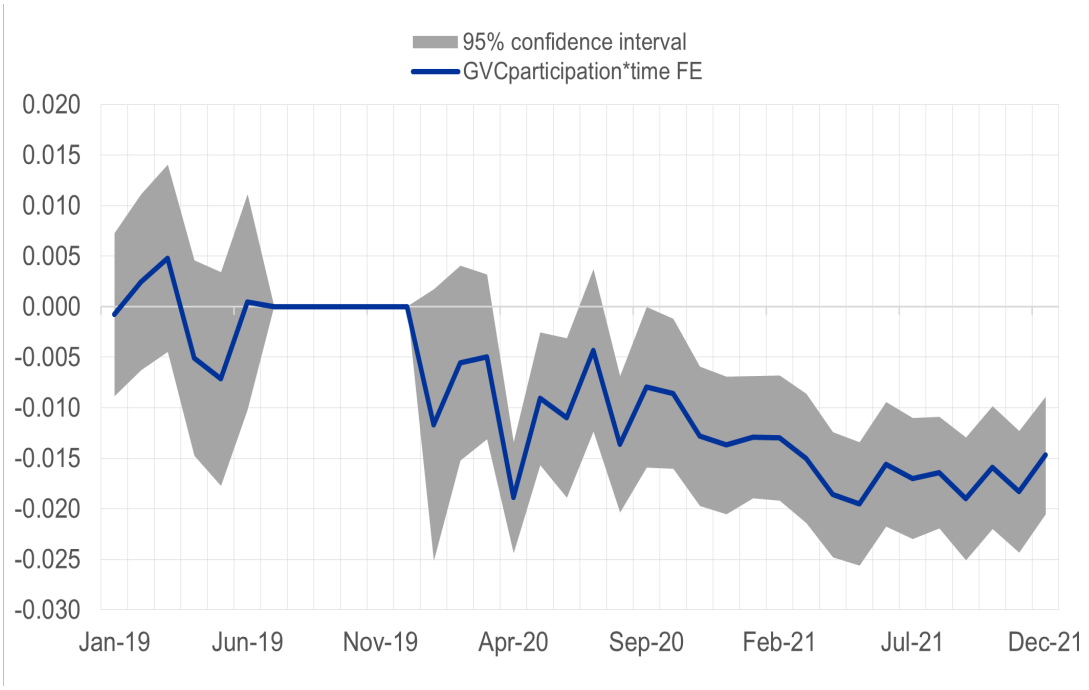
Table 8: Logit model, effect of GVC involvement on firms's export status

export status$_{it}$	(1) General-odds ratio	(2) General-marginal effect	(3) By phase -odds ratio	(4) By phase-marginal effect
GVC$_i$ × COVID19$_t$	-0.210***	-0.0117***		
	(0.0171)	(0.000954)		
COVID19$_t$	-0.629***	-0.0350***		
	(0.0140)	(0.000784)		
GVC$_i$	0.864***	0.0480***	0.864***	0.0480***
	(0.0135)	(0.000765)	(0.0135)	(0.000764)
GVC$_i$× COVID19phase1$_t$			-0.209***	-0.0116***
			(0.0344)	(0.00191)
GVC$_i$× COVID19phase2$_t$			-0.133***	-0.00741***
			(0.0314)	(0.00174)
GVC$_i$× COVID19phase3$_t$			-0.222***	-0.0124***
			(0.0182)	(0.00101)
COVID19phase1$_t$			-0.427***	-0.0237***
			(0.0285)	(0.00159)
COVID19phase2$_t$			-0.365***	-0.0203***
			(0.0258)	(0.00144)
COVID19phase3$_t$			-0.720***	-0.0400***
			(0.0149)	(0.000835)
Constant	2.553***		2.553***	
	(0.0109)		(0.0109)	
Observations	1,207,872	1,207,872	1,207,872	1,207,872
Firm FE	NO	NO	NO	NO
Time FE	NO	NO	NO	NO

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only firms that were either above the €460 000 threshold in 2019 or declared flows in January 2020 are retained. *Export status*$_{it}$ takes the value 1 if the firm has positive export flows.

Similarly to the analysis performed in equation 2, Figure 4 presents the results of the logit model in an event study setting. Figure 4 shows that, similar to the intensive margin, the negative effect of COVID-19 on GVC firms emerges only in April, with a 2% higher probability of exiting the export market. In May, this probability is only 1%. This peak in April can be explained by the fact that it was the only month in which the lockdown lasted the entire month. The negative effect of bottlenecks on the extensive margin started in August 2020, similar to the effect on the intensive margin. It is interesting that the highest probability of exit during the supply bottleneck period was 2%, the same as in April when France was in total lockdown. Lastly, there is no pre-trend, suggesting comparable treatment and control group characteristics.

Figure 4: Logit model in an event study setting, effect of GVC involvement on firm's export status
(Coefficients and 95% confidence intervals)



Note: Observations in the period July-December 2019 were dropped as a result of the condition that during that period, firms must be continuous exporters. Thus, by construction, there is perfect collinearity between the groups at that moment. For the corresponding regression, see Table A8 in Appendix.

4 Position in the GVC and export performance

4.1 Upstreamness and the intensive margin

In the following analysis, we investigate whether the negative impact of GVC participation on export performance differs depending on whether firms were located relatively more upstream or downstream in the GVC. We employ the methodology used by Antràs et al. (2012) to construct an index of upstreamness of production. We use the 2018 OECD harmonised national Input-Output database to calculate the upstreamness of 45 sectors, classified according to ISIC Rev4 Divisions. We then associate each HS6 product imported or exported by the firms, to one of these sectors and, therefore, according to a level of upstreamness. For each firm, we then compute import and export upstreamness by month, as the weighted average of the upstreamness of the goods exported or imported that month. To avoid any endogeneity linked to the unavailability of certain products, we take the average monthly upstreamness of the imports and exports of each firm, during the period July-December 2019 rather than over the whole period of the analysis. Lastly, we take the simple average of import and export upstreamness to calculate

the general position of each firm in the GVC and call this variable $Position_i$.

We use a generalised difference-in-differences model with continuous treatment, to identify the effect of GVC positioning rather than simple participation.

$$ln\,export_{it} = \beta_1\, GVC_i \times COVID19_t + \beta_2\, GVC_i \times Position_i \times COVID19_t + FE_i + FE_t + \varepsilon_{it} \qquad (4)$$

The results of equation 4 are presented in Table 9.

Table 9: Generalised difference-in-differences, effect of GVC position

ln $export_{it}$	(1) Simple average between imports upstreamness and exports upstreamness	(2) Exports upstream-ness	(3) Imports upstream-ness	(4) Simple average between imports upstreamness and exports upstreamness	(5) Exports upstream-ness	(6) Imports upstream-ness
$GVC_i \times Position_i \times COVID19_t$	0.0371***	0.000815	0.0281***			
	(0.0103)	(0.00971)	(0.00731)			
$GVC_i \times COVID19_t$	-0.158***	-0.0798***	-0.137***			
	(0.0248)	(0.0107)	(0.0188)			
$GVC_i \times Position_i \times COVID19phase1_t$				0.0840***	0.0856***	0.0451***
				(0.0117)	(0.0113)	(0.00854)
$GVC_i \times Position_i \times COVID19phase2_t$				-0.0143	-0.0200*	-0.00930
				(0.0116)	(0.0113)	(0.00838)
$GVC_i \times Position_i \times COVID19phase3_t$				0.0414***	-0.00995	0.0346***
				(0.0119)	(0.0112)	(0.00851)
$GVC_i \times COVID19phase1_t$				-0.214***	-0.0495***	-0.129***
				(0.0286)	(0.0132)	(0.0222)
$GVC_i \times COVID19phase2_t$				-0.0227	-0.0498***	-0.0340
				(0.0284)	(0.0131)	(0.0219)
$GVC_i \times COVID19phase3_t$				-0.183***	-0.0935***	-0.166***
				(0.0287)	(0.0124)	(0.0219)
Constant	11.60***	11.60***	11.60***	11.60***	11.60***	11.60***
	(0.00405)	(0.00978)	(0.00405)	(0.00406)	(0.00977)	(0.00406)
Observations	1,083,094	1,083,094	1,083,094	1,083,094	1,083,094	1,083,094
R-squared	0.819	0.819	0.819	0.819	0.819	0.819
Firm FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. $Position_i$ is a continuous index, where higher values identify more upstream firms.

Table 9 column 1 shows that the more upstream the GVC firm (average of upstreamness of imported and exported products), the less the firm was impacted by the pandemic. Columns 2 and 3 shows that this result is driven by the import position rather than the export position in the GVC. The more upstream

the input and the shorter the chain of firms to reach the French firm, the fewer the potential bottlenecks in the chain. Columns 4 to 6 show that the positive effect of being more upstream occurred during the lockdown and supply bottleneck phases, while it does not seem to play a significant role in the reopening phase. The result that the pandemic has affected downstream firms relatively more would confirm that, despite the negative shocks to have occurred in both demand and supply during the pandemic, the latter was indeed predominant. In this respect, the COVID-19 pandemic differs from the global financial crisis, which was mainly originated by a demand shock propagating up the value chain via adjustments of firms' inventory holdings (the so-called bullwhip effect, see Altomonte et al. (2012)).

