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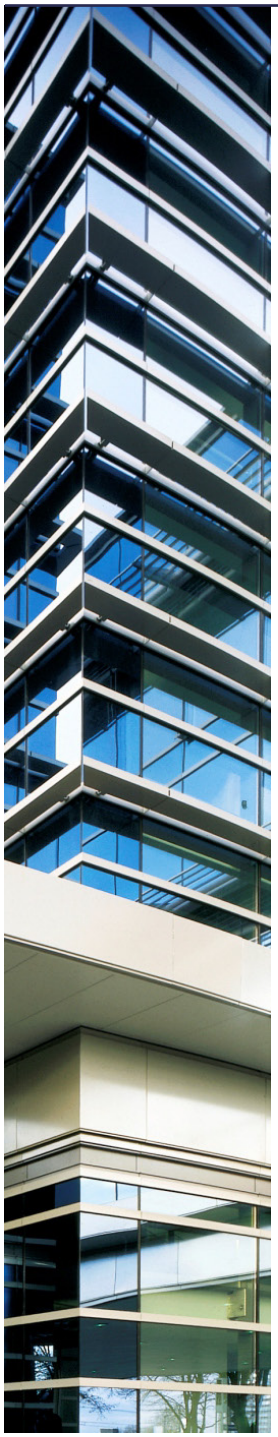
THE TRANSMISSION OF TRADE SHOCKS ACROSS COUNTRIES: FIRM-LEVEL EVIDENCE FROM THE COVID-19 CRISIS



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The transmission of trade shocks across countries: firm-level evidence from the Covid-19 crisis

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Abstract

This paper studies the margins and heterogeneity of adjustments to trade shocks by estimating how Covid-19 restrictions affected imports and exports. We use data from Lithuania, Latvia and Estonia on foreign trade at the level of the firm and the partner country and at monthly frequency from January 2019 to December 2020. The focus is on the short-term adjustment and on the first wave of the pandemic. We find that the adjustment to the restrictions mostly occurs through the intensive margin, meaning trade values are reduced rather than trade in certain markets or products ceasing. It is further observed that quantity played a more important role in the adjustment process than prices and that both upstream and downstream restrictions played an equally important role in the decline of foreign trade. It is shown that differentiated products that are difficult to replace are responsible for this adjustment pattern.

Keywords: transmission of shocks, input-output linkages, global value chains, Covid-19, workplace closing

JEL codes: F14, F61, D22

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1 Introduction

The WHO declared the end of Covid-19 as a global health emergency in May 2023, but the pandemic had by then already built a platform from which lessons may be learnt for decades. There was an unforeseen drop in global trade flows during the first wave of the Covid-19 pandemic. The drop was sizeable and unexpected, and was not related to the economic fundamentals of importers or exporters, making it a natural experiment that randomly divided firms into those exposed to a supply and demand shock and those not.

In this paper, we ask whether and how international trade shocks are transmitted across countries by studying how firms adjusted to the Covid-19 restrictions. We use data on trade transactions at the level of the firm for the three Baltic countries of Lithuania, Latvia and Estonia. The Covid-19 shock is identified using a method that follows earlier studies on shock propagation from business to business like Boehm et al. (2019), and studies on Covid-19 shock propagation like Bonadio et al. (2021). We follow the literature on the transmission of shocks across countries after natural disasters (Barrot and Sauvagnat 2016, Boehm et al. 2019, Carvalho et al. 2021) and treat the trade shock in partner countries that was caused by the restrictions as an exogenous shock like a natural disaster. Unlike earlier literature on the propagation of trade shocks during the Covid-19 crisis[1], we use firm-level data that allow us to disentangle the propagation of shocks by the intensive and extensive margins, by prices and quantities traded, and by product and firm heterogeneity. Some firm-level studies on trade during the pandemic have already appeared (Benguria 2021, Bricongne et al. 2022, Constantinescu et al. 2022, de Lucio et al. 2022, Lafrogne-Joussier et al. 2023, Amador et al. 2023, Lebastard et al. 2023), and we contribute by providing evidence from new angles, most importantly by explicitly studying all the extensive margins by destination and product, and by disentangling the role of product differentiation.

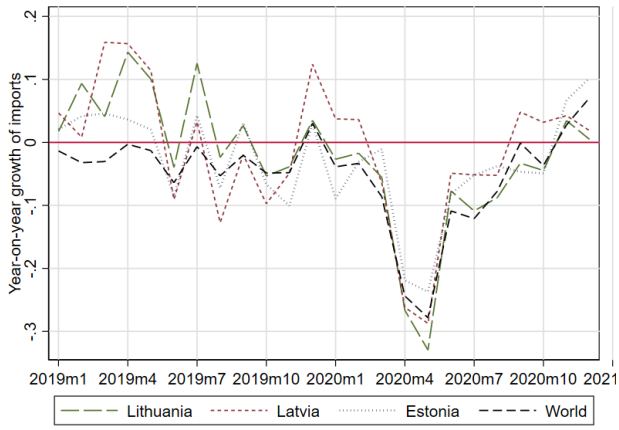
We focus on the first wave of the Covid-19 pandemic because the shock to global trade flows was unexpected at the time and its impact was effectively a natural experiment. Global trade flows dropped by one third in March and April 2020, but the recovery from this was quick, and subsequent waves of Covid-19 did not cause such large disruptions in trade (see Figure 1). Our sample countries experienced similar declines in trade during the first wave of Covid-19, as their imports and exports dropped by up to 30%. Our sample countries provide an excellent case study for analysing the

[1] See for example Sforza and Steininger (2020), Bonadio et al. (2021), Espitia et al. (2022), Bas et al. (2023), Kejžar et al. (2022), Liu et al. (2022), Berthou and Stumpner (2022), Aiyar et al. (2022), Khorana et al. (2023), Ando and Hayakawa (2022).

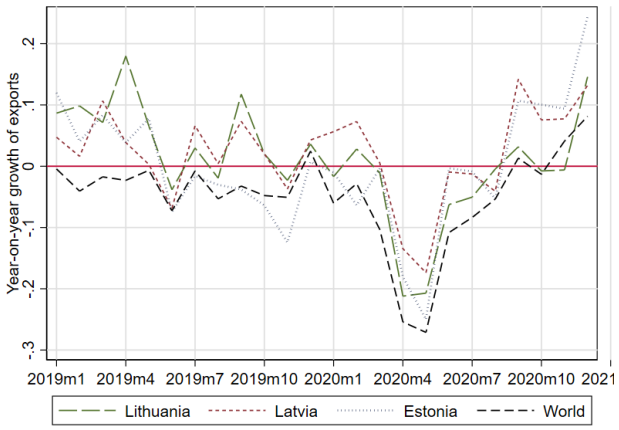
propagation of shocks through global value chains (GVCs) because they rely heavily on GVCs and are particularly sensitive to foreign shocks (Huo et al. 2019). Since exiting a GVC is a very costly option for a firm in a small open economy, most of the adjustment to the shocks takes place within the GVCs and shows up in our foreign trade data.

Figure 1: Trade flows in the world and in the three Baltic countries, 2019-2020.

(a) Imports of goods, annual growth



(b) Exports of goods, annual growth



Source: Authors' calculations from Eurostat table DS-045409.

We use firm-level data from 2019 to 2020 at monthly frequency and take a difference-in-differences style approach to estimate how lockdowns in partner countries affected the imports and exports of domestic firms. The treatment variable is derived at the firm-partner country level using the shock of the workplace closures from the Oxford Stringency Index (Hale et al. 2021). The role of backward linkages, or a shock in the upstream stages of production, is tested by estimating how workplaces closing in source countries affected the imports of domestic firms. The role of forward linkages, or a shock in the downstream stages of production or consumption, is tested by estimating how workplaces closing in destination countries affected the exports of domestic firms. Our empirical specification is inspired by a multiple-product, multiple-market trading set-up as in Bernard et al. (2011), and we use it to analyse how workplaces closing impacted various firms' trade margins like the probability of trading with a market, the value of trade, the number of products traded, the mean value of trade per product, and the price and the quantity traded. The data are available at the levels of firm, product, and partner country, and our analysis is done at the level of the firm and the partner country. The justification for this choice is that the Covid-19 shock varied geographically quite widely, but not so much across products. The product dimension is still used in the analysis to differentiate between the intensive and extensive margins, and to account for the

role of product characteristics in the pattern of adjustment.

Our paper relates to two strands of the literature. The first strand is more generally the literature on the propagation of shocks through input-output linkages, focusing on international production where input-output linkages involve global value chains. Acemoglu et al. (2016) show that supply or demand shocks that affect particular industries at the industry level are amplified by input-output linkages. The direct effect of a shock on the industry itself accounts for a smaller part of the total effect of the shock, and the larger part of the total effect comes from upstream and downstream linkages to other industries. Acemoglu et al. (2016) also show that supply shocks are propagated downstream through a variety of indirect linkages, so the production of firms is affected by the lack of intermediate inputs from suppliers, and also by problems at the suppliers of their supplier.

The second strand is more specifically the literature on how the Covid-19 pandemic impacted international trade. There are already a lot of papers documenting how the Covid-19 shock affected trade, and the most popular approach for empirical investigations has been to use the gravity model on aggregate data. Espitia et al. (2022) conduct sector-level analysis of data on exports from the US, Japan and a majority of EU countries, showing that declines in trade were smaller in sectors where remote work was more feasible during the first wave of Covid-19. They show that the decline in mobility in workplaces reduced the exports of suppliers and the decline in mobility at retailers and recreation outlets reduced the imports of customers. Bas et al. (2023) conduct product-level analysis and study how the US, Japan and 27 EU countries were affected by Covid-19 deaths in exporting countries. They find that the exports that were most vulnerable to the Covid-19 shock were exports of products that were of lower complexity and more reliant on unskilled labour, products where China was a dominant supplier of inputs, and products where input suppliers were not diversified. The results highlight that the two key features of the products that were affected more by the pandemic were the vulnerability of production to social distancing restrictions, and a lack of diversification in inputs.

Heavy reliance on intermediate inputs from China has been identified as a vulnerability for firms during the pandemic (e.g. Javorcik 2020). It has been shown that greater reliance on intermediate inputs from China held back production during the first wave of the Covid-19 pandemic (Bas et al. 2023, Kejžar et al. 2022, Lafrogne-Joussier et al. 2023), and it has also been shown that imports from China were a partial substitute for local production when the pandemic hit the importing country (Liu et al. 2022).

Another strand of the literature on trade during the pandemic assesses the costs and benefits of GVCs. Bonadio et al. (2021) show that GVCs mitigated the adjustment to the pandemic, and that complete nationalisation of supply chains rarely proved to be the best strategy for adjusting to the pandemic. The debate over the importance of forward and backward linkages in GVCs points to the larger role played by forward linkages, as Kejžar et al. (2022) and Berthou and Stumpner (2022) find evidence of demand shocks being propagated through forward linkages, but no robust evidence of supply shocks being propagated through backward linkages. Berthou and Stumpner (2022) note that social distancing restrictions had a stronger effect on demand than they did on the capacity to produce, and they estimate that a full lockdown in a country affected imports twice as much as exports.

There are already a number of papers on the Covid-19 shock to trade at the level of the firm. Bricongne et al. (2022) show that exports by large firms react more strongly to demand shocks than exports of small firms do, and this explains a large part of the decline in aggregate exports during the pandemic. That the impact is amplified for larger firms was also confirmed by Amador et al. (2023). There is, however, mixed evidence about the role of firms within GVCs in propagating shocks during the pandemic. Constantinescu et al. (2022) demonstrate that globally engaged firms recovered more quickly from the pandemic, while Lebastard et al. (2023) find that firms that bought their inputs from abroad saw a stronger decline in exports than firms that bought their inputs domestically. There are studies that point to the importance of forward linkages (de Lucio et al. 2022, Bricongne et al. 2022), and some that point to the importance of both forward and backward linkages (Amador et al. 2023). Lafrogne-Joussier et al. (2023) find that firms that had imported intermediate inputs from China before the pandemic suffered lower domestic and foreign sales than firms that imported intermediate inputs from elsewhere during the first wave of the pandemic. They also show that geographic diversification of inputs did not alleviate the shock, but having a larger stock of inventory did. Their results point to the substitutability of Chinese intermediate inputs being low. We are the first to cover the country margin in the adjustment of trade to the Covid-19 shock, and this is the first firm-level paper to study product substitutability by product differentiation and stickiness.

Our analysis reveals that the shocks in supplier countries affected imports in the Baltics immediately and substantially, and the same is observed for the propagation of shocks from customers to exports. The adjustment to the shock in partner countries was mainly made by reducing the

average trade flows to each destination and for each product in a destination, which is the intensive margin, and only to a smaller extent by cutting markets or the number of products in each market, which is the extensive margin. The decompositions similarly indicate that the majority of the adjustment was made through the quantities traded and not through prices. The finding that the adjustment went through the intensive margin is similar to the evidence about the adjustment during the Great Recession (Antràs 2020), and this pattern of adjustment probably facilitated the rapid recovery after the shock. Adjustment through quantities and not prices is similar to that typically seen after natural disasters (Boehm et al. 2019) and is probably the characteristic type of adjustment to short-term shocks.

Our findings support those papers that have found upstream and downstream restrictions to have been equally important for the decline in trade during the pandemic (Amador et al. 2023) and do not confirm that downstream restrictions played the dominant role (de Lucio et al. 2022, Bricongne et al. 2022). However, our quantification of effects shows that Covid-19 restrictions abroad were not responsible alone for the decline in trade, as demand also had a substantial effect, and occasionally even a larger one than restrictions, which supports the literature on the importance of demand during the pandemic (Berthou and Stumpner 2022).

The vulnerability to shocks was heterogeneous across products and firms. We illustrate that products that the Rauch (1999) classification shows to be difficult to replace are responsible for the transmission of shocks. Shocks to specific inputs that have low elasticity of substitution are propagated almost one-to-one to other inputs and customers (Barrot and Sauvagnat 2016, Boehm et al. 2019), and we show that these products are responsible for the decline in trade during the pandemic. Small firms and those with low productivity were more likely to withdraw from a market because of Covid-19 restrictions in a partner country, and although trade is highly concentrated and small firms play only a minor role in the aggregate picture, our results suggest that this segment of firms was probably hit hardest, since it is more costly to restore a trade relationship than to restore a value traded. There is also evidence that larger inventories reduced the vulnerability to the shock.

The paper is organised as follows: Section 2 describes our data and provides some stylised facts about foreign trade in our sample countries. Section 3 presents our empirical estimation strategy and decomposition methods. Section 4 presents the results, starting with upstream workplace closures and imports, followed by downstream workplace closures and exports, and it ends by quantifying the size of the effect from different adjustment margins and by investigating the heterogeneity of

the effect by product and firm characteristics. Lastly, Section 5 summarises our findings.

2 Data and stylised facts

The database is constructed using the same definition of variables and the same set of codes for all three countries in our sample. The data are confidential and cannot be pooled in a single database, but the confidential trade data for each individual country can be either accessed directly in national statistical institutions or processed over a VPN using the same set of codes. This approach is often called distributed micro-data analysis (see Bartelsman et al. 2004).

We merge two anonymised firm-level datasets: foreign trade micro-data and balance-sheet data for firms in each sample country[2]. The trade data cover exports and imports of goods at monthly frequency from January 2019 to December 2020, with products defined at the HS six-digit level[3]. The universe of trade flows is covered for extra-EU trade, while trade within the EU is covered only when the yearly trade of a firm with the EU is above the Intrastat reporting threshold. The Intrastat thresholds could affect the estimates for the probability of trading with EU partners, but there are two reasons why it is unlikely that those thresholds affect our estimates. The first is that the obligation for a firm to report to Intrastat is defined by its EU trade in the year before the reporting year, so that if there is a negative trade shock, firms still keep reporting for at least for a year and do not drop out of the sample. So if a firm was reporting to Intrastat in 2019 but falls below the reporting threshold in 2020 because of a negative trade shock, it is still obliged to continue reporting to Intrastat in 2020[4]. The second reason is that the Intrastat thresholds were unchanged in Lithuania and Estonia, and raised only marginally in Latvia during the period of our analysis[5].

The balance-sheet data for the firms covers the universe of firms in all the sample countries and without reporting thresholds. These data are collected at yearly frequency and we use data from 2019 and 2020. The data on trade flows are merged with the balance sheets and profit-loss

[2]The two datasets are provided by the National Statistical Institutes, the State Revenue Service, or the Business Register of each country.

[3]The original dataset is available at the eight-digit level, but we have aggregated it to the six-digit level in order to avoid the re-classification problem.

[4]See more about Intrastat reporting rules at https://europa.eu/youreurope/business/selling-in-eu/selling-goods-services/selling-products-eu/index_en.htm

[5]The reporting thresholds of 150 000 euros for exports and 250 000 euros for imports remained stable for Lithuania during the years under analysis. The thresholds were also unchanged in Estonia at 130 000 euros for exports and 230 000 euros for imports. The threshold for exports was increased in Latvia from 100 000 in 2019 to 120 000 euros in 2020 and that for imports from 200 000 to 220 000 euros.

statements of the firms involved.

The unit of analysis is at the level of the firm–trade partner country, while the product dimension is used to disentangle the extensive and intensive margins of the trade flow. The extensive margin is defined by the country margin, which is the probability of the trade relationship with a partner country being maintained, and by the product margin, which is the number of products per trade partner country, while the intensive margin is the average value of the trade flow of each product with a partner. Each trade flow is recorded by value in euros and by quantity[6], and the unit value can be derived as value divided by quantity. The unit value at this disaggregated level can be taken as a proxy for the price of a traded good[7].

