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How Do Firms Adjust When Trade Stops?*

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ABSTRACT

We investigate how firms adjust to the introduction of sudden, unanticipated and eventually long-lasting economic sanctions. In 2014, Russia introduced sanctions on imports from Europe, which caused an abrupt negative shock to the food production sector in Lithuania. We find that part-time employment is used as the first shock absorber, followed by investment and full-time employment. At the same time, firms dampen shock effects by expanding to other export markets. To rationalize this firm behavior, we provide a theoretical mechanism where forward-looking firms face nonconvexities in the labor market along with heterogeneous variable trade costs.

Keywords: economic sanctions, firm adjustment margins, part-time employment, new export markets.

JEL Classification: D22, D25, F14, F16, F51.

1 Introduction

In the current times of deglobalization and trade wars, governments are increasingly using economic sanctions and company boycotts to influence each others' actions. Some of these sanctions directly target particular foreign firms or economic sectors, which consequently experience unanticipated drops in demand for their products and thus have to adjust how they organize their activities.

When faced with economic sanctions, firms are likely to adjust on a number of dimensions. Such adjustments might interact with each other and involve a substantial degree of heterogeneity as firms are subject to non-uniform adjustment costs and expectations of demand shock severity and permanence. In addition, understanding how firms adjust to economic sanctions and boycotts helps to determine the external validity of the findings of trade liberalization, i.e., by shedding light on whether the trade liberalization-driven adjustments are symmetrically undone when the trade stops.

We look at a unique event in which a major sector of a small open economy lost its main export market for political reasons unrelated to trade or other economic conditions. Following the political tensions in 2014, Russia banned agricultural and food product imports from a number of countries, including those from the European Union (EU). As a consequence, Lithuania's food sector which was highly exposed to the Russian market suffered an unexpected loss in demand. We use a rich firm-level dataset that covers all firms in Lithuania and enables us to comprehensively quantify the adjustment margins.

Our empirical analysis is based on the reduced-form triple-differences estimates for the food manufacturing sector in the Lithuanian economy over 2011-2017. We consider affected firms to be those that had exports of banned products to Russia in 2013. We then compare firm-level responses for the firms affected by Russia's export ban and the control firms in the period after the ban (2014-2017) as compared to the period before the ban (2011-2013). We pick control firms to be from the same sector, of a similar size, and also engaging in exports of their products to countries outside of Russia, thus unaffected directly by Russia's import

ban. In this way, the procedure not only takes into account non-time-varying differences between firms but also controls for the general food sector-trends that might have varied across the firms of similar size. Our third difference compares whether the change in change was more pronounced for the affected firms that had a higher share of banned products to Russia as a fraction of their sales and thus were *more* exposed to Russia’s import ban, as compared to the change in change in affected firms that were *less* exposed to the import ban.

We find that following the Russian trade ban, affected food manufacturers experienced an immediate drop in part-time employment, a delayed drop in full-time employment, and a downward adjustment of capital investment. An average exposed firm with 6.69% pre-ban share of banned export products in its sales reduced part-time employees by 67% compared to the pre-period sample mean and full-time employees by 6.6% over the pre-shock period average. The affected firms also experienced a drop in investment and a rise in the exports to the rest of the world, destinations which can be seen as a proxy for revenue-increasing strategies exploited by manufacturers affected by the sanctions, yet this did not lead to the complete recovery of the profits for the affected firms, at least over the horizon we analyse.

Motivated by these empirical findings, we set up a stylized theoretical framework on firm optimal adjustment that delivers further predictions. We adopt a production function, similar to the one proposed by [Krusell et al. \(2000\)](#), in which we combine capital with full-time labor into a composite input. We then suggest a cost minimization problem when firms face no adjustment costs for part-time labor, non-convex adjustment costs for full-time labor, and time rigidity when adjusting for capital.

Following a simplified version of [Helpman et al. \(2010\)](#), our firms export their products in addition to selling on a domestic market. We extend [Helpman et al. \(2010\)](#) by allowing firm-specific variable trade costs that reflect varying exporting efficiency, such as efficiency in transporting goods, accessing customs, and managing a distribution network. Furthermore, we consider two foreign markets, i.e., Russia and the rest of the world.

We show that firm choices are determined by their input adjustment frictions and heterogeneous trade costs with foreign markets outside of Russia. Our stylized mechanism captures smooth capital decline and jumpy reaction in labor when absorbing the unexpected sanctions. While part-time employment is generally the first shock absorber, depending on the magnitude of the shock, firms may start adjusting full-time employment and capital, and if the shock is persistent and strong, also engage in more exports to the rest of the world.