To obtain a more intuitive interpretation of the coefficients, we split the sample of GVC firms into upstream firms (upstreamness index value above the median) and downstream firms (upstreamness index value below the median). Equation 5 is a slightly modified version of equation 4, which includes two dummy variables instead of the continuous upstreamness variable:

$$ln export_{it} = \beta_1 GVC_i \times Upstream_i \times COVID19_t + \beta_2 GVC \times (1 - Upstream_i) \times COVID19_t + FE_i + FE_t + \varepsilon_{it} \quad (5)$$

where $Upstream_i$ is a dummy variable that takes the value 1 if the firm's upstreamness index is above the median. Table 10 presents the results of equation 5 and confirms the results of Table 9: downstream GVC firms are more affected than upstream GVC firms. Column 1 shows that, compared to simple exporters, the lowest 50% of the upstreamness distribution (i.e. relatively more downstream firms) saw their exports decrease by 10%, compared to 6% for the highest 50% (i.e. relatively more upstream firms). Column 2 shows that there was no significant difference between relatively more upstream firms and simple exporters during the lockdown, while relatively more downstream firms were significantly and negatively affected. The two groups were comparable during the economic reopening phase. Lastly, both groups were negatively affected by the bottlenecks, though more so in the case of downstream firms.

Table 10: Difference-in-differences, effect of being downstream or upstream

ln export$_{it}$	(1) General	(2) By phase
GVC$_i$×Downstream$_i$×COVID19$_t$	-0.0997***	
	(0.0120)	
GVC$_i$×Upstream$_i$×COVID19$_t$	-0.0607***	
	(0.0114)	
GVC$_i$×Downstream$_i$×COVID19phase1$_t$		-0.0747***
		(0.0144)
GVC$_i$×Downstream$_i$×COVID19phase2$_t$		-0.0513***
		(0.0144)
GVC$_i$×Downstream$_i$×COVID19phase3$_t$		-0.117***
		(0.0139)
GVC$_i$×Upstream$_i$×COVID19phase1$_t$		0.000570
		(0.0140)
GVC$_i$×Upstream$_i$×COVID19phase2$_t$		-0.0547***
		(0.0138)
GVC$_i$×Upstream$_i$×COVID19phase3$_t$		-0.0744***
		(0.0131)
Constant	11.60***	11.60***
	(0.00405)	(0.00406)
Observations	1,083,094	1,083,094
R-squared	0.819	0.819
Firm FE	YES	YES
Time FE	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. $Upstream_i$ is a dummy that takes the value 1 if the firm is above the median for the upstreamness index. $Downstream_i$ takes the value 1 if the firm's upstreamness is below the median.

4.2 Upstreamness and exporter probability of survival

In this section, we investigate whether a firm's position along the value chain affects its probability of survival in the export market. We estimate this using a logit model:

$$\mathbb{1}_{it} = \alpha + \beta_1 GVC_i + \beta_2 GVC_i \times COVID19_t + \beta_3 GVC_i \times Position_i \times COVID19_t + \beta_4 COVID19_t + \varepsilon_{it} \quad (6)$$

Table 11 presents the results of equation 6 and shows that the same effects presented in Table 9 for the intensive margin apply also to the extensive margin: more upstream GVC firms are less affected than more downstream firms (column 1). However, in Table 11, this effect is positive and significant in all three phases, while in the case of the intensive margin it was positive and significant only for the lockdown and bottleneck phases. Appendix Table A9 shows that performance of relatively more upstream firms was no different to that of the control group of simple exporters.

Table 11: Logit model, effect of GVC position on survival probability

export status$_{it}$	(1) General-odds ratio	(2) General-marginal effects	(3) By phase -odds ratio	(4) By phase-marginal effects
GVC$_i$×Position$_i$×COVID19$_t$	1.021***	0.0824***		
	(0.0117)	(0.000951)		
GVC$_i$×COVID19$_t$	-2.500***	-0.202***		
	(0.0262)	(0.00214)		
COVID19$_t$	-0.272***	-0.0219***		
	(0.00959)	(0.000774)		
GVC$_i$	1.848***	0.149***	1.848***	0.149***
	(0.00998)	(0.000827)	(0.00998)	(0.000826)
GVC$_i$×Position$_i$×COVID19phase1$_t$			1.161***	0.0937***
			(0.0350)	(0.00282)
GVC$_i$×Position$_i$×COVID19phase2$_t$			1.064***	0.0858***
			(0.0314)	(0.00253)
GVC$_i$×Position$_i$×COVID19phase3$_t$			0.994***	0.0802***
			(0.0135)	(0.00110)
GVC$_i$×COVID19phase1$_t$			-2.658***	-0.214***
			(0.0716)	(0.00579)
GVC$_i$×COVID19phase2$_t$			-2.417***	-0.195***
			(0.0647)	(0.00523)
GVC$_i$×COVID19phase3$_t$			-2.498***	-0.202***
			(0.0299)	(0.00243)
COVID19phase1$_t$			-0.204***	-0.0165***
			(0.0200)	(0.00162)
COVID19phase2$_t$			-0.161***	-0.0130***
			(0.0178)	(0.00144)
COVID19phase3$_t$			-0.311***	-0.0251***
			(0.0105)	(0.000847)
Constant	1.303***		1.303***	
	(0.00688)		(0.00688)	
Observations	1,176,096	1,176,096	1,176,096	1,176,096
Firm FE	NO	NO	NO	NO
Time FE	NO	NO	NO	NO

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. *Exporter status$_{it}$* takes the value 1 if the firm has positive export flows. GVCi is equal to 1 if the firm imported at least once in the six months immediately before the crisis. *Position$_i$* is a continuous index where a higher value indicates higher degree of upstreamness.

5 Diversification of source countries for imported inputs

5.1 Diversification and the intensive margin

The pandemic has raised the question of whether diversification within GVCs may improve firm resilience. In this section, we estimate the effect of diversification of imports among GVC firms on their

export performance by looking into three dimensions of diversification: product diversification, measured as the average monthly number of HS6 products imported between July and December 2019; country diversification, measured as the average monthly number of source countries from which GVC firms imported between July and December 2019; and sourcing-country diversification by product, measured as the average monthly number of countries from which each imported HS6 product was sourced between July and December 2019. The regression is similar to equation 4 but using one of these three diversification variables as the regressors instead of GVC position. The results, presented in Table 12, suggest no significant effect.

Table 12: Generalised difference-in-differences, effect of diversification

ln export$_{it}$	(1) Country diversification	(2) Product diversification	(3) Country diversification by product
GVC$_i$×Diversification$_i$×COVID19$_t$	0.00120	0.000228*	-0.00352
	(0.000966)	(0.000121)	(0.00824)
GVC$_i$×COVID19$_t$	-0.0829***	-0.0810***	-0.0715***
	(0.0110)	(0.00985)	(0.0157)
Constant	11.67***	11.67***	11.67***
	(0.00364)	(0.00364)	(0.00364)
Observations	1,156,272	1,156,272	1,156,272
R-squared	0.823	0.823	0.823
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. In column 1, $Diversification_i$ is a continuous variable for the average number of source countries from which GVC firms imported by month, between July and December 2019, column 2 shows the average number of HS6 products imported by month during the same period and column 3 shows the average by month of the number of countries from which each imported HS6 product was sourced during the same period.

The absence of a role played by diversification is in line with the findings of Lafrogne-Joussier et al. (2022), where, rather than examining the number of source countries by product in general, a firm diversifies its GVC involvement whenever its "core" imported products (representing at least 1% of its imports before the pandemic) are sourced from at least two countries.

Table 13: Difference-in-differences, effect of diversification of source countries for the core products

ln $export_{it}$	(1) 1%	(2) 5%	(3) 10%	(4) 15%	(5) 20%	(6) 25%	(7) 30%
$GVC_i \times NoDiversificationCoreProduct_i \times COVID19_t$	0.0194	-0.0100	-0.0102	-0.0191*	-0.0165*	-0.0239**	-0.0213**
	(0.0164)	(0.0107)	(0.00988)	(0.00979)	(0.00991)	(0.0102)	(0.0104)
$GVC_i \times COVID19_t$	-0.0941***	-0.0698***	-0.0710***	-0.0674***	-0.0697***	-0.0678***	-0.0696***
	(0.0177)	(0.0122)	(0.0112)	(0.0108)	(0.0105)	(0.0104)	(0.0102)
Constant	11.67***	11.67***	11.67***	11.67***	11.67***	11.67***	11.67***
	(0.00364)	(0.00364)	(0.00364)	(0.00364)	(0.00364)	(0.00364)	(0.00364)
Observations	1,156,272	1,156,272	1,156,272	1,156,272	1,156,272	1,156,272	1,156,272
R-squared	0.823	0.823	0.823	0.823	0.823	0.823	0.823
Firm FE	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. *$NoDiversificationCoreProduct_i$* is equal to 1 if the firm's core products were imported from only one source country during the pre-pandemic period. Core products are defined as products representing a minimum percentage (see column titles) of the total imported products in the six months immediately before the crisis.