Table 1 summarises the trade margins in destinations and Table A.1 in the Appendix provides other characteristics of firms for our sample. The three sample countries are similar for the values traded and for the number of products traded in each destination. Each firm on average imports four products from a destination and exports three products to a destination, and the imports being more diverse than the exports is also reflected by the trade flows imported being smaller than those exported. The sizes and productivity levels of firms are also similar, and the average firm is a small firm in the Eurostat definition, employing fewer than 50 workers.

The three sample countries are small open economies where imports of goods were 50-60% of GDP and exports of goods 40-50% of GDP before the pandemic[8]. They are tightly integrated into global value chains, and foreign intermediates are a more important component of exports than the domestic value added created during the production process. The backward participation, or

[6]The Lithuanian data only contain monthly trade values by product and partner country trade flow; volume or quantity data is imputed using Eurostat's Comext trade dataset by merging the price-level data at the 6-digit HS product code, partner country and trade flow direction level with the values in the trade dataset.

[7]We calculate the unit value, which is our proxy for prices, for the firm and the partner country level by aggregating the unit values at the firm, product and partner country level. In doing so we use the modified Laspeyres price index:

$$UV_{i,c,t} = \frac{\sum_p P_{i,c,p,t} \cdot Q_{i,c,p,0}}{\sum_p P_{i,c,p,0} \cdot Q_{i,c,p,0}} = \sum_{p \in I_{i,c,t}} \frac{P_{i,c,p,t}}{P_{i,c,p,0}} \cdot \frac{Value_{i,c,p,0}}{\sum_{p \in I_{i,c,t}} Value_{i,c,p,0}},$$

where $UV_{i,c,t}$ stands for the unit value of the trade flow of firm i to/from partner country c in month t, $P_{i,c,p,t}$ denotes the unit value at the firm, product (p) and partner country level in month t, and $P_{i,c,p,0}$ corresponds to the disaggregated unit value in the base period, defined as the average unit value in 2019–2020. $Q_{i,c,p,0}$ denotes the quantities in kg or other units of measurements, and $Value_{i,c,p,0}$ is the value in euros. We use the broadly based period instead of a particular month since the product composition of the trade flows of firms changes substantially from one month to another. For the same reason the calculations only use the set of products ($I_{i,c,t}$) that were exported to or imported from the country concerned in month t. By following this approach we solve the problem that arises from the use of different units of measurements for different products in trade statistics. We also account for the differences in value per unit across products, as the weights are determined by trade values in euros. The usual caveats of unit values should be taken into account, especially given that we defined products at the HS six-digit levels and structural changes may occur in trade flows within a six-digit code. Equally, the Laspeyres price index does not account for the changes in six-digit HS product composition over time.

[8]Source: Eurostat table NAMA 10 GDP.

foreign value added as a share of gross exports, is large and accounts for 32% in Lithuania, 26% in Latvia, and 35% in Estonia, while the forward participation, or the domestic value added in foreign exports, is more modest and stands at 26% in Lithuania and 24% in Estonia and Latvia[9].

Table 1: Descriptive statistics of trade margins, manufacturing and trade in 2019-2020

	Lithuania		Latvia		Estonia	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
Imports	no. of flows: 45 204		no. of flows: 23 390		no. of flows: 28 581	
Value of trade flow, th. EUR	51.4	955.2	46.9	340.7	40.0	287.9
No. of products per destination	3.8	13.4	3.9	14.4	4.0	15.3
Mean value per product	23.0	480.3	19.6	96.9	16.2	84.1
Imports	no. of firms: 8 543		no. of firms: 3 519		no. of firms: 6 058	
No. of products per firm	11.6	33.6	14.6	41.1	11.5	35.5
No. of destinations per firm	2.8	3.3	3.5	3.5	2.6	3.1
Exports	no. of flows: 33 312		no. of flows: 21 419		no. of flows: 17 366	
Value of trade flow, th. EUR	74.0	632.6	60.3	340.8	67.8	337.9
No. of products per destination	3.1	11.6	3.1	12.1	3.0	9.3
Mean value per product	45.4	456.9	39.0	263.6	41.8	253.8
Exports	no. of firms: 7 084		no. of firms: 4 207		no. of firms: 3 653	
No. of products per firm	6.3	21.2	6.5	23.9	6.2	17.8
No. of destinations per firm	2.7	3.9	2.6	3.7	2.5	3.2

Notes: The table reports unweighted descriptive statistics at the firm-destination or firm level. The database is collapsed to the average of each object over the whole timespan at the firm-destination level or at the firm level and the descriptive statistics are then derived from these collapsed data.
Source: Authors' calculations from administrative data.

Our sample countries are strongly engaged in foreign trade, but the value chain they participate in is very regional, because their trade is highly concentrated in neighbouring countries and the goods are rarely traded across continents. Tables A.2 and A.3 present the ten largest import and export partners for Lithuania, Latvia and Estonia. Roughly 70% of imports and exports come from the ten largest trade partners and goods are mostly traded at distances of around 1000 kilometres, and transportation between these partners should not take longer than a couple of days.

Transportation to more distant partners is done by sea or air, so the main mode of transport to China and Canada is sea[10] and transportation takes six weeks to China and four weeks to Canada[11]. The main mode of transportation used from Lithuania to the US is air, and the time needed for this is again measured in days and not weeks. These modes of transport are relevant for our methodological specification and provide an indication of how long it takes for shocks to be transmitted between countries. Because the more distant trade partners have a very small role in

[9]Source: OECD TiVa database tables DEXFVAPSH and FEXFVAPSH for 2020.
[10]Source: Extra-EU transportation mode by Eurostat table DS_058213.
[11]Source: brlogistics.net

the economies of our sample countries, we will assume that the transmission of shocks occurs within a month.

3 Methodology

The Covid-19 pandemic was similar to a natural disaster in many ways, most importantly because the shock was both exogenous and unexpected, at least in the first wave of the pandemic in early 2020. We consequently follow the literature on the transmission of shocks across countries after natural disasters (see e.g. Barrot and Sauvagnat 2016, Boehm et al. 2019, Carvalho et al. 2021). There are, however, two major notable differences between the Covid-19 pandemic and a natural disaster like an earthquake. The first is that Covid-19 did not happen at a single moment in time, but affected the economy over a prolonged period, with the intensity of the shock varying from one month to another. The second is that Covid-19 had a substantial impact on trade throughout the entire world, though the timing and the extent of the effect varied across countries, and to a lesser extent across products. Both these points make it harder to identify shocks from Covid-19 to international trade.

Instead of using a binary variable (like in e.g. Boehm et al. 2019), we identify the effect of shocks from Covid-19 to international trade following Bonadio et al. (2021), who derive a continuous treatment variable that captures restrictions at the country-level[12]. In a similar way to Bonadio et al. (2021), Amador et al. (2023), and Bricongne et al. (2022), we use the indicators for Covid-19 Government Response Stringency[13] collected by the University of Oxford (see Hale et al. 2021) to measure the magnitude of Covid-19 shocks across countries. An alternative would be to use formal activity reports from Google[14], while some papers use the Covid-19 incidence indicators for new cases or deaths reported by the WHO[15,16]. We choose to use the stringency indicators from the University of Oxford for our results because they give a better country coverage and comparability.

To relate the treatment variable to international trade and global value chains as closely as possible, we choose a sub-index of workplace closures as our measure of the Covid-19 shock. We

[12]Unlike Bonadio et al. (2021) we do not incorporate the dimension of working from home in our treatment variable. As our level of analysis is at the firm-partner level, the firm-partner fixed effects control for the cross-sectional difference in the product mix.

[13]See https://data.humdata.org/dataset/oxford-covid-19-government-response-tracker

[14]See https://www.google.com/covid19/mobility

[15]See https://www.who.int/emergencies/diseases/novel-coronavirus-2019

[16]Most of the papers test the robustness of their findings by switching from one shock measure to the other (Bas et al. 2023, Kejžar et al. 2022) and some also control for both the incidence of Covid-19 and lockdown policies simultaneously (Liu et al. 2022, Amador et al. 2023).

prefer the workplace closures index to the overall stringency index, since stringency covers many aspects of social distancing policies that are not related to work or international trade, such as limitations on gatherings or the cancellation of public events[17]. In addition, de Lucio et al. (2022) find that the workplace closures sub-index is the most tightly related of the eight sub-indexes to the decline in foreign trade.

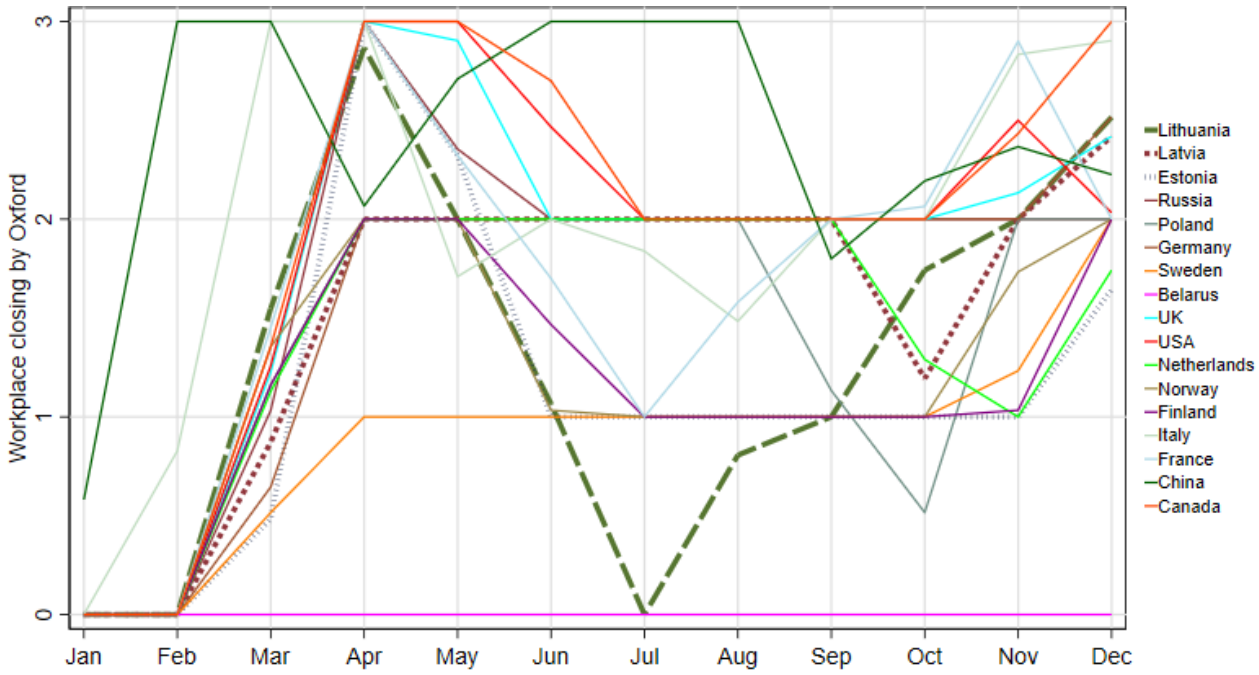
The workplace closures index takes values from 0 to 3, from no measures being applied to all workplaces except essential ones like food shops and doctor's surgeries being required to close or move to working from home. Figure 2 reports the workplace closures index in the Baltic States and in their ten largest trading partners as listed in Tables A.2 and A.3. There is a substantial degree of heterogeneity in the closure of workplaces across different trade partners, which was a consequence of both the different degrees of severity of the pandemic and the different policy responses applied. The peak of workplace closures was in April 2020, when almost all countries introduced their strictest restrictions on operating workplaces. These restrictions were loosened by the summer and imposed again at the end of 2020, though the second rise was much less synchronised across countries. It should be noted that the Covid-19 shock to trade was the strongest at the time of the first wave, and although there were many more confirmed cases and deaths at the end of 2020 during the second wave of Covid-19, trade flows did not react to that second wave (see also Figure 1).

Another important fact to note is the high degree of synchronisation between the policy responses in the countries of the Baltic and Northern Europe region with the exceptions of Sweden and Belarus. There was no formalised collaboration between the Baltic countries during the first wave of the pandemic beyond the coordination of cross-border movement in what was called the "Baltic Bubble", which opened the borders between the three Baltic countries before the EU internal borders were reopened. However, the policy responses in the Baltic countries shared many similarities in the first wave of the pandemic. The three countries did not introduce strict lockdowns during the pandemic and the social distancing measures applied were quite mild compared to those in other European countries. The instructions to work from home as much as possible were introduced for workplaces, but there were no enforced closures of any sectors other than the recreational sector. The first wave of the pandemic was also relatively mild in the number of Covid-19 cases and deaths in this region (Webb et al. 2022).

To exploit the variability in the workplace closures index across countries, we follow Amador

[17]China for example had very stringent containment measures for other social distancing but not for workplace closures.

Figure 2: Workplace closures in selected countries in 2020, Oxford Covid-19 Government Response Stringency index



Source: Authors' calculations using information from Oxford Covid-19 Government Response Stringency index, https://data.humdata.org/dataset/oxford-covid-19-government-response-tracker

et al. (2023) and use data at the firm-partner country level in our regression analysis[18]. We proceed with a difference-in-differences style approach to estimate how the closure of workplaces in partner countries affected the international trade of firms in Lithuania, Latvia and Estonia. Whether a firm chooses to engage in trade is modelled separately from the value of trade. The decision to engage in trade is estimated by the linear probability model using a balanced panel of trade flows, where the binary variable indicates whether any international trading took place during the given month in 2019–2020, where subscript i is the firm, c the partner country, and t the month. The value of trade is estimated using the sample of non-zero trade flows, where flows have been taken as logarithms ($\ln(Value_{i,c,t})$). We also study the channels through which Covid-19 affected international trade. The extensive and intensive margins of trade are first disentangled following the approach by Berthou and Fontagné (2013):

$$\frac{\partial \ln(Value_{i,c,t})}{\partial X_{c,t}} = \frac{\partial \ln(N_{i,c,t})}{\partial X_{c,t}} + \frac{\partial \ln(\bar{V}_{i,c,t})}{\partial X_{c,t}}, \tag{1}$$

[18]Some papers use an even finer firm-product-partner country level of analysis (see e.g. Bricongne et al. 2022, de Lucio et al. 2022). We do not go down to the product level because of the lack of variation in the Oxford Stringency Index across products.

where the total effect on the value of trade in euros, $Value_{i,c,t}$, is decomposed into two effects, one from the extensive margin, $N_{i,c,t}$, measured as the number of products going to each partner country, and one from the intensive margin, $\bar{V}_{i,c,t}$, measured as the average trade flow for each product in a given partner country. The subscript i is for the firm, c is for the partner country, and t is for the month, while $X_{c,t}$ denotes a workplace closures index that is either upstream in the partner countries from which the firm imports, or downstream in destination countries for exports.

The effect of Covid-19 on trade values can be decomposed not only into the intensive and extensive margin channels, but also into the price and quantity effects:

$$\frac{\partial \ln(Value_{i,c,t})}{\partial X_{c,t}} = \frac{\partial \ln(UV_{i,c,t})}{\partial X_{c,t}} + \frac{\partial \ln(Q_{i,c,t})}{\partial X_{c,t}}, \tag{2}$$

where $UV_{i,c,t}$ indicates the unit values, which is our proxy for the price of the trade flows, and $Q_{i,c,t}$ indicates the quantities. It may be noted however, that the unit values of exports and imports are calculated at the firm-partner country level and so do not account for changes in the product composition over time. This drawback should be kept in mind when interpreting the price and quantity channels.

We estimate separate specifications for imports and exports. The import equation covers all the firm-partner country pairs that had non-zero imports in 2019 and focuses only on the propagation of upstream Covid-19 shocks[19]. The effect on imports of upstream workplace closures is estimated as follows:

$$IM_{i,c,t} = \beta_1 Upstream_{c,t} + \beta_2 Local_{r,t} + \beta_3 \ln(Turnover_{s,t}) + \alpha_{i,c} + \epsilon_{i,c,t}, \tag{3}$$

where s is a sector at the NACE two-digit level, and r is a region[20]. The variable for merchandise imports, $IM_{i,c,t}$, is either a dummy variable showing whether the firm was importing from a given country in a given month, or the logarithm of the value of imports, the logarithm of the number of products imported at the six-digit HS level, the logarithm of the mean value of imports for each product, the logarithm of the unit values of imports, or the logarithm of the quantity of imports. The explanatory variables are $Upstream_{c,t}$, which indicates workplace closures at the partner country

[19]It is possible to restrict the sample to firms that simultaneously import and export. This would allow the effect on imports of downstream Covid-19 shocks from the export destination countries to be added. However, we lack information on which import flow is used in the production of a specific export flow. A weighted downstream stringency index would consequently need to be created for each firm and that measure would be highly correlated across all firms.

[20]There are 10 regions in Lithuania, six in Latvia and 15 in Estonia.

level, $Local_{r,t}$ for the number of Covid-19 cases per thousand inhabitants at the regional level in the firm's home country[21], $\ln(Turnover_{s,t})$ for the logarithm of sector turnover, which accounts for domestic, industry-specific shocks, $\alpha_{i,c}$ for the firm-partner country fixed effects, and $\epsilon_{i,c,t}$ as the error term with conventional properties. The upstream workplace closures in the country of origin are measured on a four-point scale by the Oxford Covid-19 Government Response Stringency index shown in Figure 1. We expect the value of the coefficient β_1 to be negative for all the specifications except the one for the unit values of imports, meaning that the closure of workplaces in the partner country has a negative effect on domestic imports.