We establish that the scope of other adjustments can be expressed in terms of the part-time employment margin, which serves as a proxy for the severity of the shock. In particular, capital investment is predicted to drop more, the larger the part-time employment adjustment. Similarly, the layoffs of full-time labor and the increase in the share of exports to the rest of the world are more likely if the shock is large and persistent and the part-time employment adjustment is sizeable.

Our empirical findings are in line with the interpretation provided in our theory that part-time employment, as the most flexible margin, is adjusted first, and may precede further, costlier changes. More importantly, food manufacturers that in the short term reduced part-time employment relatively more, later reduced capital investment and laid off full-time employees. These results suggest that firm adjustment on the most flexible margin can capture its expected permanence of shock when such heterogeneity is not directly observable.

Taken together, these findings suggest that at times of global uncertainty, open economies need even more flexible labor regulations allowing for an array of different work contracts. Policymakers should also increase efforts to reduce reliance on one particular trade partner.

Our paper contributes to several streams of literature. In broad terms, our paper belongs to the literature analysing negative trade shocks and their economic consequences on different firms. With our empirical setting, we are able to overcome the identification challenge that many international trade barriers, which lead to substantial negative demand shocks, are likely to be correlated with the other more direct macroeconomic adjustments. For instance, they could be linked to changes in domestic worker wage expectations and labor supply.

Technological shocks can also trigger alterations to trade agreements but are also likely to lead to demand changes directly or through the production function recompositions. In our case, rather than observing a trade shock stemming from a trade-agreement, tariff change or currency depreciation, we study a complete trade ban, i.e., limiting the exports of a range of products to a particular destination country, which is unlikely to be related to Lithuanian domestic economy or its other potential export markets. As we have detailed micro-level data on the affected firms, we can identify the magnitude of firm-level responses based on the variation of shock size across the firms.

We exploit the trade shock to provide the evidence on which adjustments firms adopt when they are faced with the drop in demand for their production. Contrary to a one-dimensional focus as in [Hogan and Ragan \(1995\)](#), [Mouelhi \(2007\)](#), [Fabiani et al. \(2015\)](#), [Asquith et al. \(2019\)](#), [Tanaka et al. \(2019\)](#), who analyze labor margin adjustments, or [Kee and Krishna \(2008\)](#), [Bernard et al. \(2009\)](#), [Morales et al. \(2019\)](#), [Eaton et al. \(2022\)](#) who are interested in trade adjustments, we study multiple (competing) adjustment margins, somewhat similar to [Bernard et al. \(2006\)](#), [Eslava et al. \(2010\)](#), and [Bertola et al. \(2012\)](#). While [Bernard et al. \(2006\)](#) track manufacturing activity reallocation and product-mix changes, [Eslava et al. \(2010\)](#) and [Casacuberta and Gandelman \(2012\)](#) are looking at employment and capital adjustments, and [Bertola et al. \(2012\)](#) analyze price versus cost and wage versus employment adjustments, we analyze how firms change their full-time and part-time labour, investment, and new market selection choices after the shock.

Our paper is also related to a strand of literature discussing trade liberalization effects on the labor market (e.g., [Dix-Carneiro and Kovak \(2019\)](#), [Dix-Carneiro \(2014\)](#), [Caliendo et al. \(2019\)](#), [Dix-Carneiro et al. \(2023\)](#)). Yet while these papers mostly look into general equilibrium effects and cross-industry or inter-regional adjustments of the labor market, we take a look at the adjustments within a firm and uncover part-time vs. full-time relationship, providing more granular evidence on the scope and the extent of the adjustments. With this, we abstract from general equilibrium implications in our model and only look into intra-firm

adjustments. We also allow for other margins, in addition to labor, to play a role. Finally, a stark difference of our paper from the above-mentioned literature is the nature of the shock: trade liberalization is typically considered as a negative cost-push shock, provided that reduced tariffs result in higher international competition in the domestic market. In our case, the sanctions of international trade ban is a demand shock to the producers.

We also go a step further by trying to provide the mechanism responsible for these adjustments. Our approach is thus similar to [Levchenko et al. \(2010\)](#), who find compositional effects and the use of intermediate inputs being responsible for the largest trade drops, [Matsuura et al. \(2011\)](#) who find adjustments being dependent on firm’s revenue volatility, [Bricongne et al. \(2012\)](#) who show the role of financial frictions and firm size, and [Iacovone et al. \(2013\)](#) who find that plant size affects its performance after shock. In our case, firm-specific labor and capital intensities, and the nature of labor and capital adjustment costs are the key drivers in firm responses to the trade shock.