In Table 13, we further test the role of diversification as defined in Lafrogne-Joussier et al. (2022), allowing the threshold for a product to be identified as "core" as varying between 1% and 30% of overall imports between July and December 2019. The results point to a significant negative effect of the absence of diversification for products representing more than 15% of total imports; on the contrary, diversification for non-core products does not play a significant role. On top of the worse export performances due to the global value chains, non-diversification of sourcing countries for core products represented an additional vulnerability for GVC firms. Appendix Table A10 shows that the effects stem from the bottleneck phase and are not significant in the first two phases. This might be because the first COVID-19 shock hit all parts of the world almost simultaneously and, therefore, diversification among providers was virtually impossible. However, supply bottlenecks were concentrated mostly in Asia, allowing diversification to play a role thereafter.

Table 14: Difference-in-differences, effect of distance of source countries

export status$_{it}$	(1) Most populated cities	(2) Most populated cities, population-weighted	(3) Capitals
GVC$_i$×CloseSourcing$_i$×COVID19phase1$_t$	-0.0153	-0.0172	-0.0157
	(0.0130)	(0.0130)	(0.0130)
GVC$_i$×CloseSourcing$_i$×COVID19phase2$_t$	-0.0429***	-0.0465***	-0.0434***
	(0.0129)	(0.0129)	(0.0129)
GVC$_i$×CloseSourcing$_i$×COVID19phase3$_t$	-0.0688***	-0.0718***	-0.0682***
	(0.0122)	(0.0123)	(0.0123)
GVC$_i$×DistantSourcing$_i$×COVID19phase1$_t$	-0.0602***	-0.0582***	-0.0597***
	(0.0136)	(0.0136)	(0.0136)
GVC$_i$×DistantSourcing$_i$×COVID19phase2$_t$	-0.0410***	-0.0371***	-0.0404***
	(0.0134)	(0.0133)	(0.0133)
GVC$_i$×DistantSourcing$_i$×COVID19phase3$_t$	-0.126***	-0.123***	-0.127***
	(0.0132)	(0.0132)	(0.0132)
Constant	11.74***	11.74***	11.74***
	(0.00363)	(0.00363)	(0.00363)
Observations	1,081,552	1,081,552	1,081,552
R-squared	0.827	0.827	0.827
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. *CloseSourcing$_i$* is a dummy that takes the value 1 if the firm is below the median for the average weighted distance between France and its source countries (weight by value of imports from each destination in the last 6 months before the crisis). *DistantSourcing$_i$* is the same but above the median. Distance between France and each country is measured in three ways: distance between the most populated cities, distance between the most populated cities using a population-weighted approach, and distance between the two capitals. For more information, please see the documentation of the CEPII gravity database and Conte et al. (2022).

Table 14 compares GVC firms importing their inputs from closer and more faraway countries. It appears that during the first lockdown, GVC firms importing from closer destinations were affected much in the same way as simple exporters. Also, during the economic reopening, there was no significant

difference between GVC firms importing from closer and more faraway destinations. However, between September 2020 and December 2021, export losses among GVC firms importing from closer destinations were two times lower than those experienced by GVC firms importing from further away. We then test the impact of importing from specific destinations on the exports of GVC firms (Appendix Figure A4). The firms with the highest shares of inputs imported from the EU were the less affected during the lockdown phase. Conversely, firms with the highest share of inputs from China and Japan were the most affected for the same period. Furthermore, GVC firms importing mostly from the EU suffered from the supply bottleneck later, with the negative effects being visible only from April 2021. The results shown in Figure A4 seem to confirm the results of Table 14: the further away geographically the main source country, the more negative the effect on exports, on average. However, these results should be interpreted with caution given the presence of some pre-trend for a few countries.

5.2 Diversification and exporter probability of survival

We next look at the effect of source country diversification in relation to core imported products, on the survival rate of firms operating in the export market. We rerun equation 6, using a dummy for diversification of the 25% most frequent imported products, instead of upstreamness. Table 15 shows that, in contrast to the intensive margin (Table A10), diversification of core products has a positive effect in all three phases, not just the supply bottleneck phase. Since there is no significant effect on volume, this means that the positive impact was mostly on small firms.

Table 15: Logit model, effect of diversification of source countries for core products on firm's export status

export status$_{it}$	(1) General-odds ratio	(2) General-marginal effects	(3) By phase-odds ratio	(4) By phase-marginal effects
GVC$_i$×NoDiversificationCoreProudct25pct$_i$×COVID19$_t$	-0.688***	-0.0381***		
	(0.0115)	(0.000647)		
GVC$_i$×COVID19$_t$	-0.582***	-0.0322***		
	(0.0180)	(0.00100)		
COVID19$_t$	-0.629***	-0.0348***		
	(0.0140)	(0.000781)		
GVC$_i$	0.864***	0.0478***	0.864***	0.0478***
	(0.0135)	(0.000762)	(0.0135)	(0.000761)
GVC$_i$×NoDiversificationCoreProudct25pct$_i$×COVID19phase1$_t$			-0.587***	-0.0325***
			(0.0348)	(0.00193)
GVC$_i$×NoDiversificationCoreProudct25pct$_i$×COVID19phase2$_t$			-0.727***	-0.0402***
			(0.0322)	(0.00179)
GVC$_i$×NoDiversificationCoreProudct25pct$_i$×COVID19phase3$_t$			-0.697***	-0.0386***
			(0.0132)	(0.000739)
GVC$_i$×COVID19phase1$_t$			-0.531***	-0.0294***
			(0.0383)	(0.00212)
GVC$_i$×COVID19phase2$_t$			-0.520***	-0.0288***
			(0.0346)	(0.00192)
GVC$_i$×COVID19phase3$_t$			-0.599***	-0.0332***
			(0.0192)	(0.00107)
COVID19phase1$_t$			-0.427***	-0.0236***
			(0.0285)	(0.00158)
COVID19phase2$_t$			-0.365***	-0.0202***
			(0.0258)	(0.00143)
COVID19phase3$_t$			-0.720***	-0.0399***
			(0.0149)	(0.000832)
Constant	2.553***		2.553***	
	(0.0109)		(0.0109)	
Observations	1,207,872	1,207,872	1,207,872	1,207,872
Firm FE	NO	NO	NO	NO
Time FE	NO	NO	NO	NO

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Exporter $status_{it}$ takes the value 1 if the firm has positive export flows. $NoDiversificationCoreProduct25pct_i$ is equal to 1 if the firm's core products were imported from only one source country. Core products are defined as products representing at least 25% of total imported products in the six months immediately before the crisis.

6 Conclusion

This paper investigates the causal effect of supply chain linkages on exporter performance using a difference-in-differences methodology, and survival probability based on a logit model. In addition to the first wave (February-April 2020) and the recovery phase (May-August 2020) of the COVID-19 crisis, we also analyse the period September 2020 to December 2021, when disruptions to GVCs intensified. We exploit monthly disaggregated data for the universe of French exporters and provide evidence that GVC exporters were hit harder throughout the pandemic than non-GVC firms. At the intensive margin, GVC firms were affected especially negatively during the supply bottleneck period. The survival probability for a GVC firm in the export market largely decreased during the lockdown and the supply bottleneck phases. In terms of the firm's positioning in the global production network, we find that downstream firms were the most negatively affected, likely due to the compounding of the shock along the chain. Upstream firms were the least damaged, probably because they were better insulated against foreign providers. Diversification of source countries for core imported inputs reduced the effects of bottlenecks on export volumes and increased the chances of firm survival in the export market in all three phases. Firms should aim at more sound strategies for the sourcing of key inputs in order to increase resilience to supply-chain shocks. Future research could focus on the post-first wave strategies pursued by GVC firms and how GVC firms have adapted to this unprecedented stress on their supply chains through ex-post source diversification or reshoring.