The export equation studies the propagation of downstream Covid-19 shocks in the destination countries for exports, letting us focus on the sample of firm-destination country pairs for which exports were non-zero in 2019. Trade flows for exports depend on the downstream workplace closures:

$$\begin{aligned} EX_{i,c,t} =& \beta_1 Downstream_{c,t} + \beta_2 Local_{r,t} + \beta_3 \ln(Turnover_{s,t}) \\ &+ \beta_4 \ln(Imports_{i,c,t}) + \alpha_{i,c} + \epsilon_{i,c,t}, \end{aligned} \tag{4}$$

where $Downstream_{c,t}$ indicates the workplace closing in the destination country, and $Imports_{i,c,t}$ is a measure of world demand proxied by the index of the annual nominal imports of the top 50 importers for each six-digit HS product category, aggregated using the product weights in the firm-destination in 2019[22].The downstream workplace closures in the destination country are measured on a four-point scale by the Oxford Covid-19 Government Response Stringency index shown in Figure 1. $EX_{i,c,t}$, like in equation (3), denotes various variables for exports, either a dummy variable showing whether the firm was exporting to a given destination in a given month, or the logarithm of the value of exports, the logarithm of the number of products exported, the logarithm of the mean export value of each product, the logarithm of the unit values of exports, or the logarithm of the quantity of exports.

The baseline specifications of equations (3) and (4) do not contain time fixed effects (λ_t), though

[21]The workplace restrictions abroad are taken as a proxy for the Covid-19 shock abroad, and we would have preferred to use the same proxy for domestic restrictions. Unfortunately, the workplace closure measure from Oxford is reported at the level of the country and does not vary over regions. As there were occasionally massive differences across regions in how Covid-19 spread within the Baltic countries, mostly notably in Estonia, where there was a Covid-19 hotspot in the islands, we used the infection rate here in order to capture this variation.

[22]The 50 largest importers account for three quarters of global imports in 2020 and offer a good proxy for global demand product by product.

these are typically included in similar regressions (see e.g. Lafrogne-Joussier et al. 2023, Amador et al. 2023). This is largely because of the geographical scope of Baltic trade, which is mostly concentrated within the Baltic and Northern Europe region, though direct trade with China still plays a secondary role. This means we cannot follow the strategy of Lafrogne-Joussier et al. (2023), who focused on trade with China and drew on the fact that China faced Covid-19 and imposed restrictions earlier than other countries.[23] Although we define the upstream workplace closures in the import equation (3) and the downstream workplace closures in the export equation (4) at the firm-country level, there is not enough heterogeneity in the Oxford Stringency Index across countries, especially during the first wave. As a result, time fixed effects would account for the majority of the Covid-19 restrictions at once and so do not allow the effect to be identified properly.

In addition to estimating equations (3) and (4) in levels (like Lafrogne-Joussier et al. 2023, de Lucio et al. 2022), we check the robustness of our results by estimating similar difference-in-differences regressions for the logarithmic annual growth rates of the import and export variables in the spirit of Bricongne et al. (2022) and Amador et al. (2023). While the definitions of the variables for the upstream and downstream workplace closures remain unchanged, we transform the variable for sectoral turnover and global demand into logarithmic annual growth. The growth specification includes firm and country fixed effects separately, since the growth rate already excludes differences in the initial levels and in seasonality, so we only need to account for firm-specific and country-specific trends. The level equations are estimated for the data from 2019–2020, but the growth rate regressions are only estimated for 2020.

[23] Sweden was the only important partner of the Baltic countries that had fewer restrictions on workplaces than the other main trading partners during the first wave of Covid-19 (see Figure 2). Trade with Sweden also declined much less than that with other partners for Latvia and Lithuania, as the year-on-year decline in trade with Sweden was about half that with other trading partners in April 2020. The case of Estonia is, however, quite different to this, because the decline in trade with Sweden was larger than with other trading partners during this period. Estonian trade with Sweden is dominated by multinational companies and the ownership mix is probably behind this larger decline in trade. It has been shown that the trade of multinational companies declined more as a result of the Covid-19 shock than did that of domestically sourcing companies (Lebastard et al. 2023). This comparative case of the trade of the Baltic countries with Sweden also demonstrates the advantages and disadvantages of our identification strategy. There may be exceptions where the decline in trade was a result of bottlenecks in the value chain somewhere other than in the partner country, while in most cases the decline in trade was indeed related to the restrictions imposed in the partner country.

4 Results

4.1 Workplace closures and imports

We report the estimated effect of closures of upstream workplaces on imports in this subsection. Table 2 presents the results for the probability of a firm importing. These results capture the adjustment to the upstream closure of workplaces by the partner country margin. Upstream closures have a statistically significant negative effect on the probability of a firm importing in all countries. Increasing the index of upstream workplace closures by two units in a partner country, say from 0 to 2, which roughly corresponds to the average increase faced by Baltic importers in spring 2020, reduces the probability of importing from that particular destination by 0.4-2.8 percentage points. This effect is quite small and may point to the reluctance of firms to break ties with their trade partners despite the unprecedented restrictions. To the best of our knowledge we are the first to investigate the role of the firm-destination margin in the adjustment to the Covid-19 shock and to confirm the relevance of this partner margin in the adjustment. Local infections also have a mostly negative effect on imports, while the industry-level turnover is related positively to the probability of importing[24].

Table 2: The effect of workplace closures in supplier countries on the probability of importing, 2019–2020

	Lithuania	Latvia	Estonia
	(1)	(2)	(3)
$Upstream_{c,t}$	-0.002*	-0.011***	-0.014***
	(0.001)	(0.001)	(0.002)
$Local_{r,t}$	-0.002	-0.001***	-0.001
	(0.002)	(0.000)	(0.001)
$\ln(Turnover_{s,t})$	-0.001	0.058***	0.062***
	(0.002)	(0.011)	(0.014)
Firm FE			
Country FE			
Firm x Country FE	✓	✓	✓
No. of observations	1 085 045	557 352	679 266
R^2	0.001	0.005	0.006

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table 3 shows the same results for the value of imports conditional on imports being non-zero. These results capture the adjustment by the total value of imports if trade with the partner was not

[24]We perform a more formal contribution analysis for each adjustment margin and explanatory variable in Section 4.3.

interrupted. Workplace closures have a large negative and statistically significant effect on imports from the partner country, as an increase of two units in workplace closures reduces the flow of imports from the country affected by 14-20%. Unlike the effect on the probability of importing, this decline is sizeable and may reflect the prevalence of the intensive margin of adjustment. These numbers are in line with the aggregate decline in trade observed in the Baltics in Spring 2020 (see Figure 1). Our results are also similar to those estimated in the literature on the topic. Amador et al. (2023) estimate from Portuguese data that the effect of a change from no stringency to 75% stringency, which is the weighted average stringency in our data in April 2020, is a decline of 15 log points in imports, and Bricongne et al. (2022) find a very similar elasticity from French data, with a decline of around 15-18%. The study by de Lucio et al. (2022) using Spanish data finds that upstream workplace closures have no statistically significant effect on imports in the value margin. The relationship between import value and local cases of illness is also occasionally negative and statistically significant in our data, while the relationship with industry-level turnover is again strong and positive.

Table 3: The effect of workplace closures in supplier countries on the value of imports, 2019–2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$Upstream_{c,t}$	-0.098***	-0.070***	-0.091***
	(0.015)	(0.013)	(0.014)
$Local_{r,t}$	-0.020*	0.001	-0.012
	(0.011)	(0.004)	(0.008)
$\ln(Turnover_{s,t})$	1.078***	0.859***	0.895***
	(0.191)	(0.113)	(0.107)
Firm FE			
Country FE			
Firm x Country FE	✓	✓	✓
No. of observations	497 055	259 559	305 017
R^2	0.082	0.022	0.029

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

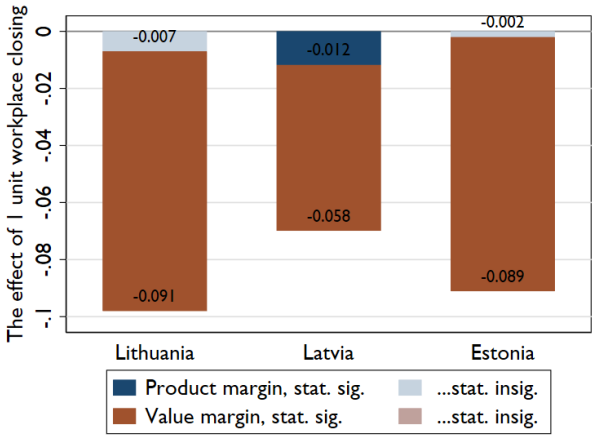
The effects may differ across industries because manufacturing and trading firms are different by nature; manufacturers mostly import the intermediate inputs used in their production processes, while trading companies import all kinds of goods including final use goods. We test the role of industry in our results by splitting the sample of importers in each Baltic country into manufacturing firms and trading firms, and we estimate the effect for each group separately. Table B.1 and Table B.2 in the Appendix present these estimates. The results are similar across sectors and

suggest that the pass through of the Covid-19 shock did not depend on whether the firm was engaged in producing goods or intermediating them.

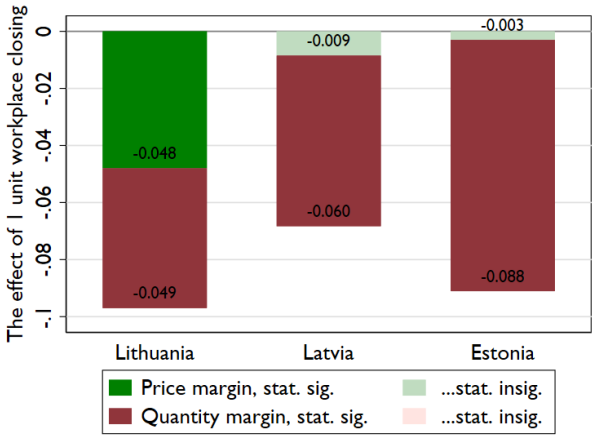
We go further in studying the impact of Covid-19 restrictions on trade and decompose the effect of upstream workplace closures on the value of imports into the extensive margin of the number of products traded, and the intensive margin of value per product traded. Figure 3 presents the results for all three Baltic States. Figure 3a shows that the intensive margin dominates the effect of upstream workplace closures on imports, while the number of products traded, or the extensive margin, shows only a small reaction to the Covid-19 restrictions. We observe from this that importers try to maintain the set of products imported from a given partner country despite the disruption to trade, and mostly adjust the amount of each product that is imported. These adjustment margins to Covid-19 shocks have not been investigated before, since Amador et al. (2023) and Bricongne et al. (2022) do not study the product margin, while de Lucio et al. (2022) conduct exit analysis for the products without disentangling the roles of the product and value margins.

Figure 3: The effect of workplace closures in supplier countries on the log of the value of imports with further decomposition, 2019–2020

(a) Extensive and intensive margins



(b) Unit values and volumes



Notes: The figures reflect the impact of upstream workplace closures on the logarithm of import values, and its further decomposition into the intensive and extensive margins and into price and quantity. The solid colour of the bar indicates statistical significance ($p < 0.1$). The estimations with standard errors can be found in Tables B.3 and B.4 in the Appendix.
Source: Authors' calculations from administrative data.

We similarly decompose the effect of workplace closures on the value of imports into the price and volume channels. Figure 3b shows that in most cases the adjustment occurred through the volumes traded, not adjustments in prices as proxied by unit values. Lithuania is a notable exception to this,

as adjustment through prices is also relevant, though this result is not confirmed by the robustness analysis in Table B.6.

The robustness of our findings is tested by the regressions for annual growth rates, and the results are reported in Tables B.5 and B.6 in the Appendix. The results remain qualitatively unchanged, as upstream closures reduce the value of imports to a degree that is statistically and economically significant. An increase from 0 to 2 in the workplace closures in the partner country is related to a reduction of 11-16% in imports, meaning the effect is very close in size to our baseline estimates. The adjustment mainly comes through the reduced value of imports of each product at the intensive margin and through quantities and not prices.

4.2 Workplace closures and exports

We next present the results on downstream workplace closures and exports, keeping the same structure as in the previous section. Table 4 shows how the workplace closures in a destination country affect the probability of a firm exporting to that destination. The effect on the probability of the firm trading is again stronger and statistically significant in Latvia and Estonia, while it is weaker for Lithuania. Increasing the workplace closure restrictions by two units reduces the probability of a firm exporting to that destination by up to 3.8 percentage points, which points to the willingness of exporters to maintain their ties to their partners. Although this adjustment margin of firms is economically significant, it has again to the best of our knowledge been overlooked by studies of the Covid-19 shock to trade. Local infections have less of a limiting role for exporting than they had for importing, while the results for the demand proxy show a positive relationship with turnover at the domestic industry level, but not with global demand.

Table 5 adds to the previous result by reporting the effect of downstream closures on the value traded. Like with imports, we find that restrictions in trading partners are strongly and statistically significantly related to the values traded in all the sample countries and sectors. An increase of two units in workplace restrictions in a destination country is related to values exported to that destination being 9-21% lower, pointing to export values declining substantially without trading ties being broken completely. Again, the elasticities estimated in the literature are in the same range, as a shock of the same size corresponds to a decline in exports of 7% in de Lucio et al. (2022), 15% in Amador et al. (2023), and 44% in Bricongne et al. (2022). We find no evidence of local infections affecting exporting, which is somewhat different to the case with imports, where

the effect of local infections on imports was occasionally statistically significant. Like for imports, the demand component is highly important for exports, and both domestic and global activity are strongly and positively related to the value exported. The results are again very similar for the manufacturing and trade sectors; see Tables C.1 and C.2 in the Appendix.

Table 4: The effect of workplace closures in destination countries on the probability of a firm exporting, 2019–2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$Downstream_{c,t}$	-0.000	-0.019***	-0.018***
	(0.000)	(0.002)	(0.003)
$Local_{r,t}$	-0.001	-0.001*	0.001
	(0.001)	(0.001)	(0.002)
$\ln(Turnover_{s,t})$	0.019	0.064***	0.041***
	(0.018)	(0.011)	(0.011)
$\ln(Imports_{i,c,t})$	-0.019	0.052	0.013
	(0.018)	(0.035)	(0.037)
Firm FE			
Country FE			
Firm x Country FE	✓	✓	✓
No. of observations	916 334	508 104	412 536
R^2	0.000	0.009	0.006

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

The results of the decomposition of value into the extensive margin for products and the intensive margin for value per product, and into prices and quantities are presented in Figure 4. Like with imports, we confirm that the most important adjustment margin in the response to disruptions to trade driven by the Covid-19 restrictions was value per product or the intensive margin, while the number of products traded in a destination country played a smaller role. This may indicate that firms tried to maintain their niche export markets in order to ease their return to those markets after the removal of restrictions.

Again we observe that the adjustment is dominated by quantities, which is in line with the findings of de Lucio et al. (2022). They conduct their analysis at a more disaggregated level than we do, taking the firm-partner-product level, with products defined at the very detailed six-digit HS level. Their approach effectively controls for composition effects, while our approach derives a price index at the firm-partner level and confirms their findings. However, in contrast to de Lucio et al. (2022) we find that the adjustment through a decline in prices is not negligible, which is in line with economic fundamentals since restrictions in a destination put pressure on producers to cut prices. The price margin is more important for the downstream restrictions or exports than it was

for the upstream restrictions or imports, suggesting that prices may adjust differently to demand and supply shocks. These results are in line with the findings on natural disasters, as they show that the adjustment to supply shocks takes place only through quantity and not through prices (Boehm et al. 2019).

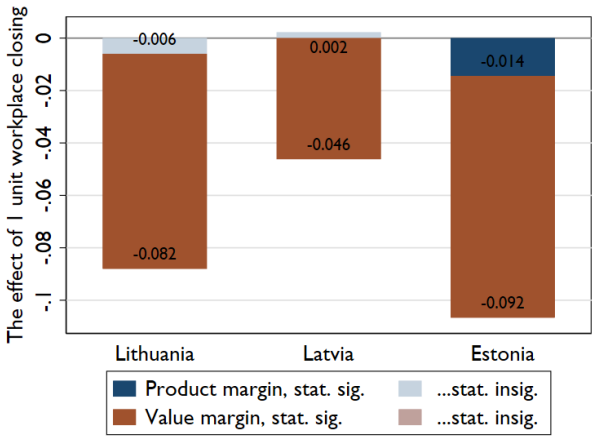
Table 5: The effect of workplace closures in destination countries on the value of exports, 2019–2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$Downstream_{c,t}$	-0.088***	-0.044***	-0.107***
	(0.018)	(0.008)	(0.029)
$Local_{r,t}$	-0.010	0.0002	-0.009
	(0.019)	(0.002)	(0.013)
$\ln(Turnover_{s,t})$	0.818***	0.838***	0.708***
	(0.129)	(0.067)	(0.076)
$\ln(Imports_{i,c,t})$	0.873***	0.425***	0.873*
	(0.274)	(0.120)	(0.469)
Firm FE			
Country FE			
Firm x Country FE	✓	✓	✓
No. of observations	389 152	216 661	184 257
R^2	0.078	0.022	0.033

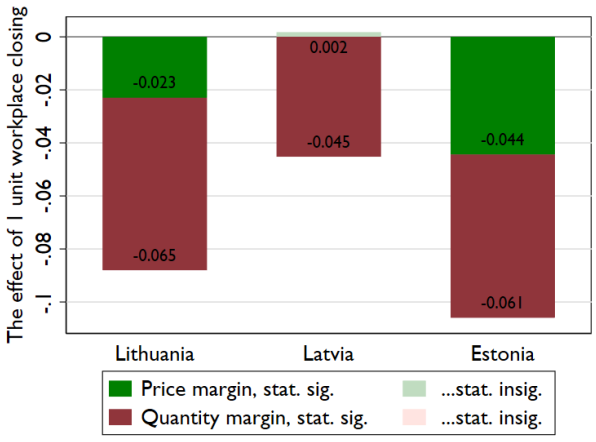
Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Figure 4: The effect of workplace closures in destination countries on the log of the value of exports with further decomposition, 2019–2020

(a) Extensive and intensive margins



(b) Unit values and volumes



Notes: The figures reflect the impact of downstream workplace closures on the logarithm of export values, and its further decomposition into the intensive and extensive margins and into price and quantity. The solid colour of the bar indicates statistical significance ($p < 0.1$). The estimations with standard errors can be found in Tables C.3 and C.4 in the Appendix.
Source: Authors' calculations from administrative data.