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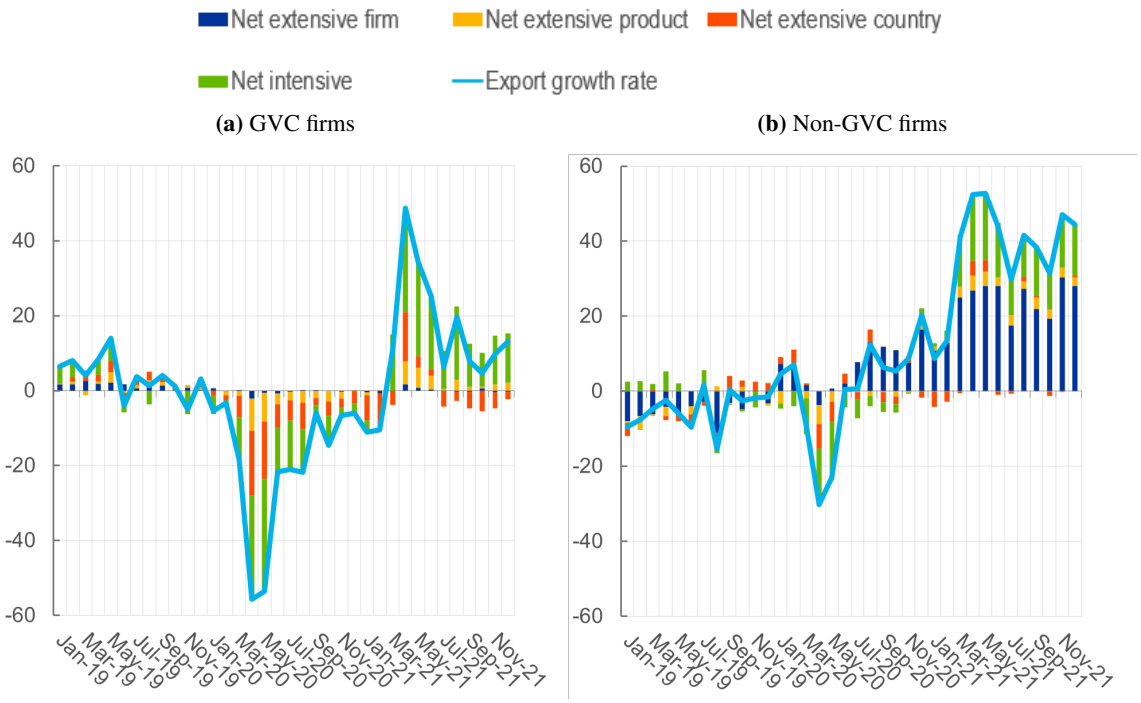
Appendix

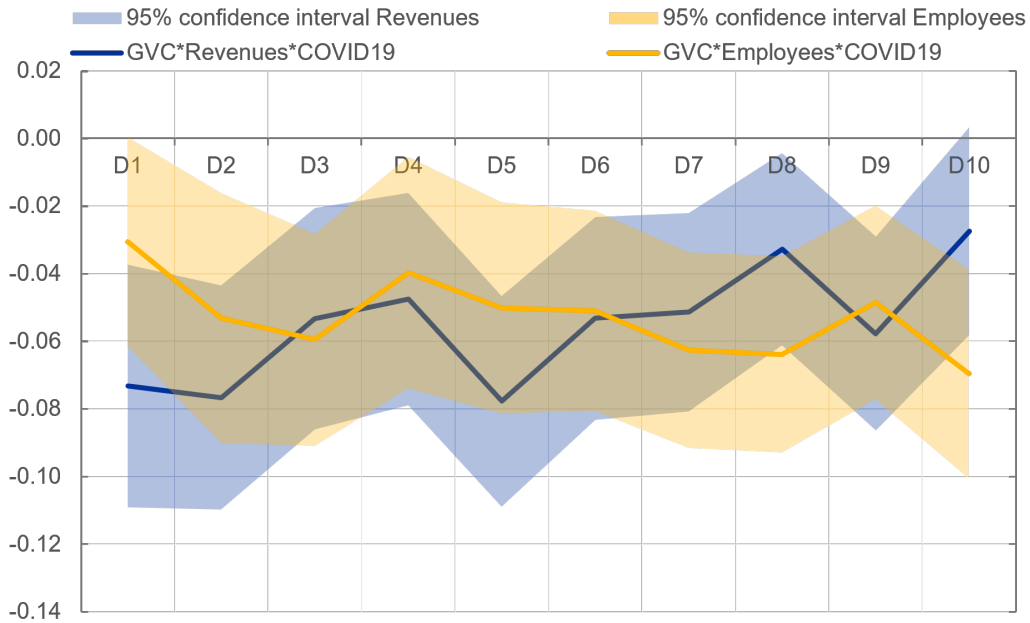
A Figures

Figure A1: Export developments by GVC status, decomposition by margin
((y-o-y percentage change from mid-point growth rates multiplied by 100)



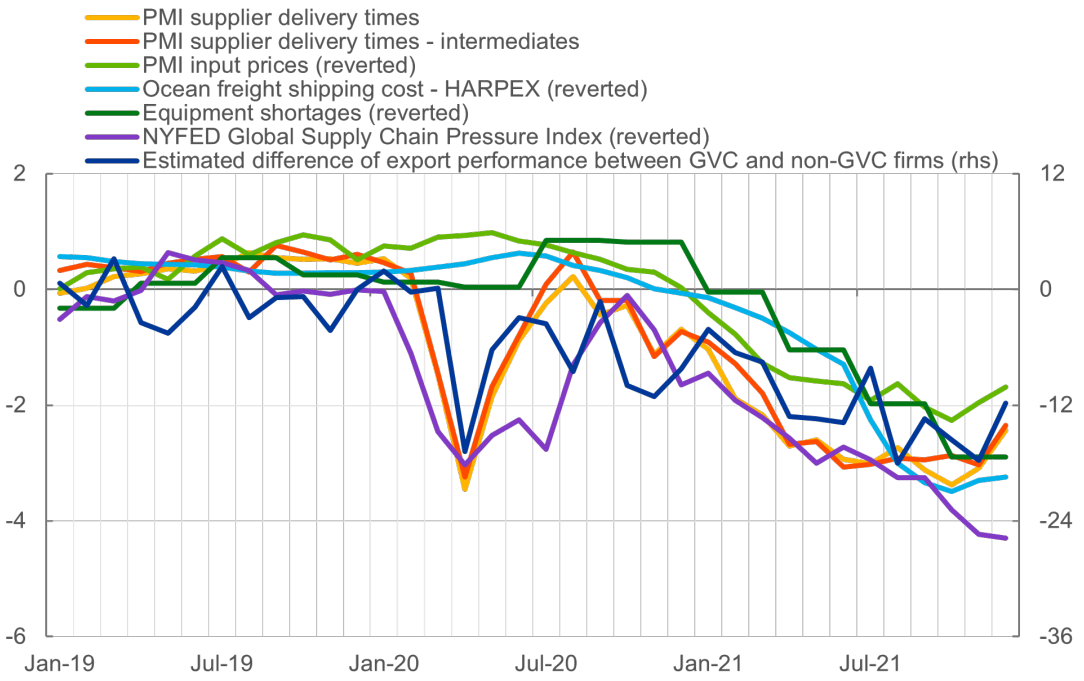
Source: Direction générale des douanes et droits indirects and authors' own calculations.
Note: Mid-point growth rates methodology (Bricongne et al., 2022, 2012; Buono et al., 2008; Davis and Haltiwanger, 1992). GVC firms imported at least once over the six months before the crisis (July to December 2019). Net intensive (extensive) margin is computed as the sum of the contributions of the positive and negative intensive (extensive) margins. Net extensive margins are computed as the sum of entries and exits. Export growth rate is the weighted sum of the mid-point growth rates.

Figure A2: Difference between GVC and non-GVC export performance by firm size deciles



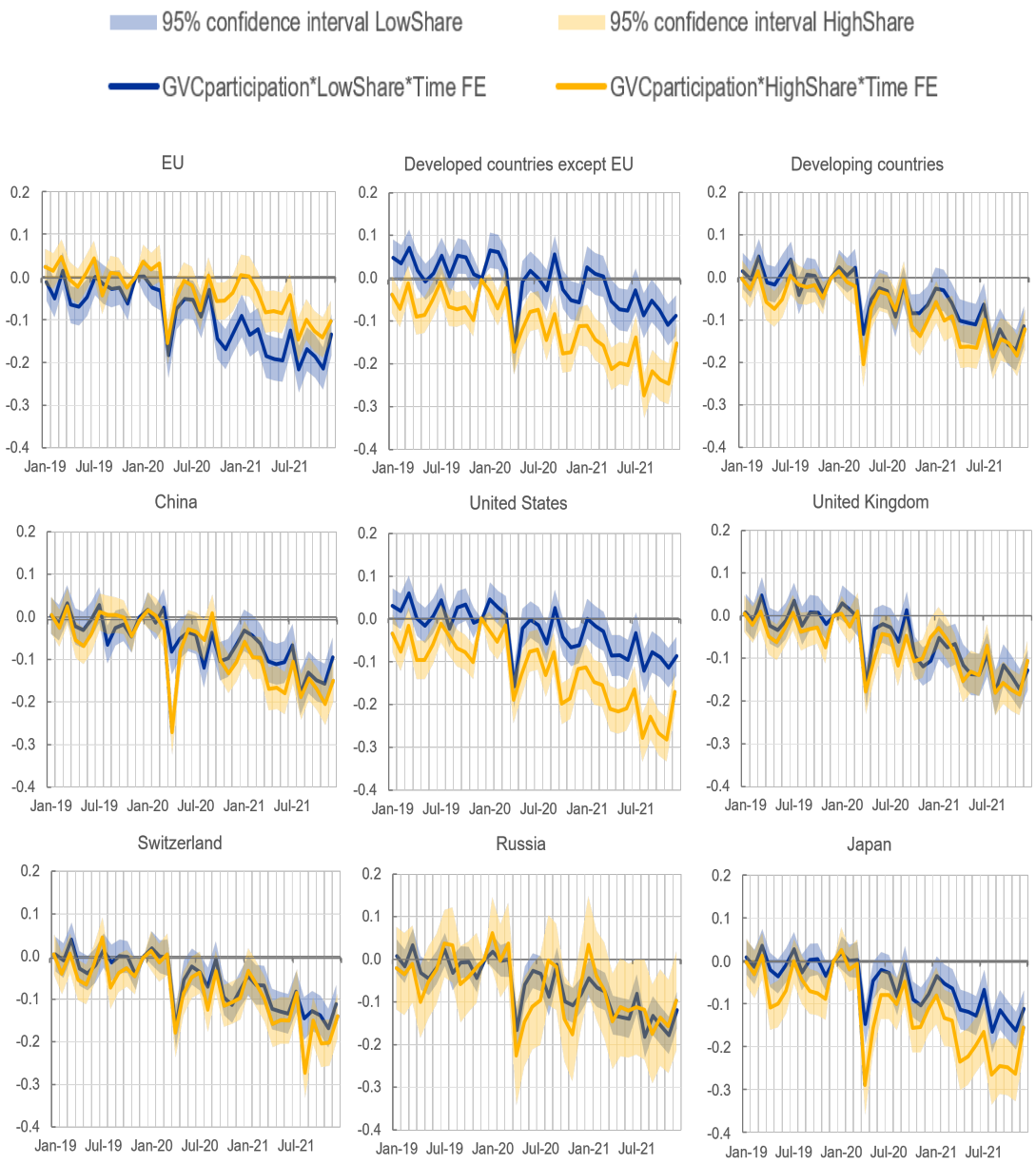
Source: Direction générale des douanes et droits indirects, INSEE and authors' own calculations.
Note: Number of employees is full-time equivalent, in 2019. Revenues is total sales (nominal) of GVC firms in 2019. Table A1 is the corresponding table.

Figure A3: Difference between GVC and non-GVC export performance and bottleneck indicators



Source: Direction générale des douanes et droits indirects, Markit, S&P Global, Harper Petersen, European Commission and authors' own calculations.
Note: All the indexes were normalised using z-score, over the period January 2000 - October 2022. An increase in PMI supplier delivery times for all and intermediate goods means an improvement i.e., a decrease in delivery time. The Harper Petersen Charter Rates Index (HARPEX) reflects the worldwide price development on the charter market for container ships. The European Commission measures equipment shortages as a factor limiting production in terms of the percentage of respondents reporting an increase minus the percentage of respondents reporting a decrease. All bottleneck indicators relate to France except HARPEX which is global. Estimated difference in export performance is taken from Figure 2.

Figure A4: Effect of dependency by source country



Note: Only continuous exporters in the six months immediately before the crisis are retained. *LowShare* takes the value 1 if the share of goods imported from the country is below the median (among GVC firms) in the six months before the pandemic, while *HighShare* is the opposite. Reference point is December 2019. Graphs on the first row represent all the countries France imports from, divided into three groups: EU, developed non-EU and developing countries. Developed countries are USA, GBR, JPN, CAN, AUS, NOR, CHE, ISL, SGP, NLZ, ISR and KOR, being the countries outside of the EU with the highest Human Development Index (HDI). Developing countries are the rest of the world (non-EU and non-developed countries). Countries selected (second and third rows) are the biggest sourcing countries of France outside the EU.

B Tables

Table A1: Effect of size by decile on GVC firm performance during COVID-19

ln export$_{it}$	(1) Total revenue	(2) Number of employees
GVC$_i$×SizeD1$_i$×COVID19$_t$	-0.0732***	-0.0305*
	(0.0183)	(0.0158)
GVC$_i$×SizeD2$_i$×COVID19$_t$	-0.0766***	-0.0531***
	(0.0169)	(0.0189)
GVC$_i$×SizeD3$_i$×SCOVID19$_t$	-0.0533***	-0.0594***
	(0.0167)	(0.0160)
GVC$_i$×SizeD4$_i$×SCOVID19$_t$	-0.0475***	-0.0396***
	(0.0160)	(0.0175)
GVC$_i$×SizeD5$_i$×SCOVID19$_t$	-0.0777***	-0.0501***
	(0.0159)	(0.0160)
GVC$_i$×SizeD6$_i$×SCOVID19$_t$	-0.0532***	-0.0509***
	(0.0153)	(0.0151)
GVC$_i$×SizeD7$_i$×SCOVID19$_t$	-0.0514***	-0.0625***
	(0.0150)	(0.0148)
GVC$_i$×SizeD8$_i$×SCOVID19$_t$	-0.0327**	-0.0638***
	(0.0145)	(0.0148)
GVC$_i$×SizeD9$_i$×SCOVID19$_t$	-0.0577***	-0.0484***
	(0.0146)	(0.0146)
GVC$_i$×SizeD10$_i$×SCOVID19$_t$	-0.0274*	-0.0695***
	(0.0157)	(0.0158)
Constant	10.89***	10.89***
	(0.00432)	(0.00432)
Observations	1,110,148	1,110,148
R-squared	0.807	0.807
Firm FE	YES	YES
Time FE	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. GVC_i is a dummy equal to 1 if the firm imported at least once in the six months before the crisis. Number of employees is expressed in full-time equivalent, in 2019. Revenues is the total sales of GVC firms in 2019.

Table A2: Difference-in-differences, effect of GVC involvement with different starting dates for the treatment

ln export$_{it}$	(1) January 2020	(2) February 2020	(3) March 2020
GVC$_i$×COVID19$_t$	-0.0704***	-0.0768***	-0.0816***
	(0.00960)	(0.00967)	(0.00975)
Constant	11.66***	11.67***	11.67***
	(0.00378)	(0.00364)	(0.00351)
Observations	1,156,272	1,156,272	1,156,272
R-squared	0.823	0.823	0.823
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only continuous exporters between July and December 2019 are retained. GVC_i is equal to 1 if the firm imported at least once during the same period. Pre-treatment period is January 2018 to the beginning of the treatment. COVID-19 (treatment period) is up to December 2021. Column titles indicate the treatment start date.

Table A3: Event study, effect of GVC involvement

ln export$_{it}$	
GVC$_i$×y2019m1$_t$	0.00658 (0.0200)
GVC$_i$×y2019m2$_t$	-0.0166 (0.0200)
GVC$_i$×y2019m3$_t$	0.0319 (0.0198)
GVC$_i$×y2019m4$_t$	-0.0342* (0.0199)
GVC$_i$×y2019m5$_t$	-0.0452** (0.0200)
GVC$_i$×y2019m6$_t$	-0.0186 (0.0200)
GVC$_i$×y2019m7$_t$	0.0235 (0.0198)
GVC$_i$×y2019m8$_t$	-0.0293 (0.0210)
GVC$_i$×y2019m9$_t$	-0.00857 (0.0192)
GVC$_i$×y2019m10$_t$	-0.00729 (0.0183)
GVC$_i$×y2019m11$_t$	-0.0426** (0.0176)
GVC$_i$×y2020m1$_t$	0.0193 (0.0194)
GVC$_i$×y2020m2$_t$	-0.00293 (0.0189)
GVC$_i$×y2020m3$_t$	0.000990 (0.0208)
GVC$_i$×y2020m4$_t$	-0.168*** (0.0247)
GVC$_i$×y2020m5$_t$	-0.0624*** (0.0222)
GVC$_i$×y2020m6$_t$	-0.0294 (0.0209)
GVC$_i$×y2020m7$_t$	-0.0358* (0.0209)
GVC$_i$×y2020m8$_t$	-0.0849*** (0.0225)
GVC$_i$×y2020m9$_t$	-0.0125 (0.0206)
GVC$_i$×y2020m10$_t$	-0.0996*** (0.0210)
GVC$_i$×y2020m11$_t$	-0.111*** (0.0209)
GVC$_i$×y2020m12$_t$	-0.0822*** (0.0205)
GVC$_i$×y2021m1$_t$	-0.0414* (0.0228)
GVC$_i$×y2021m2$_t$	-0.0653*** (0.0229)
GVC$_i$×y2021m3$_t$	-0.0754*** (0.0223)
GVC$_i$×y2021m4$_t$	-0.132*** (0.0232)
GVC$_i$×y2021m5$_t$	-0.134*** (0.0228)
GVC$_i$×y2021m6$_t$	-0.138*** (0.0229)
GVC$_i$×y2021m7$_t$	-0.0818*** (0.0237)
GVC$_i$×y2021m8$_t$	-0.180*** (0.0247)
GVC$_i$×y2021m9$_t$	-0.134*** (0.0233)
GVC$_i$×y2021m10$_t$	-0.156*** (0.0228)
GVC$_i$×y2021m11$_t$	-0.177*** (0.0223)
GVC$_i$×y2021m12$_t$	-0.118*** (0.0221)
Constant	11.67*** (0.0117)
Observations	868,583
R-squared	0.829
Firm FE	YES
Time FE	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only continuous exporters in the six months immediately before the crisis are retained. GVC_i is equal to 1 if the firm imported at least once in the six months immediately before the crisis. $y2019m_{1t}$ is a dummy variable that takes the value 1 for year 2019 month 1 (Jan.). Reference point is December 2019.