The robustness of our baseline estimates is tested on the specification with yearly growth rates;

see Tables C.5 and C.6 in the Appendix. The size of the effect of workplace closures on the value of exports is of a similar magnitude to that in our baseline specification, as an increase in downstream restrictions of two units is related to a decline of 10-17% in exports. The conclusions about the dominant adjustment margins remain broadly unchanged, and we confirm that the price margin is a more important adjustment channel for downstream shocks than for upstream shocks.

4.3 Contribution analysis

We seek in this subsection to understand the economic size of the effects estimated by assigning monetary values to them. To do this, we derive the role of each explanatory variable in the decline in trade during the first wave of the pandemic. Table 6 provides the details of this calculation. We use the coefficients from Tables 2 and 3 as the response of firms to shocks upstream, and the coefficients from Table 4 and 5 as their response to shocks downstream. We then assign a change in the explanatory variables so that they reflect the average developments from April 2019 to April 2020. These changes include an average increase in the workplace closures indicator of two points, an average increase in local Covid cases of 0.5 per thousand inhabitants, a decline in industry-level demand of 20 log points for imports and 14 log points for exports, and a decline in world demand for exported products of 4 log points. The resulting effects are converted into monetary value using the size of the average trade flows reported in Table 1. To find the partner country margin we multiply the effects by the number of flows and by the average value traded with each destination, and to find the value per partner margin we multiply the effects by the average value traded.

The results indicate that the extensive margin for the partner country adjustment quantified by the regression for the probability of trading was clearly the least important channel for adjustment to Covid-19 shocks, as only 10% of the decline in trade came from this margin in Latvia and Estonia and much less in Lithuania; see the total country margin and the total value margin in Table 6. The main margin for adjustment was the decline in the value traded with each destination, which accounts for approximately 90% of the decline in trade. The most important drivers of the decline in trade were demand and workplace closures in trading partners, while local infections had a negligible role, as shown by the size of the effect for the explanatory variables. The demand component was slightly more important than workplace closures, which is in line with findings from the literature (Berthou and Stumpner 2022) and confirms that demand was affected more by the restrictions than production was.

Table 6: The economic size of the effect, differences between April 2019 and April 2020, million euros

	Imports			Exports		
	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia
	(1)	(2)	(3)	(4)	(5)	(6)
	Partner country margin (probability of trading)					
2p ↑ in workplace closures	-3.2	-24.1	-32.0	-5.4	-49.1	-42.4
0.5 cases ↑ in local infections	-0.4	-0.5	-0.6	0.0	-0.6	0.6
20/14 log p ↓ in turnover	-5.1	-12.7	-14.2	1.8	-11.6	-6.8
4 log p ↓ in world demand	-	-	-	-0.2	-2.7	-0.6
Total country margin in mil EUR	-8.7	-37.4	-46.8	-3.7	-64.0	-49.2
Total country margin in %	-0.3	-3.4	-4.1	-0.2	-5.0	-4.2
	Value per partner margin (value of trade)					
2p ↑ in workplace closures	-446.9	-153.6	-208.1	-438.4	-113.7	-252.0
0.5 cases ↑ in local infections	0.0	0.5	-6.9	-3.0	0.1	-5.3
20/14 log p ↓ in turnover	-523.0	-188.5	-204.6	-294.6	-151.5	-116.7
4 log p ↓ in world demand	-	-	-	-74.8	-22.0	-41.1
Total value margin in mil EUR	-969.9	-341.5	-419.6	-810.8	-287.0	-415.1
Total value margin in %	-41.7	-31.1	-36.7	-32.9	-22.2	-35.3

Notes: The size of the effect is estimated using the coefficients for the partner margin from Table 2 and Table 4 and for values traded from Table 3 and Table 5. The size of the shock in the explanatory variables is set so that it meets the average developments in the explanatory variables from April 2019 to April 2020. The decline in EUR is estimated in terms of the average monthly trade flows in 2019-2020 reported in Table 1.
Source: Authors' calculations from administrative data.

The estimates made from French and Spanish data indicate that downstream restrictions had a substantially larger effect on exports than upstream restrictions did on imports. Bricongne et al. (2022) find the effect of restrictions to be twice as large for exports as for imports, while de Lucio et al. (2022) find that the restrictions only had an effect from downstream closures and only on exports, and that imports were not affected by upstream restrictions. Contrary to this, our results suggest that the effects of upstream and downstream closures were quite equal in size with only a slightly stronger effect from downstream closures on exports, which is very similar to the estimates of Amador et al. (2023) using Portuguese data. However, like the literature on firm-level estimates, we do not disentangle the second round effects and capture only the direct effect from upstream or downstream partners.

4.4 Product heterogeneity

Trade relationships are usually sticky, and more so for non-homogeneous products that are difficult to replace. Antràs (2020) shows that global value chains are sticky because engaging in international activities involves sunk costs for firms. He argues that sticky relationships were the reason why trade adjusted through the intensive margin and not the extensive margin during the Great Recession. Firms adjusting through the value traded without breaking their trade links also allowed trade to

recover quickly after the shock. Our evidence on how trade adjusted to the Covid-19 shock shows a very similar pattern to that found during the Great Recession.

We study how firms adjusted through the heterogeneity of their imported or exported products in this subsection. We follow the classification of differentiated products of Rauch (1999) and split the firm-destination trade flows into three categories for goods traded on an organised exchange, reference priced products, and differentiated products[25]. The products traded on an organised exchange are homogeneous products that are easy to replace following trade shocks, while reference priced products are more difficult to replace, and differentiated products are the most difficult to replace following trade shocks. We follow the conservative version of the classification suggested by Rauch (1999), under which more than half of the value traded came from differentiated products[26].

The results for the effect of workplace closures on imports and exports and by product differentiation are presented in Table 7. Each coefficient in the table reports the results of a separate regression and the effect of workplace closures on trade; the rest of the coefficients are not reported. The firm-destination trade flows are split into three by product category and equations 3 and 4 are estimated separately for each product category.

Table 7: The reaction to Covid-19 restrictions by product differentiation

	Imports			Exports		
	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia
	(1)	(2)	(3)	(4)	(5)	(6)
	Partner country margin (probability to trade)					
Organised exchange	0.002	-0.006	-0.0003	-0.001	-0.004***	-0.003
	(0.003)	(0.006)	(0.002)	(0.001)	(0.001)	(0.003)
Reference priced	-0.006***	-0.009**	-0.001	-0.002	-0.008***	-0.004
	(0.002)	(0.004)	(0.006)	(0.005)	(0.002)	(0.004)
Differentiated products	-0.018***	0.000	-0.004	-0.007*	-0.011***	-0.010***
	(0.006)	(0.007)	(0.007)	(0.004)	(0.002)	(0.002)
	Value per partner margin (value of trade)					
Organised exchange	-0.047	0.004	0.009	-0.046*	-0.065	-0.038
	(0.031)	(0.037)	(0.060)	(0.027)	(0.045)	(0.055)
Reference priced	-0.040***	-0.082**	-0.004	-0.023	-0.063***	-0.086***
	(0.013)	(0.022)	(0.026)	(0.036)	(0.018)	(0.033)
Differentiated products	-0.138	-0.087***	-0.098***	-0.060***	-0.047***	-0.103***
	(0.097)	(0.028)	(0.016)	(0.017)	(0.013)	(0.034)

Notes: Product differentiation follows the classification suggested by Rauch (1999) in its conservative version.
Source: Authors' calculations from administrative data.

[25]The SITC rev. 3 classification used is from https://econweb.ucsd.edu/~jrauch/rauch_classification.html, which allows us to match roughly 80% of our SITC products in the sample.

[26]Differentiated products accounted for 69% of the value imported, reference priced products for 26%, and products on an organised exchange for 5% in 2019. Similar proportions hold for exports, as differentiated products accounted for 68% of value exported, reference priced for 26% and products on an organised exchange for 7%.

It is found that differentiated products reacted most strongly to the Covid-19 restrictions in partner countries, and reference priced products were occasionally also traded less because of the restrictions. The most homogeneous category of organised exchange products did not show any reaction to the upstream Covid-19 restrictions. These were not the most homogeneous products, whose trade links broke or for which trade declined due to workplace restrictions, but the products that are taken as the stickiest or the most difficult to replace; this regularity holds for the restrictions both upstream and downstream. This may indicate that workplace closures did not affect trade in homogenous products, as partner firms could be replaced in the market, while workplace closures evidently affected trade in non-homogeneous products that are difficult to replace, because partner firms were difficult to replace in the market.

The robustness of these findings is tested with the alternative trade relationship stickiness indicator of Martin et al. (2023). This indicator uses business-to-business relationships in international trade to derive product stickiness, where products with a longer business-to-business relationship are taken as indicating sticky relationships. We find within differentiated products that the relationships with the shortest duration were the most likely to break during the pandemic, which is in line with Bas et al. (2023). The results are shown in Figures D.1, D.2, E.1 and E.2. However, there is no evidence that there was a systematic interruption of trade linkages by product duration within the group of products that are homogeneous or traded in organised exchange. Our results consequently suggest that the majority of the adjustment to trade shocks took place within those products that are difficult to replace and that usually have a business-to-business relationship of short duration. This also shows that product homogeneity and the duration of the business-to-business relationship do not necessarily capture the same attributes of product stickiness when the products are adjusting to workplace closures.

4.5 Firm heterogeneity

Lastly, we examine how firms of different size, productivity, and inventories adjust to trade shocks. How vulnerable a firm is to trade shocks depends on its characteristics, and there is evidence suggesting that larger firms were more exposed to lockdowns during the pandemic (Bricongne et al. 2022, Amador et al. 2023). This has been attributed to larger firms being more dependent on foreign GDP or having higher demand elasticity. Firm productivity is a significant driver for the entry into foreign markets of a firm or a product (Melitz 2003, Bernard et al. 2011). Structured management

practices, which are crucial components of firm productivity, facilitated the adjustment to the Covid-19 shock and helped firms introduce remote work (Schivardi et al. 2022). Adjusting inventories has been discussed as a potential strategy for firms needing to make their supply chains more resilient in response to the Covid-19 shock (Miroudot 2020), but there is little empirical evidence that piling up stocks was actually helpful in adjusting to the trade shocks in the pandemic. Table 8 summarises our findings across various dimensions of firm heterogeneity. The results for individual regressions can be found in the Appendix, and the table shows the overall direction of the relationship.

Table 8: The reaction to Covid-19 restrictions by firm characteristics

	Imports			Exports		
	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia
	(1)	(2)	(3)	(4)	(5)	(6)
	Partner country margin (probability of trading)					
Firm size by employment: micro, small, medium, large in 2019	↓	↓	↓	↓	↓	↓
Firm productivity quartiles in 2019 ↓	↓	↓	↓	↓	∼	
Finished products to turnover in 2019	↓	↓	∼	↓	↓	↓
Supplies to turnover in 2019	↓	∼	∼	↓	∼	↓
	Value per partner margin (value of trade)					
Firm size by employment: micro, small, medium, large in 2019	↑	↓	∼	↑	↓	∼
Firm productivity quartiles in 2019	↑	∼	↓	∼	∼	∼
Finished products to turnover in 2019	∼	∼	∼	∼	↓	↓
Supplies to turnover in 2019	↑	∼	∼	↑	∼	∼

Notes: ↓ denotes that the vulnerability to shocks declines with this firm characteristic, ↑ denotes that vulnerability to shocks increases with this firm characteristic, and ∼ indicates that the relationship is non-linear or statistically insignificant at the 10% level of significance.
Source: Authors' calculations from administrative data.

There are two important contributions to the literature on firm size and vulnerability to trade shocks here. The first is that we cannot confirm that larger firms are more responsive to trade shocks, as shown in Figures F.1 and G.1. There is a clear negative relationship between firm size and vulnerability to trade shocks at the destination or country margin as smaller firms are more likely to cease trading because of workplace closing than larger firms are. The evidence for the value traded or the intensive margin is mixed, as the results show both negative and positive relationships, but mostly show a statistically insignificant relationship. This intensive margin is a crucial adjustment factor that accounted for the majority of the decline in trade during the pandemic. The findings suggest that the vulnerability to trade shocks that comes from firm size may be country-specific[27].

[27]We acknowledge that our estimation strategy is also slightly different from those in related papers, as we explicitly

The second contribution is that we find the vulnerability to shocks by firm size to be very similar to the vulnerability to shocks by firm productivity, as shown in Figures F.2 and G.2. Firms with low productivity are much more likely to stop trading in the market after the introduction of restrictions than firms with high productivity are, while whether the relationship between restrictions and value traded is positive, negative or statistically significant depends on the country and whether the shock is upstream or downstream. A strong negative correlation between firm size and the probability of exit may indicate that there are fixed adjustment costs to shocks that are similar to the fixed entry costs in the Melitz (2003) model. Maintaining a supplier or a client during a lockdown might involve action at a site in a partner country, and keeping up such contacts or networks is much more costly in relative terms for smaller firms than for larger firms.

The results for inventories show that firms that had accumulated more finished products or supplies in 2019 were less sensitive to restrictions in 2020. This relationship is negative in most cases for the extensive, or country, margin. We ran these estimates separately for manufacturing and trading firms, because the operation of trading firms is less sensitive to intermediates. Table 8 shows the results for manufacturing, while the results for all the sectors are shown in Tables F.1, F.4, G.1 and G.4 in the Appendix. Accumulating inventories against unexpected shocks in the value chain is helpful, as indicated by the findings of Lafrogne-Joussier et al. (2023), and it is likely that firms will internalise this experience by accumulating more stocks in the future. Stock building can consequently be considered an effective strategy for improving the resilience of the supply chain.

5 Conclusions

Our paper estimates the effects of Covid-related restrictions on the imports and exports of firms in Lithuania, Latvia and Estonia, the three relatively similar, small, open economies in the Baltics. We use foreign trade data at the firm-partner country level at monthly frequency from January 2019 to December 2020, focusing on short-term adjustment to trade shocks.

We find that shocks in supplier countries affected imports immediately and substantially, and the same is observed for the impact on exports of shocks from customers. The majority of the adjustment to the shock occurred through a reduction in the average trade flows to each destination and for each product in a destination, or the intensive margin, and only to a smaller extent through a reduction in markets or in products per market, or the extensive margin. Adjusting through

control for demand and our measure of sensitivity to shocks addresses more narrowly shocks from workplace closure.

the intensive margin without breaking ties between trade partners was also the key mechanism for adjustment during the Great Recession, and it facilitated a fast recovery after that trade shock (Antràs 2020). The pattern and mechanisms for adjustment that we observe during the pandemic are very similar. Given that small firms and ones with low productivity were the most likely to lose partners because of the restrictions in partner countries, it may be expected that adjustment to the pandemic took longest and was most complicated for this segment of firms. Similarly, the decompositions indicate that the majority of the adjustment occurred through the quantities traded and not through prices, and this resembles the pattern of adjustment to trade disruptions caused by natural disasters (Boehm et al. 2019).

The upstream and downstream restrictions were found to be equally important for the decline in trade during the pandemic, like in Amador et al. (2023), and we do not find confirmation that downstream restrictions played the dominant role, in contrast to the findings of de Lucio et al. (2022) and Bricongne et al. (2022). Moreover, our quantification of the effects shows not only that restrictions were responsible for the decline in trade, but also that demand had a substantial and occasionally even larger effect than restrictions did.

We show that differentiated products or reference priced products under the Rauch (1999) classification, which are those that are more difficult to replace, react most strongly to trade shocks. This suggests that relationships with differentiated suppliers and customers are the key source of shock propagation in GVCs. These findings are in line with the estimates for adjustments after natural disasters, which find that specific inputs or inputs with low elasticity of substitution are the most difficult to replace, and shocks to these inputs propagate almost one-to-one to other suppliers and customers (Boehm et al. 2019, Barrot and Sauvagnat 2016). We show that the same holds for the shocks downstream, as differentiated products are also the most difficult to replace in export markets.

These results open the door for further analysis of how the Covid-19 pandemic affected trade. One avenue for further studies is how firms adjust to pandemics over the longer run. Initiatives have already been launched to re-shore products that face supply bottlenecks back to Europe, and this is in line with our results for how products that are difficult to replace adjust[28]. The longer-run adjustment of firms and other decision-makers to the resilience of GVCs is still ongoing, and it offers multiple avenues for further studies.