Table A4: Difference-in-differences by phase, effect of strategic product criteria: diversification of concentration, importance in demand and substitutability of the imported input

ln export$_{it}$	(1) Importance of extra EU imports in total demand	(2) Non substitutability of extra EU imports with EU production	(3) Concentration of EU imports from extra EU sources
GVC$_i$×Criteria$_i$×COVID19phase1$_t$	-0.00243***	-0.0357**	-0.223***
	(0.000345)	(0.0143)	(0.0466)
GVC$_i$×Criteria$_i$×COVID19phase2$_t$	-0.000375	0.00240	0.0730
	(0.000341)	(0.0157)	(0.0467)
GVC$_i$×Criteria$_i$×COVID19phase3$_t$	-0.00240***	-0.0258*	0.0967**
	(0.000360)	(0.0134)	(0.0475)
GVC$_i$×COVID19phase1$_t$	0.0348**	-0.0273**	0.00840
	(0.0154)	(0.0126)	(0.0154)
GVC$_i$×COVID19phase2$_t$	-0.0304**	-0.0431***	-0.0585***
	(0.0154)	(0.0128)	(0.0153)
GVC$_i$×COVID19phase3$_t$	-0.0229	-0.0881***	-0.120***
	(0.0151)	(0.0120)	(0.0151)
Constant	11.66***	11.66***	11.66***
	(0.00471)	(0.00471)	(0.00471)
Observations	856,555	856,555	856,555
R-squared	0.829	0.829	0.829
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only continuous exporters in the six months immediately before the crisis are retained. GVC_i is equal to 1 if the firm imported at least once in the six months immediately before the crisis. Pre-treatment period is January 2018 to January 2020. COVID-19 (treatment period) is February to April 2020 for phase one, May to August 2020 for phase two and September 2020 to December 2021 for phase three. $Importance_i$ is a continuous variable, calculated as the share of extra-EU imports in total EU imports; $Non\,Substitutability_i$ is a continuous variable, calculated as the ratio between extra-EU imports and total EU exports; $Concentration_i$ is a continuous variable, calculated using the Herfindahl-Hirschman Index and the market share of the extra-EU supplying countries. For more information on the methodology used to build these variables, see European Commission (2021).

Table A5: Re-aggregation of the 45 Industries of the OECD Input-Output Tables

Aggregation	OECD IOT Industries (from ISIC 4 Divisions)
1.Agriculture and food	D01T02 Agriculture, hunting, forestry D03 Fishing and aquaculture
2.Energy	D05T06 Mining and quarrying, energy producing products
3.Mining and quarrying	D07T08 Mining and quarrying, non-energy producing products D09 Mining support service activities
1.Agriculture and food	D10T12 Food products, beverages and tobacco
4.Textiles	D13T15 Textiles, textile products, leather and footwear
5.Wood and paper	D16 Wood and products of wood and cork D17T18 Paper products and printing
6.Chemicals, plastics, and non-metallic mineral products	D19 Coke and refined petroleum products D20 Chemical and chemical products D21 Pharmaceuticals, medicinal chemical and botanical products D22 Rubber and plastics products D23 Other non-metallic mineral products
7.Basic metals and metal products	D24 Basic metals D25 Fabricated metal products
8.Computer, electronic equipment and machinery	D26 Computer, electronic and optical equipment D27 Electrical equipment D28 Machinery and equipment, nec
9.Motor vehicles and transport equipment	D29 Motor vehicles, trailers and semi-trailers D30 Other transport equipment
8.Computer, electronic equipment and machinery	D31T33 Manufacturing nec; repair and installation of machinery and equipment
2.Energy	D35 Electricity, gas, steam and air conditioning supply
14.Other services	D36T39 Water supply; sewerage, waste management and remediation activities
10.Construction	D41T43 Construction
11.Wholesale and retail	D45T47 Wholesale and retail trade; repair of motor vehicles
12. Transportation	D49 Land transport and transport via pipelines D50 Water transport D51 Air transport D52 Warehousing and support activities for transportation D53 Postal and courier activities
13.Accommodation and food service activities	D55T56 Accommodation and food service activities
14.Other services	D58T60 Publishing, audiovisual and broadcasting activities D61 Telecommunications D62T63 IT and other information services D64T66 Financial and insurance activities D68 Real estate activities D69T75 Professional, scientific and technical activities D77T82 Administrative and support services D84 Public administration and defence; compulsory social security D85 Education D86T88 Human health and social work activities D90T93 Arts, entertainment and recreation D94T96 Other service activities D97T98 Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use

Table A6: Difference-in-differences by phase, effect of importing products qualified as strategic

ln export$_{it}$	Strategic product	Others
GVC$_i$×Strategic/Others$_i$×y2019m1$_t$	0.00885 (0.0236)	0.00565 (0.0210)
GVC$_i$×Strategic/Others$_i$×y2019m2$_t$	-0.0206 (0.0239)	-0.0148 (0.0210)
GVC$_i$×Strategic/Others$_i$×y2019m3$_t$	0.0369 (0.0236)	0.0298 (0.0207)
GVC$_i$×Strategic/Others$_i$×y2019m4$_t$	-0.0612*** (0.0235)	-0.0222 (0.0208)
GVC$_i$×Strategic/Others$_i$×y2019m5$_t$	-0.0610*** (0.0235)	-0.0383* (0.0209)
GVC$_i$×Strategic/Others$_i$×y2019m6$_t$	-0.0310 (0.0235)	-0.0131 (0.0208)
GVC$_i$×Strategic/Others$_i$×y2019m7$_t$	0.0214 (0.0232)	0.0244 (0.0207)
GVC$_i$×Strategic/Others$_i$×y2019m8$_t$	0.0474* (0.0247)	-0.0627*** (0.0220)
GVC$_i$×Strategic/Others$_i$×y2019m9$_t$	0.0157 (0.0225)	-0.0191 (0.0202)
GVC$_i$×Strategic/Others$_i$×y2019m10$_t$	0.0128 (0.0215)	-0.0160 (0.0191)
GVC$_i$×Strategic/Others$_i$×y2019m11$_t$	-0.0403* (0.0206)	-0.0436** (0.0185)
GVC$_i$×Strategic/Others$_i$×y2020m1$_t$	0.0441* (0.0231)	0.00832 (0.0203)
GVC$_i$×Strategic/Others$_i$×y2020m2$_t$	0.0139 (0.0226)	-0.0103 (0.0198)
GVC$_i$×Strategic/Others$_i$×y2020m3$_t$	-0.00705 (0.0247)	0.00464 (0.0218)
GVC$_i$×Strategic/Others$_i$×y2020m4$_t$	-0.253*** (0.0302)	-0.130*** (0.0257)
GVC$_i$×Strategic/Others$_i$×y2020m5$_t$	-0.0747*** (0.0266)	-0.0567** (0.0232)
GVC$_i$×Strategic/Others$_i$×y2020m6$_t$	0.00695 (0.0247)	-0.0454** (0.0219)
GVC$_i$×Strategic/Others$_i$×y2020m7$_t$	-0.0347 (0.0246)	-0.0362* (0.0219)
GVC$_i$×Strategic/Others$_i$×y2020m8$_t$	-0.00805 (0.0266)	-0.119*** (0.0235)
GVC$_i$×Strategic/Others$_i$×y2020m9$_t$	0.0270 (0.0247)	-0.0300 (0.0215)
GVC$_i$×Strategic/Others$_i$×y2020m10$_t$	-0.0793*** (0.0251)	-0.109*** (0.0219)
GVC$_i$×Strategic/Others$_i$×y2020m11$_t$	-0.104*** (0.0254)	-0.114*** (0.0219)
GVC$_i$×Strategic/Others$_i$×y2020m12$_t$	-0.0602** (0.0250)	-0.0920*** (0.0215)

$GVC_i \times Strategic/Others_i \times y2021m1_t$	-0.0227 (0.0277)	-0.0497** (0.0238)
$GVC_i \times Strategic/Others_i \times y2021m2_t$	-0.0455 (0.0277)	-0.0741*** (0.0239)
$GVC_i \times Strategic/Others_i \times y2021m3_t$	-0.0648** (0.0272)	-0.0800*** (0.0233)
$GVC_i \times Strategic/Others_i \times y2021m4_t$	-0.148*** (0.0280)	-0.124*** (0.0243)
$GVC_i \times Strategic/Others_i \times y2021m5_t$	-0.143*** (0.0277)	-0.130*** (0.0239)
$GVC_i \times Strategic/Others_i \times y2021m6_t$	-0.130*** (0.0274)	-0.141*** (0.0240)
$GVC_i \times Strategic/Others_i \times y2021m7_t$	-0.0867*** (0.0284)	-0.0795*** (0.0248)
$GVC_i \times Strategic/Others_i \times y2021m8_t$	-0.126*** (0.0297)	-0.205*** (0.0258)
$GVC_i \times Strategic/Others_i \times y2021m9_t$	-0.121*** (0.0279)	-0.139*** (0.0243)
$GVC_i \times Strategic/Others_i \times y2021m10_t$	-0.150*** (0.0275)	-0.158*** (0.0238)
$GVC_i \times Strategic/Others_i \times y2021m11_t$	-0.196*** (0.0273)	-0.168*** (0.0233)
$GVC_i \times Strategic/Others_i \times y2021m12_t$	-0.120*** (0.0268)	-0.117*** (0.0231)
Constant	11.67*** (0.0117)	
Observations	868,583	
R-squared	0.829	
Firm FE	YES	
Time FE	YES	

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. To ease readability, the regression is split across two columns: $ln\,Export_{it} = \sum_{j=-12}^{21} \beta_j\, COVID19_{jt} \times GVC_i \times Strategic\ product_i + \sum_{k=-12}^{21} \beta_k\, COVID19_{kt} \times GVC_i \times (1 - Strategic\ product_i) + FE_i + FE_t + \varepsilon_{it}$. Only continuous exporters between July and December 2019 are retained. GVC_i is equal to 1 if the firm imported at least once in the six months immediately before the crisis. $Strategic\ product_i$ takes the value 1 if the GVC firm imported at least one of the 137 strategic products at least once in the six months immediately before the pandemic. The reference time for the event study is December 2019.

Table A7: Probit model, effect of GVC involvement on firm's export status

export status$_{it}$	(1) General	(2) By phase
GVC$_i$×COVID19$_t$	-0.0633***	
	(0.00837)	
COVID19$_t$	-0.321***	
	(0.00709)	
GVC$_i$	0.396***	0.396***
	(0.00634)	(0.00634)
GVC$_i$×COVID19phase1$_t$		-0.0721***
		(0.0171)
GVC$_i$×COVID19phase2$_t$		-0.0399***
		(0.0155)
GVC$_i$×COVID19phase3$_t$		-0.0649***
		(0.00901)
COVID19phase1$_t$		-0.215***
		(0.0147)
COVID19phase2$_t$		-0.183***
		(0.0131)
COVID19phase3$_t$		-0.370***
		(0.00766)
Constant	1.459***	1.459***
	(0.00531)	(0.00531)
Observations	1,207,872	1,207,872
Firm FE	NO	NO
Time FE	NO	NO

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only continuous exporters in the six months immediately before the crisis are retained. Only firms that were either above the €460,000 threshold in 2019 or declared flows in January 2020 are retained. $Exportstatus_{it}$ takes the value 1 if the firm has positive export flows. GVC_i is equal to 1 if the firm imported at least once in the six months immediately before the crisis. Pre-treatment period is January 2018 to January 2020. COVID-19 (treatment period) is February 2020 to December 2021. $COVID19phase1_t$ is February to April 2020, $COVID19phase2_t$ is May to August 2020 and $COVID19phase3_t$ is September 2020 to December 2021.

Table A8: Logit model in an event study setting, effect of GVC involvement on export status

export status$_{it}$	(1) Odds ratio	(2) Marginal effect
GVC$_i$×y2019m1$_t$	-0.0121 (0.0658)	-0.000760 (0.00412)
GVC$_i$×y2019m2$_t$	0.0387 (0.0711)	0.00243 (0.00445)
GVC$_i$×y2019m3$_t$	0.0767 (0.0757)	0.00481 (0.00474)
GVC$_i$×y2019m4$_t$	-0.0809 (0.0789)	-0.00507 (0.00494)
GVC$_i$×y2019m5$_t$	-0.114 (0.0862)	-0.00713 (0.00540)
GVC$_i$×y2019m6$_t$	0.00776 (0.0872)	0.000486 (0.00546)
o.GVC$_i$×y2019m7$_t$	-	-
o.GVC$_i$×y2019m8$_t$	-	-
o.GVC$_i$×y2019m9$_t$	-	-
o.GVC$_i$×y2019m10$_t$	-	-
o.GVC$_i$×y2019m11$_t$	-	-
o.GVC$_i$×y2019m12$_t$	-	-
GVC$_i$×y2020m1$_t$	-0.187* (0.110)	-0.0117* (0.00687)
GVC$_i$×y2020m2$_t$	-0.0889 (0.0789)	-0.00557 (0.00494)
GVC$_i$×y2020m3$_t$	-0.0790 (0.0666)	-0.00495 (0.00418)
GVC$_i$×y2020m4$_t$	-0.302*** (0.0451)	-0.0189*** (0.00282)
GVC$_i$×y2020m5$_t$	-0.145*** (0.0537)	-0.00908*** (0.00336)
GVC$_i$×y2020m6$_t$	-0.176*** (0.0645)	-0.0110*** (0.00404)
GVC$_i$×y2020m7$_t$	-0.0692 (0.0656)	-0.00433 (0.00411)
GVC$_i$×y2020m8$_t$	-0.216*** (0.0551)	-0.0136*** (0.00345)
GVC$_i$×y2020m9$_t$	-0.127* (0.0648)	-0.00795* (0.00406)
GVC$_i$×y2020m10$_t$	-0.137** (0.0607)	-0.00861** (0.00380)
GVC$_i$×y2020m11$_t$	-0.205*** (0.0562)	-0.0128*** (0.00352)

$GVC_i \times y2020m12_t$	-0.219***	-0.0137***
	(0.0556)	(0.00348)
$GVC_i \times y2021m1_t$	-0.205***	-0.0129***
	(0.0493)	(0.00309)
$GVC_i \times y2021m2_t$	-0.207***	-0.0130***
	(0.0504)	(0.00316)
$GVC_i \times y2021m3_t$	-0.240***	-0.0150***
	(0.0522)	(0.00327)
$GVC_i \times y2021m4_t$	-0.297***	-0.0186***
	(0.0506)	(0.00317)
$GVC_i \times y2021m5_t$	-0.311***	-0.0195***
	(0.0497)	(0.00312)
$GVC_i \times y2021m6_t$	-0.250***	-0.0156***
	(0.0505)	(0.00316)
$GVC_i \times y2021m7_t$	-0.272***	-0.0170***
	(0.0490)	(0.00307)
$GVC_i \times y2021m8_t$	-0.263***	-0.0164***
	(0.0452)	(0.00283)
$GVC_i \times y2021m9_t$	-0.303***	-0.0190***
	(0.0495)	(0.00310)
$GVC_i \times y2021m10_t$	-0.254***	-0.0159***
	(0.0496)	(0.00311)
$GVC_i \times y2021m11_t$	-0.292***	-0.0183***
	(0.0490)	(0.00307)
$GVC_i \times y2021m12_t$	-0.235***	-0.0147***
	(0.0476)	(0.00298)
$y2019m1_t$	0.411***	0.0257***
	(0.0529)	(0.00332)
$y2019m2_t$	0.578***	0.0362***
	(0.0566)	(0.00355)
$y2019m3_t$	0.710***	0.0445***
	(0.0598)	(0.00375)
$y2019m4_t$	0.864***	0.0541***
	(0.0638)	(0.00400)
$y2019m5_t$	1.074***	0.0673***
	(0.0699)	(0.00438)
$y2019m6_t$	1.056***	0.0661***
	(0.0694)	(0.00435)
$o.y2019m7_t$	-	-
$o.y2019m8_t$	-	-
$o.y2019m9_t$	-	-
$o.y2019m10_t$	-	-
$o.y2019m11_t$	-	-