[28]See e.g. policy analysis for the European Parliament at https://www.europarl.europa.eu/RegData/etudes/STUD/2021/653626/EXPO_STU(2021)653626_EN.pdf.

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Appendices

A Descriptive statistics

Table A.1: Descriptive statistics of explanatory variables, manufacturing and trade in 2019-2020

	Lithuania		Latvia		Estonia	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
			Imports			
$Upstream_{c,t}$ in Apr 2020	2.234	0.678	2.366	0.678	2.253	0.612
$Local_{r,t}$ in Apr 2020	0.335	0.222	0.335	0.136	0.543	0.561
$\ln(Turnover_s)$ btw Apr 2020 & 2019	-0.181	0.179	-0.204	0.159	-0.181	0.151
Employment, FTE	127.1	556.9	103.0	464.0	81.7	237.4
Labour productivity, th. EUR	38.2	61.4	42.9	71.8	45.0	232.6
Finished products to turnover	0.108	0.311	0.040	0.123	0.010	0.036
Supplies to turnover	0.219	0.411	0.152	0.435	0.203	0.179
			Exports			
$Downstream_{c,t}$ in Apr 2020	2.209	0.750	2.432	0.671	2.164	0.609
$Local_{r,t}$ in Apr 2020	0.327	0.228	0.307	0.144	0.572	0.719
$\ln(Turnover_s)$ btw Apr 2020 & 2019	-0.182	0.213	-0.166	0.165	-0.153	0.178
Employment, FTE	137.8	393.4	80.9	186.5	91.8	168.3
Labour productivity, th. EUR	43.7	68.8	47.4	83.1	42.6	237.6
Finished products to turnover	0.175	0.380	0.056	0.257	0.021	0.051
Supplies to turnover	0.266	0.440	0.118	0.293	0.182	0.164

Notes: The table reports unweighted descriptive statistics at the firm-destination level and conditional on participation in trade.
$Upstream_{c,t}$ and $Downstream_{c,t}$ denote workplace closing by Covid-19 Government Response Stringency collected by the University of Oxford that takes values from 0 to 3, from no measures being applied to all workplaces except essential ones like food shops and doctor's surgeries being required to close or move to working from home. $Local_{r,t}$ denotes the number of Covid-19 cases per thousand inhabitants at the regional level.
Employment is measured as headcount, not as FTE for Lithuania.
Turnover is reported by the firms as the value of the goods and services sold.
Source: Authors' calculations from administrative data.

Table A.2: Ten largest import partners in 2019

	Lithuania		Latvia		Estonia	
	Import share	Distance, km	Import share	Distance, km	Import share	Distance, km
Russia	0.145	794	0.069	848	0.086	872
Poland	0.118	394	0.089	560	0.064	831
Germany	0.117	1273	0.111	1265	0.101	1421
Latvia	0.071	263			0.087	277
Netherlands	0.054	1371	0.040	1332	0.042	1459
Italy	0.049	1706	0.040	1870	0.025	2126
Sweden	0.037	677	0.033	442	0.094	378
Estonia	0.034	528	0.083	277		
France	0.033	1700				
China	0.029	6567			0.040	6372
Lithuania			0.169	263	0.097	528
Finland			0.040	358	0.126	81
Canada			0.035	6776		
Sum	0.687		0.708		0.761	
Weighted average		1131		1004		1003

Sources: Trade values Eurostat table DS_018995; distance between the most important cities CEPII data.

Table A.3: Ten largest export partners in 2019

	Lithuania		Latvia		Estonia	
	Export share	Distance, km	Export share	Distance, km	Export share	Distance, km
Russia	0.140	794	0.141	848	0.060	872
Latvia	0.095	263			0.091	277
Poland	0.079	394	0.034	560		
Germany	0.076	1273	0.068	1265	0.063	1421
Estonia	0.051	528	0.111	277		
Sweden	0.045	677	0.061	442	0.105	378
Belarus	0.039	170				
Great Britain	0.038	1730	0.052	1680		
USA	0.037	6956			0.068	6653
Netherlands	0.036	1371	0.025	1332	0.033	1459
Lithuania			0.158	263	0.061	528
Denmark			0.040	724	0.041	836
Norway			0.023	843	0.037	787
Finland					0.163	81
Sum	0.636		0.713		0.723	
Weighted average		1103		691		1128

Sources: Trade values Eurostat table DS_018995; distance between the most important cities CEPII data.

B Workplace closures and imports

Table B.1: The effect of workplace closures in supplier countries on the probability of importing by sector, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Upstream_{c,t}$	0.000	-0.001***	-0.012***	-0.010***	-0.007***	-0.017***
	(0.000)	(0.000)	(0.002)	(0.002)	(0.002)	(0.003)
$Local_{r,t}$	-0.001**	-0.000	-0.001**	-0.002***	-0.002	-0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.002)	(0.001)
$\ln(Turnover_{s,t})$	0.002	0.015***	0.041***	0.068***	0.032***	0.098***
	(0.001)	(0.004)	(0.013)	(0.015)	(0.010)	(0.028)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	313 502	725 386	175 716	381 636	229 554	449 712
R^2	0.001	0.000	0.004	0.006	0.003	0.009

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table B.2: The effect of workplace closures in supplier countries on the value of imports by sector, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Upstream_{c,t}$	-0.147***	-0.075***	-0.092***	-0.055***	-0.074***	-0.096***
	(0.026)	(0.013)	(0.023)	(0.015)	(0.028)	(0.014)
$Local_{r,t}$	-0.000	-0.000**	0.004	-0.001	-0.055***	0.004
	(0.000)	(0.000)	(0.003)	(0.004)	(0.018)	(0.008)
$\ln(Turnover_{s,t})$	0.949***	1.199***	0.438***	1.103***	0.692***	1.147***
	(0.217)	(0.184)	(0.085)	(0.148)	(0.118)	(0.198)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	143 427	344 315	75 986	183 573	101 642	203 375
R^2	0.152	0.030	0.014	0.026	0.034	0.031

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table B.3: The effect of workplace closures in supplier countries on the log of the value of imports with further decomposition into the extensive and intensive margins, 2019–2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$\ln(Value_{i,c,t})$	-0.098***	-0.070***	-0.091***
	(0.015)	(0.013)	(0.014)
$\ln(N_{i,c,t})$	-0.007	-0.012*	-0.002
	(0.005)	(0.006)	(0.008)
$\ln(\bar{V}_{i,c,t})$	-0.091***	-0.058***	-0.089***
	(0.017)	(0.015)	(0.016)
Firm FE			
Country FE			
Firm x Country FE	✓	✓	✓
No. of observations	497 055	259 559	305 017

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table B.4: The effect of workplace closures in supplier countries on the log of unit values and volumes of imports, 2019–2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$\ln(Value_{i,c,t})$	-0.098***	-0.070***	-0.091***
	(0.015)	(0.013)	(0.014)
$\ln(UV_{i,c,t})$	-0.048***	-0.008	-0.003
	(0.015)	(0.014)	(0.019)
$\ln(Q_{i,c,t})$	-0.049***	-0.060***	-0.088***
	(0.010)	(0.011)	(0.024)
Firm FE			
Country FE			
Firm x Country FE	✓	✓	✓
No. of observations	493 297	255 806	304 969

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table B.5: The effect of workplace closures in supplier countries on the annual log-change of the value of imports with further decomposition into the extensive and intensive margins, 2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$\ln(Value_{i,c,t}/Value_{i,c,t-12})$	-0.061***	-0.082***	-0.056***
	(0.011)	(0.016)	(0.015)
$\ln(N_{i,c,t}/N_{i,c,t-12})$	-0.089	-0.022**	-0.010
	(0.057)	(0.008)	(0.008)
$\ln(\bar{V}_{i,c,t}/\bar{V}_{i,c,t-12})$	0.029	-0.060***	-0.045***
	(0.055)	(0.018)	(0.014)
Firm FE	✓	✓	✓
Country FE	✓	✓	✓
Firm x Country FE			
No. of observations	338 971	92 522	108 135

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table B.6: The effect of workplace closures in supplier countries on the annual log growth of unit values and volumes of imports, 2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$\ln(Value_{i,c,t}/Value_{i,c,t-12})$	-0.061***	-0.082***	-0.056***
	(0.011)	(0.016)	(0.015)
$\ln(UV_{i,c,t}/UV_{i,c,t-12})$	0.023	-0.007	-0.003
	(0.026)	(0.011)	(0.020)
$\ln(Q_{i,c,t}/Q_{i,c,t-12})$	-0.084***	-0.073***	-0.053**
	(0.031)	(0.014)	(0.026)
Firm FE	✓	✓	✓
Country FE	✓	✓	✓
Firm x Country FE			
No. of observations	336 742	90 868	108 107

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

C Workplace closures and exports

Table C.1: The effect of workplace closures in destination countries on the probability of a firm exporting by sector, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Downstream_{c,t}$	0.000	-0.002***	-0.019**	-0.019***	-0.014***	-0.026***
	(0.000)	(0.001)	(0.002)	(0.004)	(0.002)	(0.007)
$Local_{r,t}$	-0.000	0.000	0.000	-0.002**	0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)	(0.003)
$\ln(Turnover_{s,t})$	0.004	-0.013	0.045***	0.095***	0.024***	0.082*
	(0.002)	(0.010)	(0.010)	(0.027)	(0.007)	(0.049)
$\ln(Imports_{i,c,t})$	-0.004	0.007*	0.016	0.079	-0.017	0.045
	(0.002)	(0.004)	(0.039)	(0.058)	(0.031)	(0.085)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	398 950	473 358	234 000	274 104	227 394	185 142
R^2	0.000	0.000	0.008	0.011	0.04	0.011

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table C.2: The effect of workplace closures in destination countries on the value of exports by sector, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Downstream_{c,t}$	-0.086***	-0.092***	-0.038***	-0.055***	-0.111***	-0.099***
	(0.025)	(0.015)	(0.009)	(0.013)	(0.039)	(0.034)
$Local_{r,t}$	-0.001	-0.004	-0.001	0.002	-0.022	0.022
	(0.003)	(0.002)	(0.002)	(0.004)	(0.017)	(0.014)
$\ln(Turnover_{s,t})$	0.781***	0.930***	0.871***	0.730***	0.708***	0.812***
	(0.137)	(0.182)	(0.063)	(0.154)	(0.098)	(0.155)
$\ln(Imports_{i,c,t})$	0.978***	0.527***	0.348**	0.517***	1.030	0.484*
	(0.334)	(0.128)	(0.143)	(0.184)	(0.681)	(0.287)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	194 858	185 358	105 100	111 561	110 304	73 953
R^2	0.101	0.026	0.025	0.020	0.038	0.026

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table C.3: The effect of workplace closures in destination countries on the log of the value of exports with further decomposition into the extensive and intensive margins, 2019–2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$\ln(Value_{i,c,t})$	-0.088***	-0.044***	-0.107***
	(0.018)	(0.008)	(0.029)
$\ln(N_{i,c,t})$	-0.006	0.002	-0.014*
	(0.006)	(0.004)	(0.008)
$\ln(\bar{V}_{i,c,t})$	-0.082***	-0.046***	-0.092***
	(0.016)	(0.008)	(0.024)
Firm FE			
Country FE			
Firm x Country FE	✓	✓	✓
No. of observations	389 152	216 661	184 257

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table C.4: The effect of workplace closures in destination countries on the log of unit values and volumes of exports, 2019–2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$\ln(Value_{i,c,t})$	-0.088***	-0.044***	-0.107***
	(0.018)	(0.008)	(0.029)
$\ln(UV_{i,c,t})$	-0.023***	0.002	-0.044***
	(0.008)	(0.004)	(0.017)
$\ln(Q_{i,c,t})$	-0.065***	-0.045***	-0.061***
	(0.016)	(0.009)	(0.019)
Firm FE			
Country FE			
Firm x Country FE	✓	✓	✓
No. of observations	385 927	213 225	178 645

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table C.5: The effect of workplace closures in destination countries on the annual log growth of the value of exports with further decomposition into the extensive and intensive margins, 2020

	Lithuania (1)	Latvia (2)	Estonia (3)
$\ln(Value_{i,c,t}/Value_{i,c,t-12})$	-0.048**	-0.058***	-0.084***
	(0.022)	(0.011)	(0.018)
$\ln(N_{i,c,t}/N_{i,c,t-12})$	0.003	-0.013**	-0.024**
	(0.009)	(0.006)	(0.010)
$\ln(\bar{V}_{i,c,t}/\bar{V}_{i,c,t-12})$	-0.051**	-0.045***	-0.060***
	(0.024)	(0.011)	(0.019)
Firm FE	✓	✓	✓
Country FE	✓	✓	✓
Firm x Country FE			
No. of observations	264 692	74 469	65 309

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table C.6: The effect of workplace closures in destination countries on the annual log growth of unit values and volumes of exports, 2020

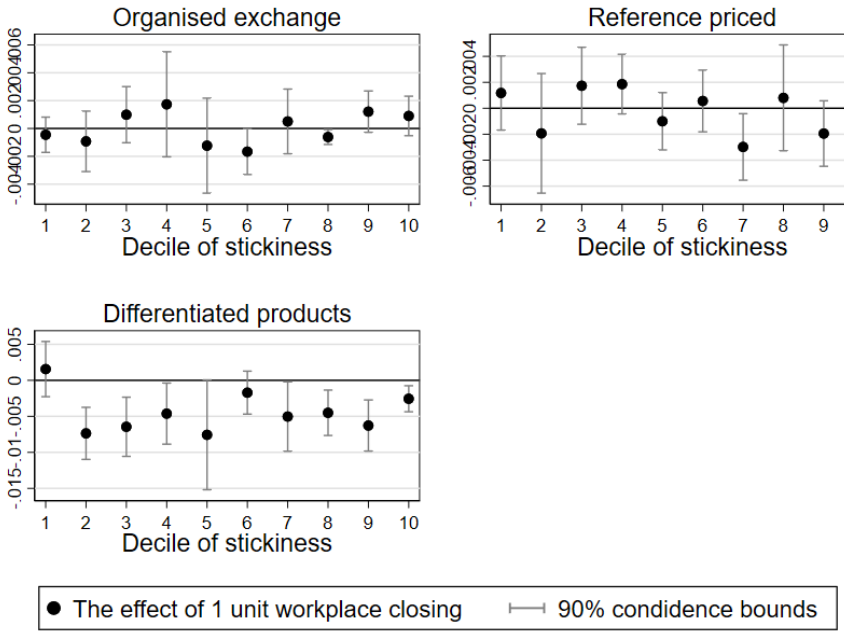
	Lithuania (1)	Latvia (2)	Estonia (3)
$\ln(Value_{i,c,t}/Value_{i,c,t-12})$	-0.048**	-0.058***	-0.084***
	(0.022)	(0.011)	(0.018)
$\ln(UV_{i,c,t}/UV_{i,c,t-12})$	-0.027**	0.006	-0.069***
	(0.011)	(0.005)	(0.020)
$\ln(Q_{i,c,t}/Q_{i,c,t-12})$	-0.021	-0.063***	-0.024
	(0.025)	(0.011)	(0.024)
Firm FE	✓	✓	✓
Country FE	✓	✓	✓
Firm x Country FE			
No. of observations	262 575	73 076	62 065

Notes: Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

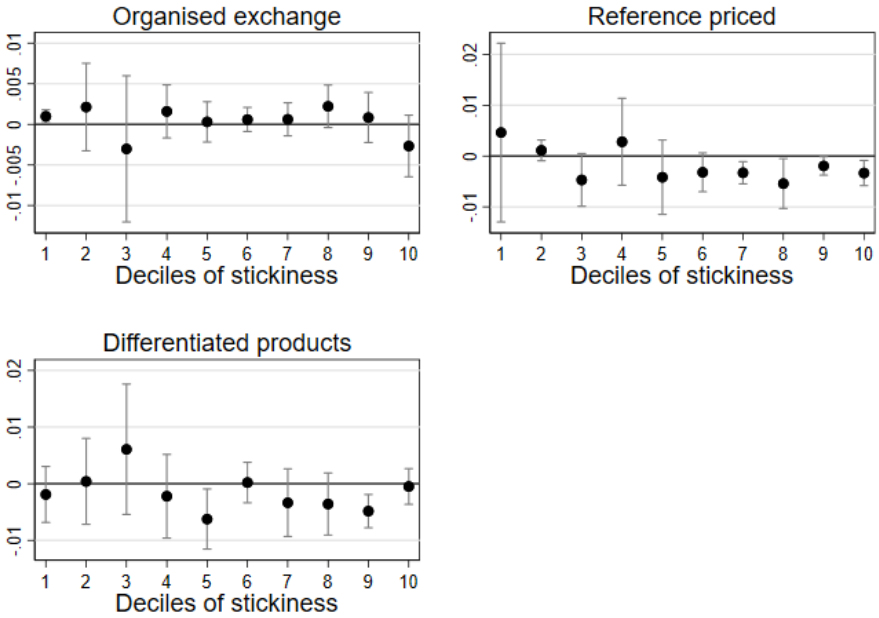
D Product heterogeneity and imports

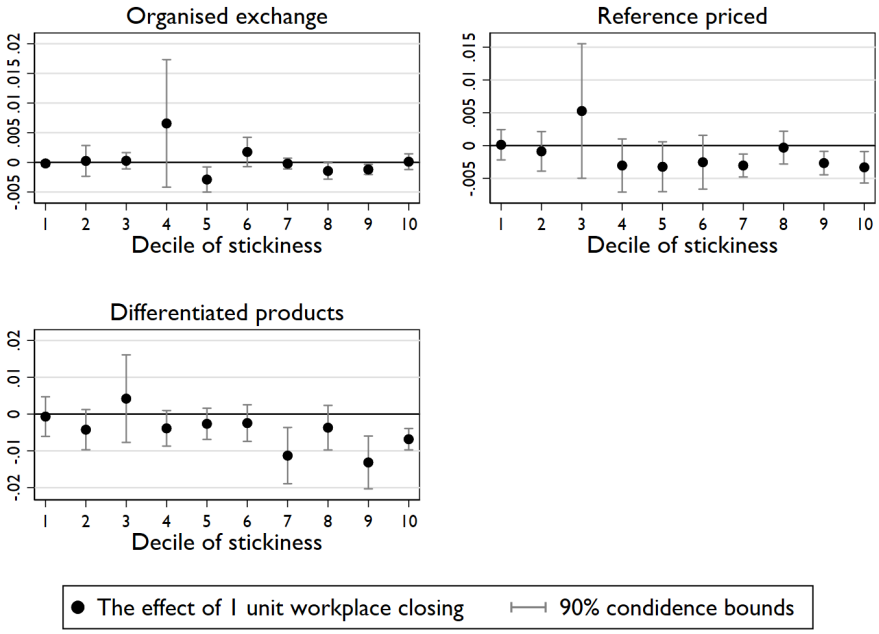
Figure D.1: The effect of workplace closures in supplier countries on the probability of importing by product homogeneity and duration, 2019–2020