o.y2019m12$_t$	-	-
y2020m1$_t$	1.624***	0.102***
	(0.0897)	(0.00563)
y2020m2$_t$	0.868***	0.0544***
	(0.0639)	(0.00401)
y2020m3$_t$	0.468***	0.0293***
	(0.0541)	(0.00339)
y2020m4$_t$	-0.547***	-0.0343***
	(0.0382)	(0.00239)
y2020m5$_t$	-0.0675	-0.00423
	(0.0443)	(0.00278)
y2020m6$_t$	0.422***	0.0264***
	(0.0532)	(0.00333)
y2020m7$_t$	0.424***	0.0266***
	(0.0532)	(0.00333)
y2020m8$_t$	0.0300	0.00188
	(0.0459)	(0.00287)
y2020m9$_t$	0.416***	0.0261***
	(0.0530)	(0.00332)
y2020m10$_t$	0.255***	0.0160***
	(0.0498)	(0.00312)
y2020m11$_t$	0.0796*	0.00498*
	(0.0467)	(0.00293)
y2020m12$_t$	0.0535	0.00335
	(0.0463)	(0.00290)
y2021m1$_t$	-0.292***	-0.0183***
	(0.0412)	(0.00258)
y2021m2$_t$	-0.226***	-0.0142***
	(0.0421)	(0.00263)
y2021m3$_t$	-0.110**	-0.00690**
	(0.0437)	(0.00274)
y2010m4$_t$	-0.183***	-0.0115***
	(0.0426)	(0.00267)
y2021m5$_t$	-0.231***	-0.0145***
	(0.0420)	(0.00263)
y2021m6$_t$	-0.207***	-0.0129***
	(0.0423)	(0.00265)
y2021m7$_t$	-0.290***	-0.0182***
	(0.0412)	(0.00258)
y2021m8$_t$	-0.547***	-0.0343***
	(0.0382)	(0.00239)
y2021m9$_t$	-0.248***	-0.0156***
	(0.0417)	(0.00262)

$y2021m10_t$	-0.258***	-0.0162***
	(0.0416)	(0.00261)
$y2021m11_t$	-0.281***	-0.0176***
	(0.0413)	(0.00259)
$y2021m12_t$	-0.387***	-0.0243***
	(0.0400)	(0.00251)
$GVCparticipation_i$	0.890***	0.0558***
	(0.0156)	(0.000984)
Constant	2.005***	
	(0.0126)	
Observations	1,056,888	1,056,888
Firm FE	NO	NO
Time FE	NO	NO

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only continuous exporters in the six months immediately before the crisis are retained. Only firms that were either above the €460,000 threshold in 2019 or declared flows in January 2020 are retained. $Exporterstatus_{it}$ takes the value 1 if the firm has positive export flows. GVC_i is equal to 1 if the firm imported at least once in the six months immediately before the crisis. $y2019m1_t$ takes the value 1 for year 2019 month 1 (Jan.). Reference point is year 2018. Observations in the period July-December 2019 have been dropped because we require firms to be continuous exporters during that period. By construction, therefore, there is perfect collinearity between the groups at that time.

Table A9: Logit model, effect of being downstream or upstream on firm's export status

export status$_{it}$	(1) General-odds ratio	(2) General-marginal effects	(3) By phase -odds ratio	(4) By phase-marginal effects
GVC$_i$×Downstream$_i$×COVID19$_t$	-0.757***	-0.0613***		
	(0.0138)	(0.00113)		
GVC$_i$×Upstream$_i$×COVID19$_t$	0.0115	0.000930		
	(0.0153)	(0.00124)		
COVID19$_t$	-0.272***	-0.0220***		
	(0.00959)	(0.000776)		
GVC$_i$	1.848***	0.150***	1.848***	0.150***
	(0.00998)	(0.000830)	(0.00998)	(0.000829)
GVC$_i$×Downstream$_i$×COVID19phase1$_t$			-0.661***	-0.0535***
			(0.0294)	(0.00238)
GVC$_i$×Downstream$_i$×COVID19phase2$_t$			-0.576***	-0.0466***
			(0.0267)	(0.00216)
GVC$_i$×Downstream$_i$×COVID19phase3$_t$			-0.808***	-0.0654***
			(0.0150)	(0.00122)
GVC$_i$×Upstream$_i$×COVID19phase1$_t$			0.144***	0.0117***
			(0.0357)	(0.00289)
GVC$_i$×Upstream$_i$×COVID19phase2$_t$			0.140***	0.0113***
			(0.0318)	(0.00257)
GVC$_i$×Upstream$_i$×COVID19phase3$_t$			-0.0344**	-0.00278**
			(0.0168)	(0.00136)
COVID19phase1$_t$			-0.204***	-0.0165***
			(0.0200)	(0.00162)
COVID19phase2$_t$			-0.161***	-0.0131***
			(0.0178)	(0.00144)
COVID19phase3$_t$			-0.311***	-0.0251***
			(0.0105)	(0.000849)
Constant	1.303***		1.303***	
	(0.00688)		(0.00688)	
Observations	1,176,096	1,176,096	1,176,096	1,176,096
Firm FE	NO	NO	NO	NO
Time FE	NO	NO	NO	NO

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only continuous exporters in the six months immediately before the crisis are retained. Only firms that were either above the €460,000 threshold in 2019 or declared flows in January 2020 are retained. *Exporter status$_{it}$* takes the value 1 if the firm has positive export flows. *GVC$_i$* is equal to 1 if the firm imported at least once in the six months immediately before the crisis. *Upstream$_i$* takes the value 1 if the firm is positioned above the median on the upstreamness index, while *Downstream$_i$* takes the value 1 if the firm is positioned below the median. Pre-treatment period is January 2018 to January 2020. In columns 1 and 2 COVID-19 (treatment period) is February 2020 to December 2021. In columns 3 and 4, COVID-19 (treatment period) is February to April 2020 for phase one, May to August 2020 for phase two and September 2020 to December 2021 for phase three.

Table A10: Difference-in-differences by phase, effect of diversification of source countries for the core products

ln export$_{it}$	(1) 1%	(2) 5%	(3) 10%	(4) 15%	(5) 20%	(6) 25%	(7) 30%
GVC$_i$×NoDiversificationCoreProduct$_i$×COVID19phase1$_t$	0.0607***	0.0147	0.0117	0.00826	0.0100	0.00639	0.00881
	(0.0180)	(0.0119)	(0.0111)	(0.0111)	(0.0113)	(0.0116)	(0.0119)
GVC$_i$×NoDiversificationCoreProduct$_i$×COVID19phase2$_t$	0.0156	-0.0109	-0.00751	-0.0212*	-0.0156	-0.0203*	-0.0146
	(0.0173)	(0.0116)	(0.0110)	(0.0110)	(0.0112)	(0.0115)	(0.0118)
GVC$_i$×NoDiversificationCoreProduct$_i$×COVID19phase3$_t$	0.0124	-0.0146	-0.0151	-0.0240**	-0.0220*	-0.0308***	-0.0290**
	(0.0191)	(0.0123)	(0.0114)	(0.0113)	(0.0115)	(0.0118)	(0.0121)
GVC$_i$×COVID19phase1$_t$	-0.0316***	-0.0338***	-0.0333**	-0.0340**	-0.0325**	-0.0343**	-0.0324**
	(0.0120)	(0.0125)	(0.0129)	(0.0133)	(0.0137)	(0.0140)	(0.0144)
GVC$_i$×COVID19phase2$_t$	-0.0375***	-0.0425***	-0.0424***	-0.0500***	-0.0481***	-0.0518***	-0.0488***
	(0.0119)	(0.0123)	(0.0128)	(0.0131)	(0.0135)	(0.0139)	(0.0143)
GVC$_i$×COVID19phase3$_t$	-0.0931***	-0.0988***	-0.101***	-0.107***	-0.107***	-0.114***	-0.114***
	(0.0113)	(0.0118)	(0.0122)	(0.0126)	(0.0130)	(0.0134)	(0.0139)
Constant	11.67***	11.67***	11.67***	11.67***	11.67***	11.67***	11.67***
	(0.00365)	(0.00365)	(0.00365)	(0.00365)	(0.00365)	(0.00365)	(0.00365)
Observations	1,156,272	1,156,272	1,156,272	1,156,272	1,156,272	1,156,272	1,156,272
R-squared	0.823	0.823	0.823	0.823	0.823	0.823	0.823
Firm FE	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses. Significance at *** p<0.01, ** p<0.05, * p<0.1. Only continuous exporters in the six months immediately before the crisis are retained. GVC_i is equal to 1 if the firm imported at least once in the six months immediately before the crisis. $NonDiversificationCoreProduct_i$ is equal to 1 if the firm's core products are imported from only one source country. Core products are defined as products representing a minimum percentage of total imported products in the six months immediately before the crisis. Column titles indicate the thresholds. Pre-treatment period is January 2018 to January 2020. COVID-19 (treatment period) is February to April 2020 for phase one, May to August 2020 for phase two and September 2020 to December 2021 for phase three.

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