(a) Lithuania, probability to import



(b) Latvia, probability to import



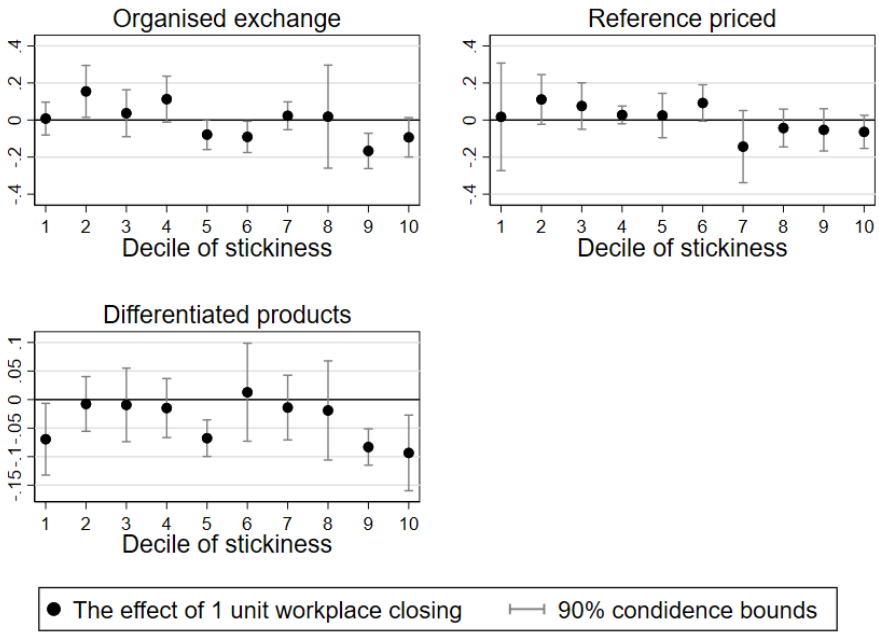


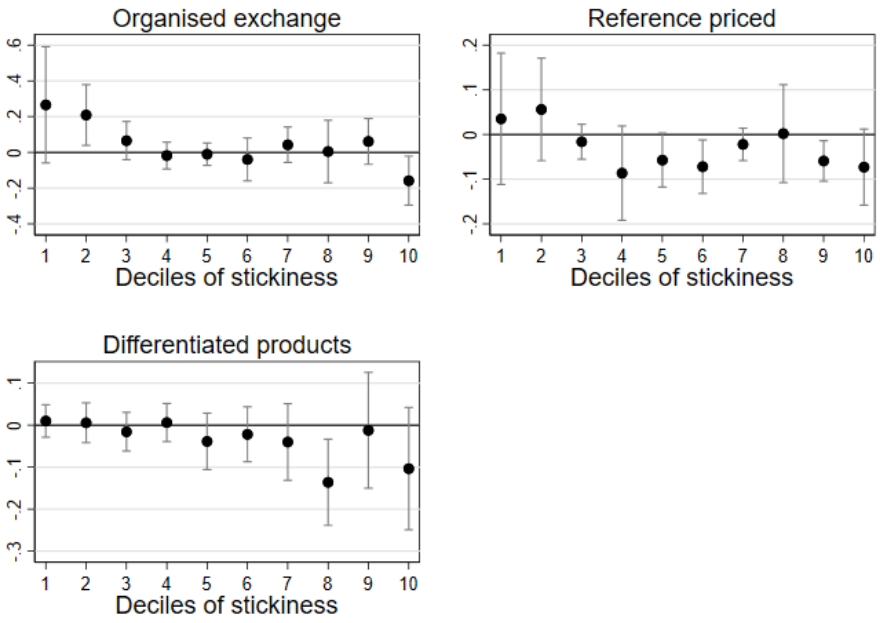
(c) Estonia, probability to import

Notes: The figures reflect the impact of upstream workplace closures on the probability of importing with 90% confidence bounds. The equation (3) is estimated by product homogeneity and product duration.
Source: Authors' calculations from administrative data.

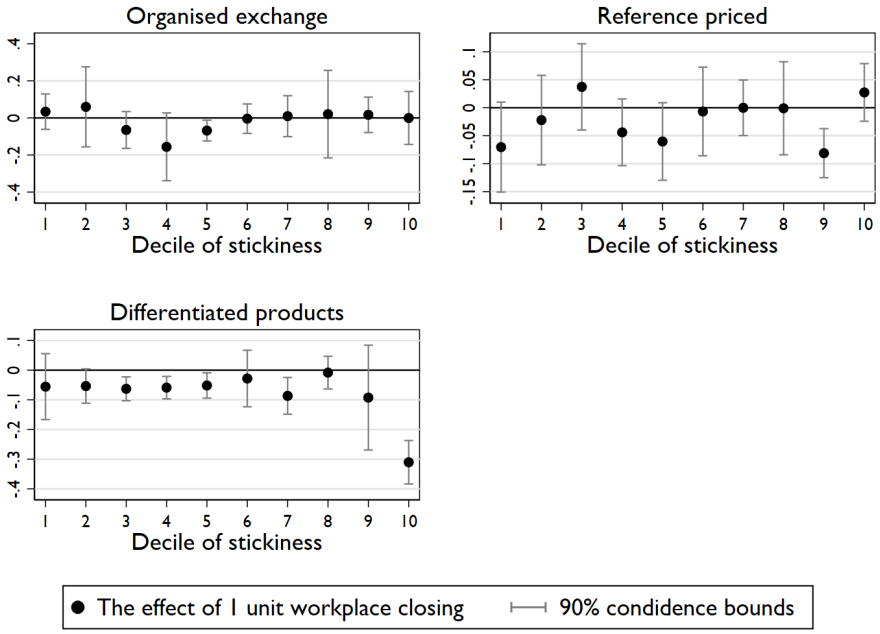
Figure D.2: The effect of workplace closures in supplier countries on the log of the value of imports by product homogeneity and duration, 2019–2020

(a) Lithuania, log of the value of imports





(b) Latvia, log of the value of imports



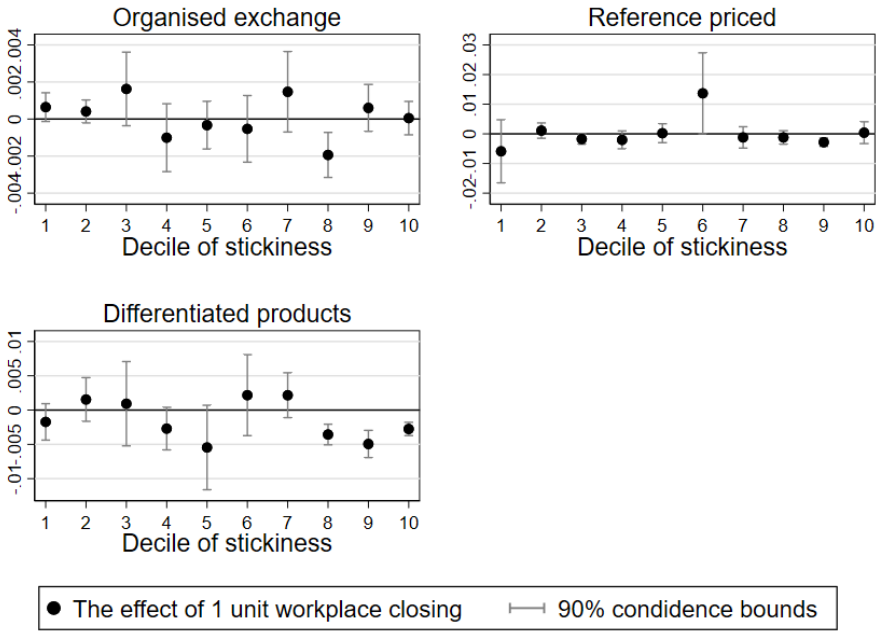
(c) Estonia, log of the value of imports

Notes: The figures reflect the impact of upstream workplace closures on the log of the value of imports with 90% confidence bounds. The equation (3) is estimated by product homogeneity and product duration.
Source: Authors' calculations from administrative data.

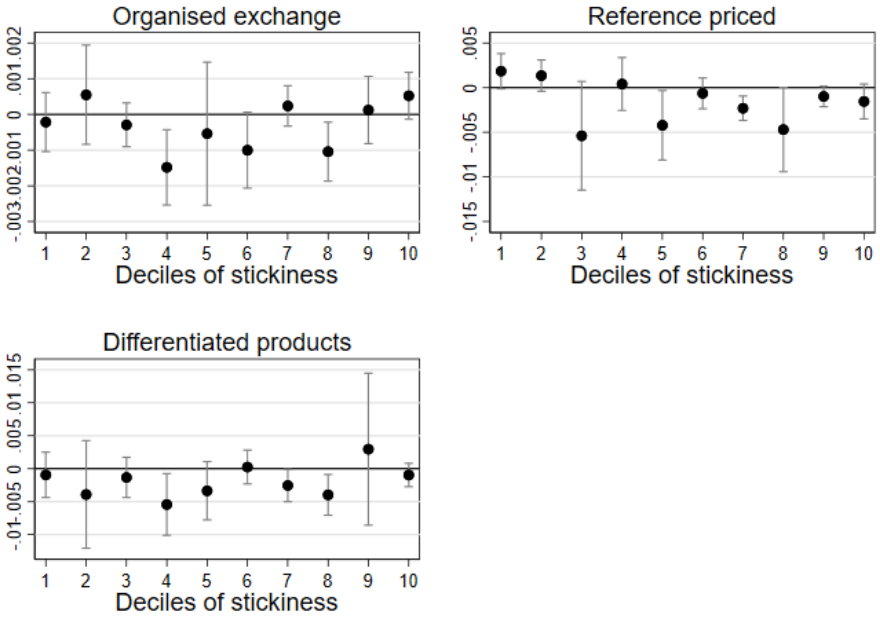
E Product heterogeneity and exports

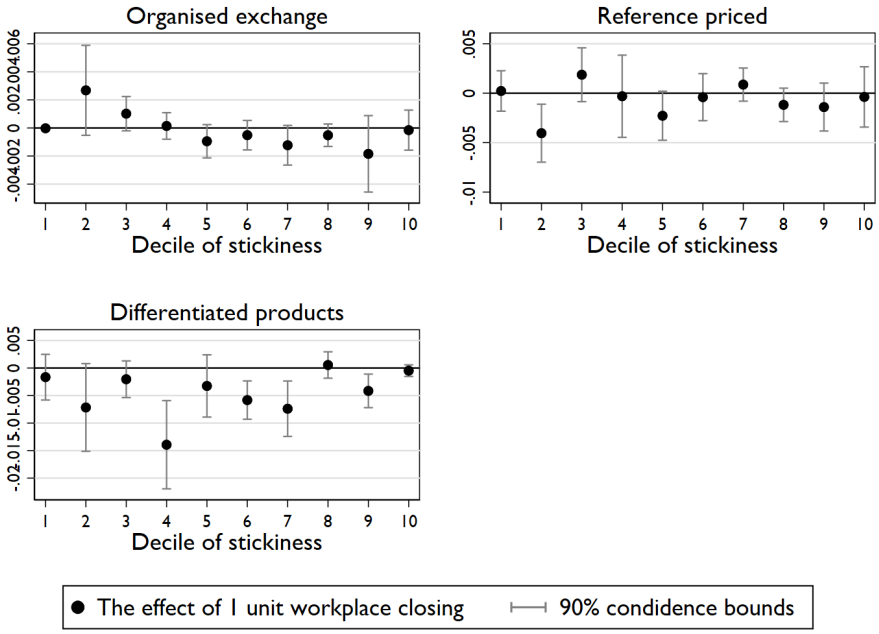
Figure E.1: The effect of workplace closures in destination countries on the probability of exporting by product homogeneity and duration, 2019–2020

(a) Lithuania, log of the value of imports



(b) Latvia, probability to export



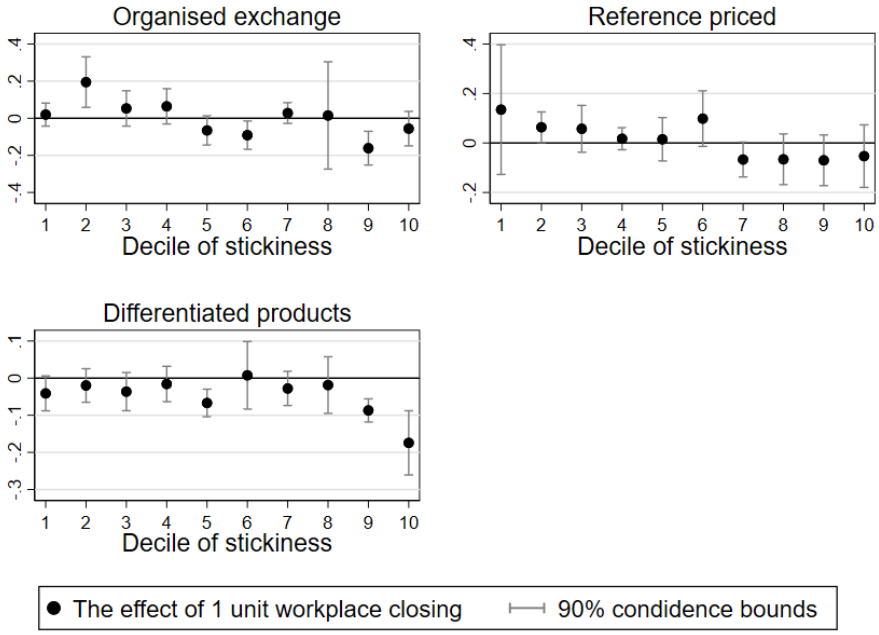


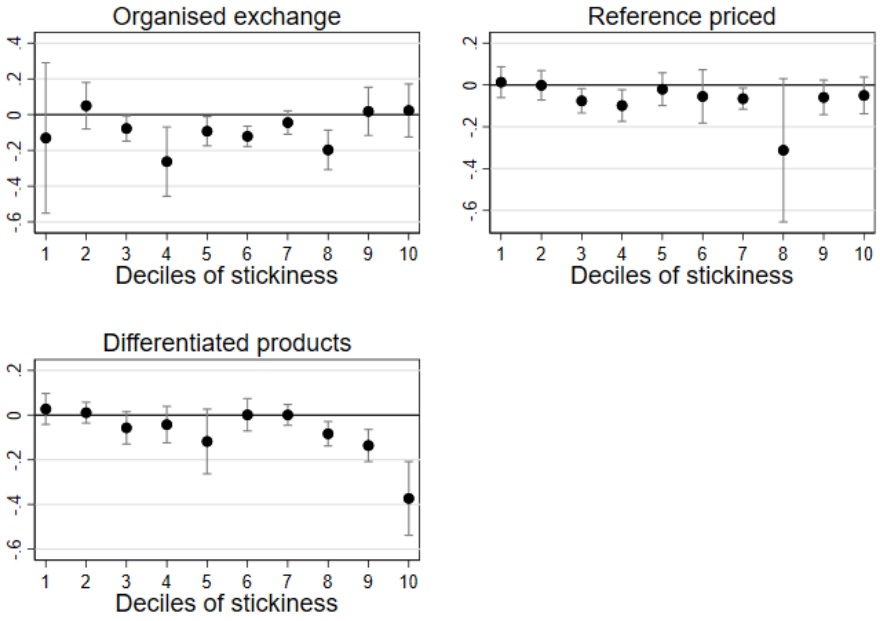
(c) Estonia, probability to export

Notes: The figures reflect the impact of downstream workplace closures on the probability of exporting with 90% confidence bounds. The equation (4) is estimated by product homogeneity and product duration.
Source: Authors' calculations from administrative data.

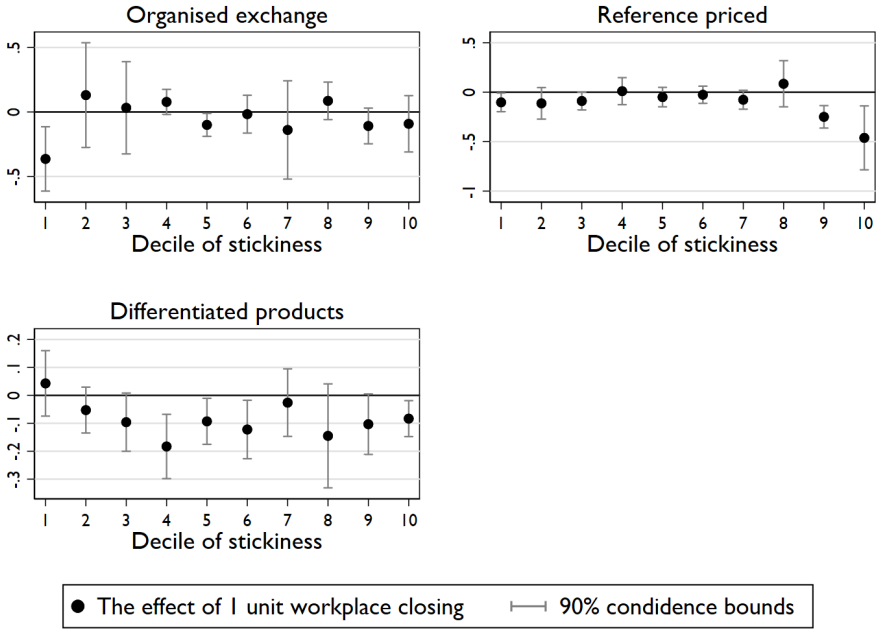
Figure E.2: The effect of workplace closures in destination countries on the log of the value of exports by product homogeneity and duration, 2019–2020

(a) Lithuania, log of the value of imports





(a) Latvia, log of the value of exports



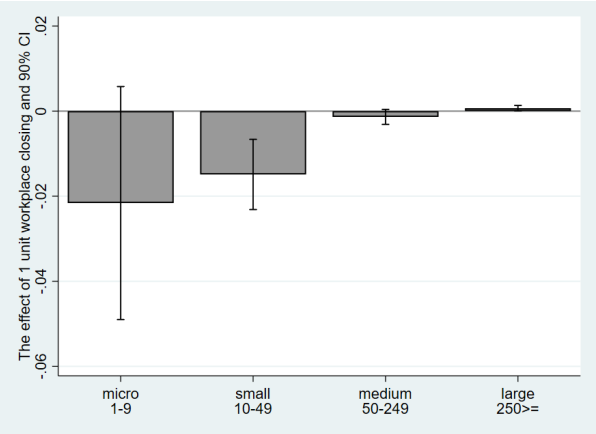
(b) Estonia, log of the value of exports

Notes: The figures reflect the impact of downstream workplace closures on the log of the value of exports with 90% confidence bounds. The equation (4) is estimated by product homogeneity and product duration.
Source: Authors' calculations from administrative data.

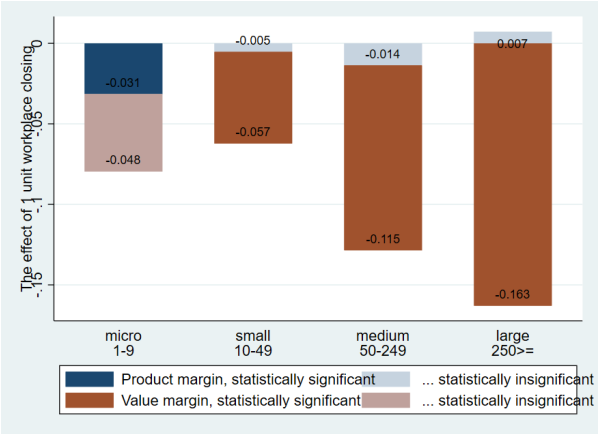
F Firm heterogeneity and imports

Figure F.1: The effect of workplace closures in supplier countries on imports by firm size, 2019–2020

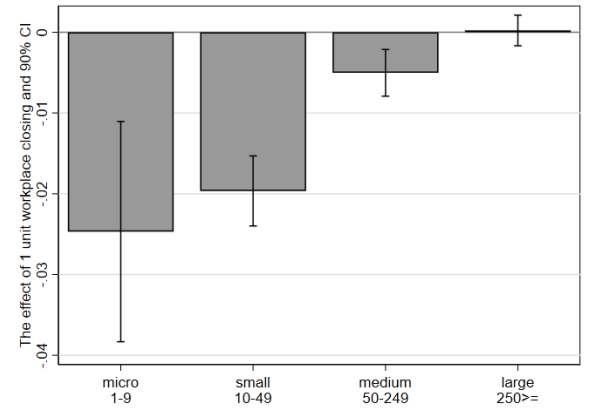
(a) Lithuania, probability to trade (manuf)



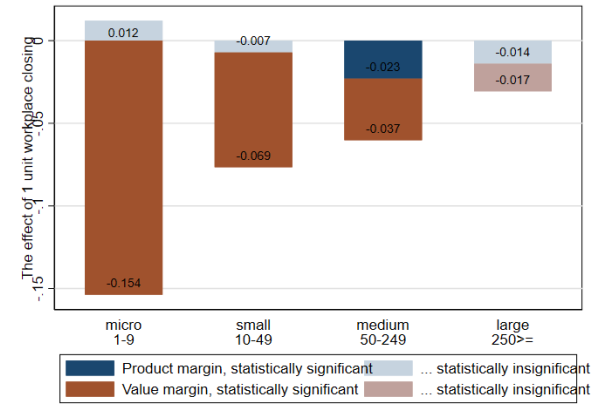
(b) Lithuania, log of the value traded (manuf)



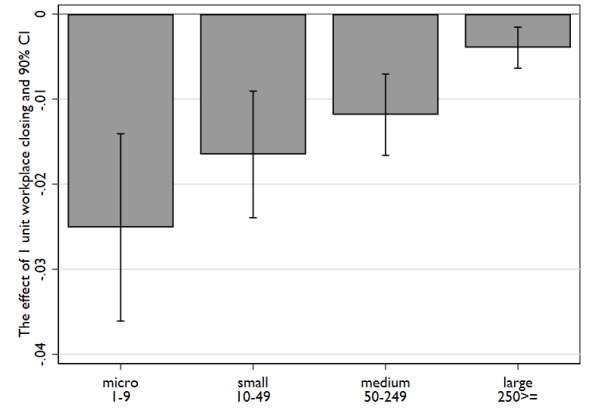
(c) Latvia, probability to trade



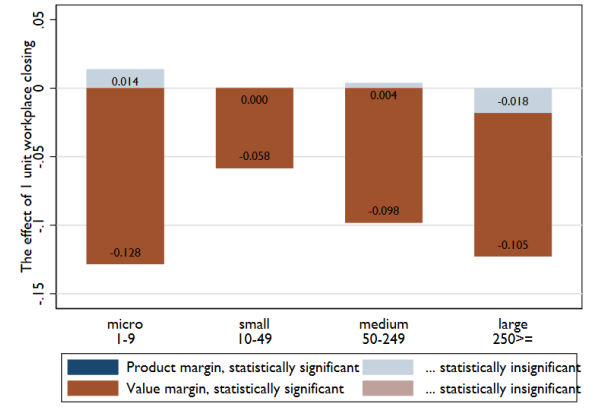
(d) Latvia, log of the value traded



(e) Estonia, probability to trade



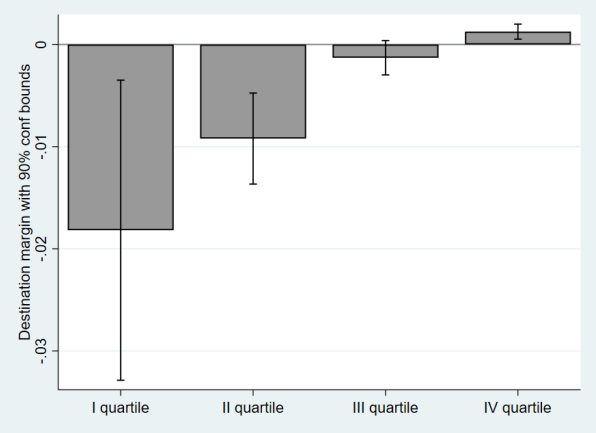
(f) Estonia, log of the value traded



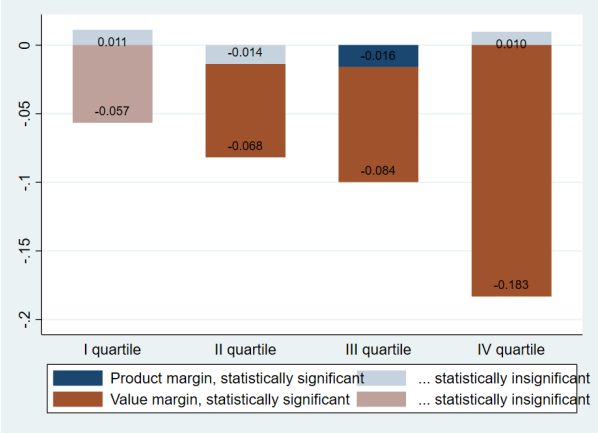
Notes: The figures reflect the impact of upstream workplace closures on the probability of importing and on the log of value imported by adjustment margins and with 90% confidence bounds. The equation (3) is estimated by interacting upstream workplace closures with firm size in 2019.
Source: Authors' calculations from administrative data.

Figure F.2: The effect of workplace closures in supplier countries on imports by firm productivity, 2019–2020

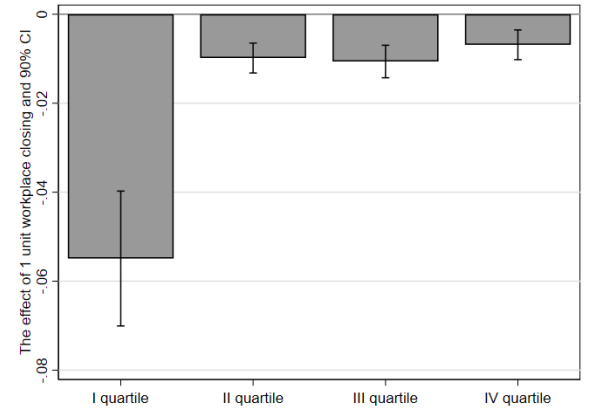
(a) Lithuania, probability to trade (manuf)



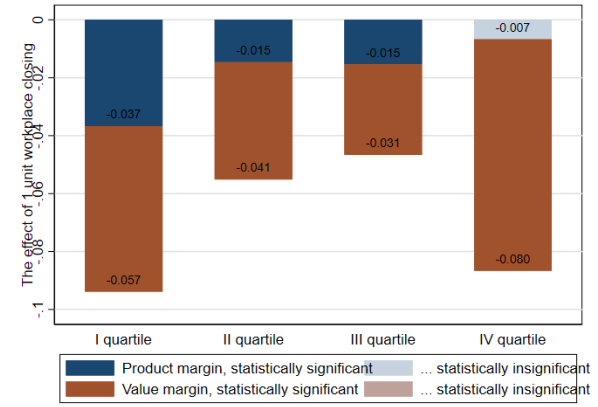
(b) Lithuania, log of the value traded (manuf)



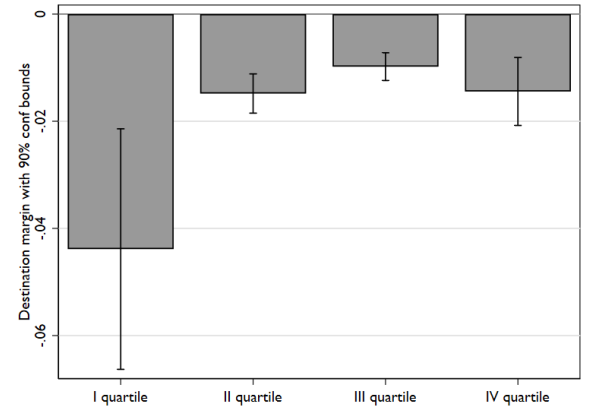
(c) Latvia, probability to trade



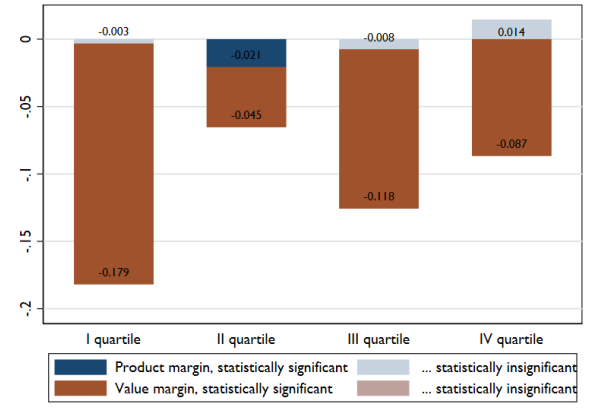
(d) Latvia, log of the value traded



(e) Estonia, probability to trade



(f) Estonia, log of the value traded



Notes: The figures reflect the impact of upstream workplace closures on the probability of importing and on the log of value imported by adjustment margins and with 90% confidence bounds. The equation (3) is estimated by interacting upstream workplace closures with firm labour productivity quartiles in 2019. Labour productivity is derived as value added per number of employees.
Source: Authors' calculations from administrative data.

Table F.1: The effect of workplace closures in supplier countries on the probability of importing, interactions with finished products, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Upstream_{c,t}$	-0.007***	-0.008***	-0.016***	-0.009***	-0.009***	-0.017***
	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)
$Upstream_{c,t} \times Finished\_products_{i,2019}$	0.007**	0.006***	0.057**	-0.005	0.062	-0.105
	(0.003)	(0.002)	(0.027)	(0.012)	(0.051)	(0.089)
$Local_{r,t}$	-0.136*	-0.032	-0.001*	-0.002***	-0.002	-0.000
	(0.077)	(0.146)	(0.001)	(0.000)	(0.002)	(0.001)
$\ln(Turnover_{s,t})$	0.003	0.032***	0.042***	0.068***	0.032***	0.098***
	(0.003)	(0.010)	(0.013)	(0.015)	(0.010)	(0.028)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	327 144	756 948	175 536	381 444	229 266	449 280
R^2	0.002	0.004	0.004	0.006	0.003	0.009

Notes: Finished products are derived as the share of firms' finished products in the balance sheet in 2019 to the firms' sales in 2019. Mean of finished products in the estimation sample are shown in the last line of the table. Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table F.2: The effect of workplace closures in supplier countries on the value of imports, interactions with finished products, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Upstream_{c,t}$	-0.156***	-0.074***	-0.081***	-0.063**	-0.075*	-0.096***
	(0.030)	(0.012)	(0.019)	(0.027)	(0.039)	(0.014)
$Upstream_{c,t} \times Finished\_products_{i,2019}$	0.014	0.017	-0.159	0.058	0.051	-0.651
	(0.043)	(0.031)	(0.527)	(0.117)	(0.535)	(0.603)
$Local_{r,t}$	-1.648	-2.930***	0.004	-0.001	-0.055***	0.004
	(1.154)	(1.060)	(0.003)	(0.004)	(0.018)	(0.008)
$\ln(Turnover_{s,t})$	0.954***	1.209***	0.434***	1.104***	0.692***	1.148***
	(0.214)	(0.187)	(0.077)	(0.148)	(0.118)	(0.198)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	143 427	344 315	75 890	183 546	101 607	203 330
R^2	0.152	0.030	0.014	0.026	0.034	0.031

Notes: Please refer to notes in Table F.1.
Source: Authors' calculations from administrative data.

Table F.3: The effect of workplace closures in supplier countries on the probability of importing, interactions with supplies, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Upstream_{c,t}$	-0.020***	-0.013***	-0.015***	-0.010***	-0.013***	-0.019***
	(0.006)	(0.002)	(0.006)	(0.002)	(0.004)	(0.005)
$Upstream_{c,t} \times Supplies_{i,2019}$	0.020***	0.014***	0.028	0.003	0.030	0.016
	(0.006)	(0.003)	(0.053)	(0.002)	(0.025)	(0.019)
$Local_{r,t}$	-0.138*	-0.014	-0.001*	-0.002***	-0.002	-0.000
	(0.077)	(0.142)	(0.001)	(0.000)	(0.002)	(0.001)
$\ln(Turnover_{s,t})$	0.004	0.030***	0.041***	0.068***	0.031***	0.099***
	(0.003)	(0.010)	(0.013)	(0.015)	(0.010)	(0.028)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	327 144	756 948	175 536	381 444	229 266	449 280
R^2	0.002	0.007	0.004	0.006	0.003	0.009

Notes: Supplies are derived as the share of firms' supplies in the balance sheet in 2019 to the firms' sales in 2019. Mean of supplies in the estimation sample are shown in the last line of the table. Huber/White/sandwich estimator standard errors in parenthesis. *, **, *** indicate statistical significance at the level of 10, 5 and 1 % respectively.
Source: Authors' calculations from administrative data.

Table F.4: The effect of workplace closures in supplier countries on the value of imports, interactions with supplies, 2019–2020

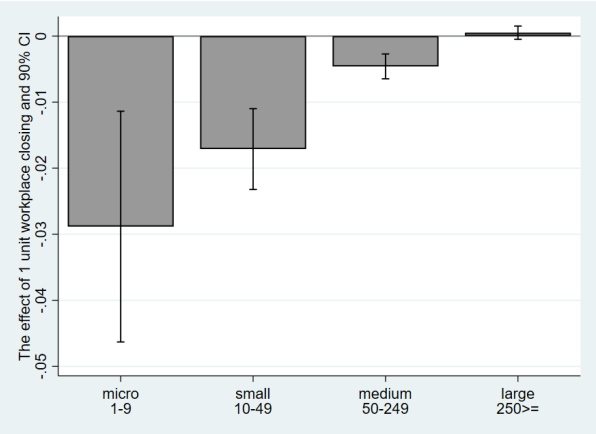
	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Upstream_{c,t}$	-0.060***	-0.068***	-0.068***	-0.055**	-0.041	-0.111***
	(0.017)	(0.017)	(0.021)	(0.015)	(0.026)	(0.024)
$Upstream_{c,t} \times Supplies_{i,2019}$	-0.087***	0.014	-0.228	-0.193	-0.190	0.091
	(0.030)	(0.019)	(0.176)	(0.245)	(0.139)	(0.090)
$Local_{r,t}$	-1.642	-2.956***	0.004	-0.001	-0.056***	0.004
	(1.155)	(1.059)	(0.003)	(0.004)	(0.018)	(0.008)
$\ln(Turnover_{s,t})$	0.945***	1.212***	0.433***	1.103***	0.698***	1.149***
	(0.216)	(0.186)	(0.084)	(0.148)	(0.119)	(0.199)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	143 427	344 315	75 890	183 546	101 607	203 330
R^2	0.153	0.030	0.014	0.026	0.034	0.031

Notes: Please refer to notes in Table F.3.
Source: Authors' calculations from administrative data.

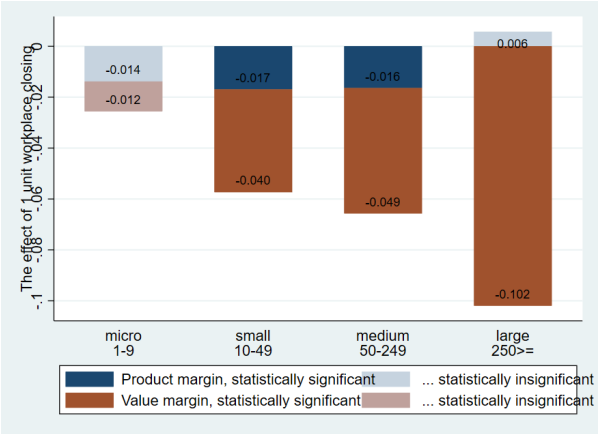
G Firm heterogeneity and exports

Figure G.1: The effect of workplace closures in destination countries on exports by firm size, 2019–2020

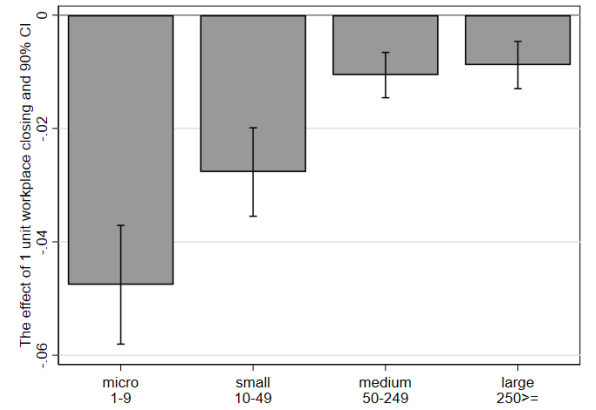
(a) Lithuania, probability to trade (manuf)



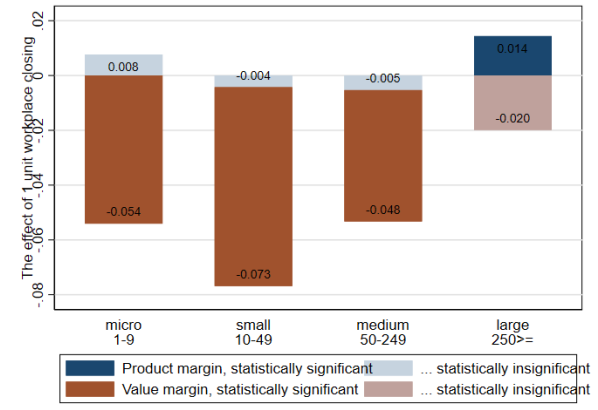
(b) Lithuania, log of the value traded (manuf)



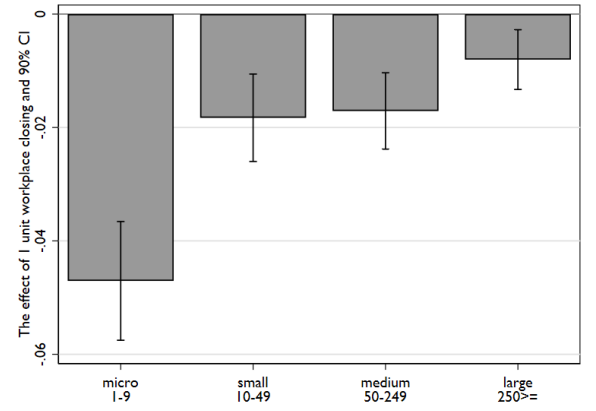
(c) Latvia, probability to trade



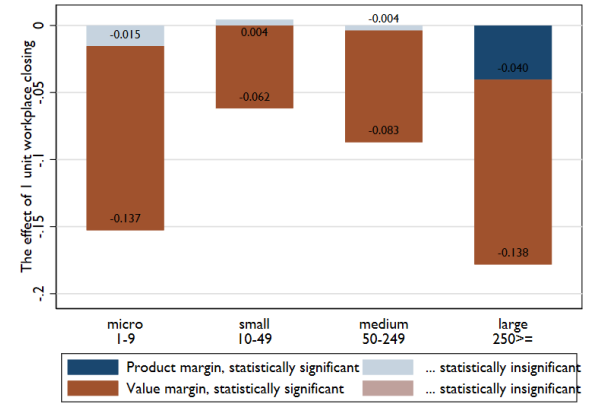
(d) Latvia, log of the value traded



(e) Estonia, probability to trade



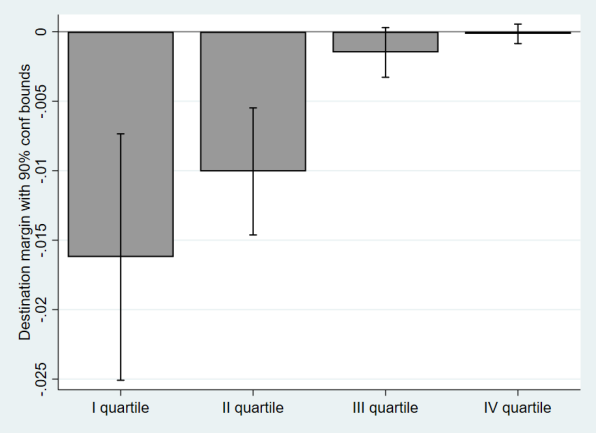
(f) Estonia, log of the value traded



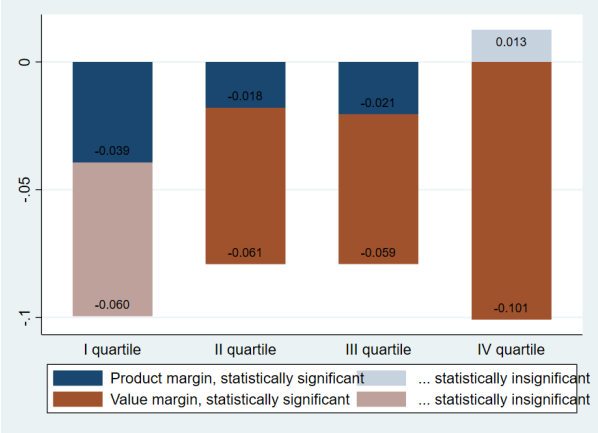
Notes: The figures reflect the impact of downstream workplace closures on the probability of exporting and on the log of value exported by adjustment margins and with 90% confidence bounds. The equation (4) is estimated by interacting downstream workplace closures with firm size in 2019.
Source: Authors' calculations from administrative data.

Figure G.2: The effect of workplace closures in destination countries on exports by firm productivity, 2019–2020

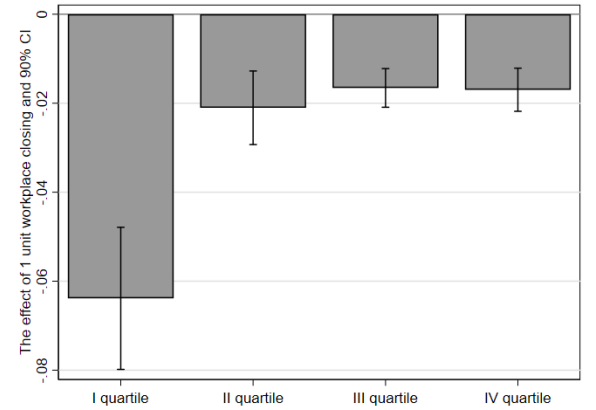
(a) Lithuania, probability to trade (manuf)



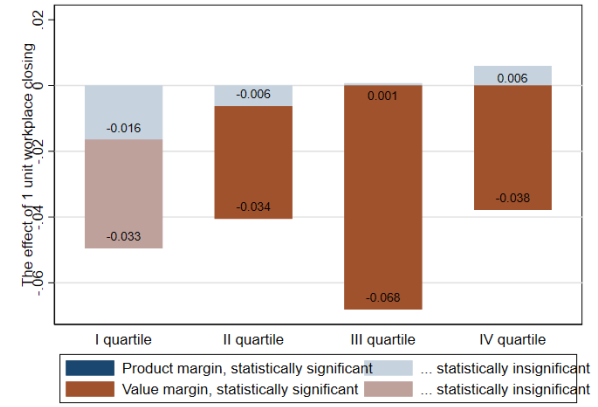
(b) Lithuania, log of the value traded (manuf)



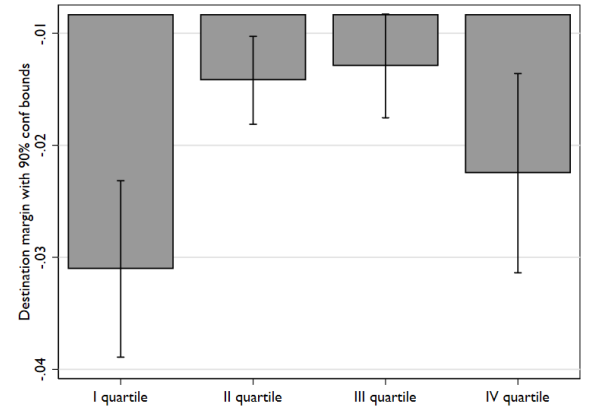
(c) Latvia, probability to trade



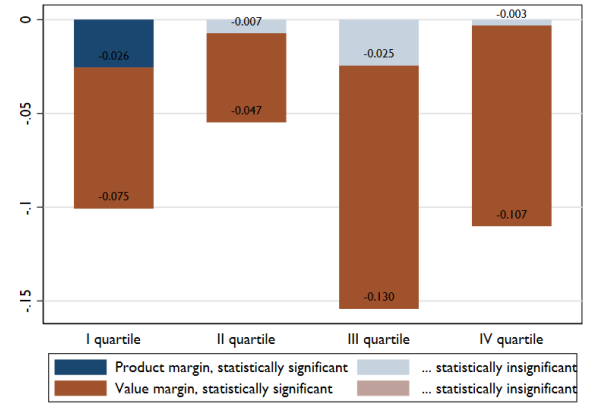
(d) Latvia, log of the value traded



(e) Estonia, probability to trade



(f) Estonia, log of the value traded



Notes: The figures reflect the impact of downstream workplace closures on the probability of exporting and on the log of value exported by adjustment margins and with 90% confidence bounds. The equation (4) is estimated by interacting downstream workplace closures with firm labour productivity quartiles in 2019. Labour productivity is derived as value added per number of employees.
Source: Authors' calculations from administrative data.

Table G.1: The effect of workplace closures in destination countries on the probability of a firm exporting, interactions with finished products, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Downstream_{c,t}$	-0.009***	-0.007***	-0.022***	-0.024***	-0.016***	-0.026***
	(0.003)	(0.002)	(0.003)	(0.005)	(0.003)	(0.008)
$Downstream_{c,t} \times Finished\_products_{i,2019}$	0.008***	0.003	0.048**	0.041*	0.053*	0.040
	(0.003)	(0.003)	(0.021)	(0.023)	(0.029)	(0.146)
$Local_{r,t}$	0.033	-0.598***	0.000	-0.002**	0.001	-0.000
	(0.038)	(0.169)	(0.000)	(0.001)	(0.002)	(0.003)
$\ln(Turnover_{s,t})$	0.002	0.051***	0.047***	0.096***	0.023***	0.082*
	(0.003)	(0.015)	(0.010)	(0.027)	(0.007)	(0.049)
$\ln(Imports_{i,c,t})$	0.004	0.045*	0.013	0.083	-0.020	0.045
	(0.005)	(0.025)	(0.040)	(0.058)	(0.031)	(0.085)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	416 352	494 004	233 652	273 852	227 226	185 022
R^2	0.002	0.004	0.008	0.012	0.004	0.011
$Finished\_products_{i,2019}$					0.027	0.002

Notes: Please refer to notes in Table F.1.
Source: Authors' calculations from administrative data.

Table G.2: The effect of workplace closures in destination countries on the value of exports, interactions with finished products, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Downstream_{c,t}$	-0.060*	-0.094***	-0.065***	-0.047***	-0.150**	-0.097***
	(0.035)	(0.016)	(0.011)	(0.017)	(0.058)	(0.034)
$Downstream_{c,t} \times Finished\_products_{i,2019}$	-0.028	0.007	0.408***	-0.077	1.276*	-0.925
	(0.048)	(0.036)	(0.130)	(0.103)	(0.678)	(0.942)
$Local_{r,t}$	-1.143	-1.460	-0.000	0.002	-0.021	0.022
	(2.733)	(1.415)	(0.002)	(0.004)	(0.017)	(0.014)
$\ln(Turnover_{s,t})$	0.781***	0.915***	0.881***	0.728***	0.703***	0.814***
	(0.140)	(0.185)	(0.063)	(0.155)	(0.094)	(0.155)
$\ln(Imports_{i,c,t})$	0.970***	0.530***	0.328**	0.509***	0.961	0.488*
	(0.338)	(0.129)	(0.140)	(0.185)	(0.670)	(0.287)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	194 858	185 358	105 051	111 525	110 284	73 937
R^2	0.101	0.025	0.026	0.020	0.041	0.027
$Finished\_products_{i,2019}$					0.027	0.002

Notes: Please refer to notes in Table F.1.
Source: Authors' calculations from administrative data.

Table G.3: The effect of workplace closures in destination countries on the probability of a firm exporting, interactions with supplies, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Downstream_{c,t}$	-0.027***	-0.015***	-0.016***	-0.019***	-0.021***	-0.035***
	(0.006)	(0.003)	(0.003)	(0.004)	(0.003)	(0.009)
$Downstream_{c,t} \times Supplies_{i,2019}$	0.026***	0.018***	-0.023	-0.031	0.040***	0.067***
	(0.006)	(0.003)	(0.020)	(0.055)	(0.014)	(0.026)
$Local_{r,t}$	0.032	-0.580***	0.000	-0.002**	0.001	-0.001
	(0.038)	(0.166)	(0.000)	(0.001)	(0.002)	(0.003)
$\ln(Turnover_{s,t})$	0.002	0.047***	0.045***	0.095***	0.024***	0.089*
	(0.003)	(0.014)	(0.010)	(0.027)	(0.007)	(0.048)
$\ln(Imports_{i,c,t})$	0.006	0.039	0.015	0.079	-0.022	0.051
	(0.005)	(0.025)	(0.039)	(0.058)	(0.031)	(0.084)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	416 352	494 004	233 652	273 852	227 226	185 022
R^2	0.007	0.007	0.008	0.011	0.004	0.012
$Supplies_{i,2019}$					0.157	0.148

Notes: Please refer to notes in Table F.3.
Source: Authors' calculations from administrative data.

Table G.4: The effect of workplace closures in destination countries on the value of exports, interactions with supplies, 2019–2020

	Lithuania		Latvia		Estonia	
	Manufacturing	Trade	Manufacturing	Trade	Manufacturing	Trade
	(1)	(2)	(3)	(4)	(5)	(6)
$Downstream_{c,t}$	-0.019	-0.115***	-0.039***	-0.054***	-0.128***	-0.137***
	(0.018)	(0.021)	(0.014)	(0.013)	(0.040)	(0.047)
$Downstream_{c,t} \times Supplies_{i,2019}$	-0.069**	0.047*	0.011	-0.216	0.104	0.260**
	(0.030)	(0.025)	(0.112)	(0.273)	(0.193)	(0.126)
$Local_{r,t}$	-1.141	-1.404	-0.001	0.002	-0.022	0.020
	(2.741)	(1.401)	(0.002)	(0.004)	(0.017)	(0.014)
$\ln(Turnover_{s,t})$	0.782***	0.905***	0.871***	0.731***	0.709***	0.839***
	(0.141)	(0.181)	(0.063)	(0.154)	(0.097)	(0.153)
$\ln(Imports_{i,c,t})$	0.965***	0.521***	0.348**	0.513***	1.014	0.503*
	(0.339)	(0.127)	(0.143)	(0.185)	(0.658)	(0.286)
Firm FE						
Country FE						
Firm x Country FE	✓	✓	✓	✓	✓	✓
No. of observations	194 858	185 358	105 051	111 525	110 284	73 937
R^2	0.101	0.026	0.025	0.020	0.038	0.028
$Supplies_{i,2019}$					0.158	0.153

Notes: Please refer to notes in Table F.3.
Source: Authors' calculations from administrative data.