Finally, we make a contribution to the literature on the topic of trade bans, or, more generally, severe trade restrictions. This literature has been expanding recently, reflecting the new era of geopolitical tensions across countries. Earlier work includes the meta-analysis of the sanction effects ([Siddiquee and van Bergeijk 2012](#)), the estimates of macroeconomic and political effects of trade restrictions with Iran ([Dizaji and van Bergeijk 2013](#)), and effects on Danish firms in the aftermath of the Danish cartoon crisis ([Hiller et al. 2014](#), [Friedrich and Zator 2019](#)). More recent research discusses the effects of Russia’s sanctions on firms in Western European countries ([Crozet and Hinz 2020](#), [Klomp 2020](#), [Crozet et al. 2021](#), [Deng et al. 2022](#)) and China–US trade war effects ([Fajgelbaum et al. 2019](#), [Amiti et al. 2020a,b](#), [Flaen and Pierce 2020](#), [He et al. 2021](#), [Fajgelbaum et al. 2021](#), [Fajgelbaum and Khandelwal 2022](#)). These studies are mostly concerned with macroeconomic effects for the countries engaged in the trade war rather than micro-level adjustments across multiple dimensions.

2 Motivation

2.1 Trade Shock and Data

The negative trade shock that we analyze is Russia’s import ban of agricultural and food products as well as certain raw materials from the EU, the United States (US) and some other countries in 2014.¹ The ban came as a result of the political tensions between Russia and the EU and was not related to economic reasons. In particular, in response to the Russia-Ukraine conflict, in February 2014, the EU, the US, and a few other Western countries introduced non-trade (primarily, financial) sanctions against certain Russian individuals. In August 2014, Russia responded by imposing import restrictions on a number of agricultural and food products from these countries. The range of products subject to Russian import restrictions mainly included meats, dairy products, fruits, and vegetables.² These import restrictions were initially introduced for one year but they have been extended annually since their adoption, and thus it is likely that at some point they started to be perceived as near-permanent.

This shock was particularly important to Lithuania, a small open economy, and a member of the EU, as Russia has been one of the most important trade partners for Lithuanian agricultural and food product exports. In 2013, 20% of Lithuanian exports were directed to Russia. Around 18% of them contained banned product exports. Since Lithuania is a small open economy and exports make 80% of its GDP, a shock to the exports to Russia was a significant event, especially for industries exporting a considerable amount of banned products. As shown in Table 1, in 2014, the year of the ban, exports of banned products to Russia shrunk by 38% (the ban was imposed in August) and by another 89% in 2015. Exports of all products to Russia decreased by 7% in 2014 and by another 27% in 2015, thus

¹The full list includes the countries of the EU, the US, Switzerland, Canada, Australia, Norway, Ukraine, Albania, Montenegro, Iceland, and Lichtenstein. More information about this decree is available at: https://ec.europa.eu/food/horizontal-topics/international-affairs/eu-russia-sps-issues/russian-import-ban-eu-products_en.

²The complete list of banned product codes is given in the Appendix A.

the ban affected a considerable proportion of country’s exports.³

Table 1: Firm exports and the exposure to the trade ban from Russia

	Total Economy	Food Manufacturing
Value added, m EUR, 2013	28,727	1,276
Total exports, m EUR, 2013	23,470	1,429
Total exports, % of GDP	81%	5%
Banned exports, m EUR, 2013	887	136
Banned exports, % of Total exports	4%	9%
Banned exports, m EUR, 2014	547	79
Banned exports, y-o-y % change	-38%	-41%
Banned exports, m EUR, 2015	61	5
Banned exports, y-o-y % change	-89%	-94%
Banned exports, m EUR, 2016	13	0
Banned exports, y-o-y % change	-79%	-99%

Source: National Accounts Statistics

We use a detailed firm-level dataset from Statistics Lithuania. The data consists of the whole population of food manufacturing firms in Lithuania⁴ over 2011 to 2017. This time window provides us with enough power to study the adjustment margins and their dynamics over time for up to four years after the event while controlling for the trends prior to the event. The dataset covers firm balance sheet and income statement variables at a rather disaggregated level, as well as firm-level employment characteristics. Crucially, it also includes detailed data on firm-level trade, such as international trade values by 8-digit HS products and destination (source) country exports (imports), allowing us to track which specific firms have been affected by the trade ban.

³Across Lithuanian firms, the ten most affected products (based on 8-digit HS codes) were: Cheese and curd; Milk and cream, not concentrated, not containing added sugar; Milk and cream, concentrated or containing added sugar Meat of bovine animals, fresh or chilled; Prepared or preserved fish, caviar; Whey and products consisting of natural milk constituents; Apples, pears, and quinces; Citrus fruit; Fruit; Vegetables.

⁴Based on Eurostat data, Lithuanian firms compare similarly to the rest of the EU in terms of the margins we study in this paper. Average part-time and full-time employment is right at the median of EU-28 sample in 2013. In fact, an average Lithuanian food manufacturing firm (that includes exporters and non-exporters) in the food manufacturing sector has slightly more employees than the average firm in the EU.

2.2 Direct Outcomes for Affected Firms

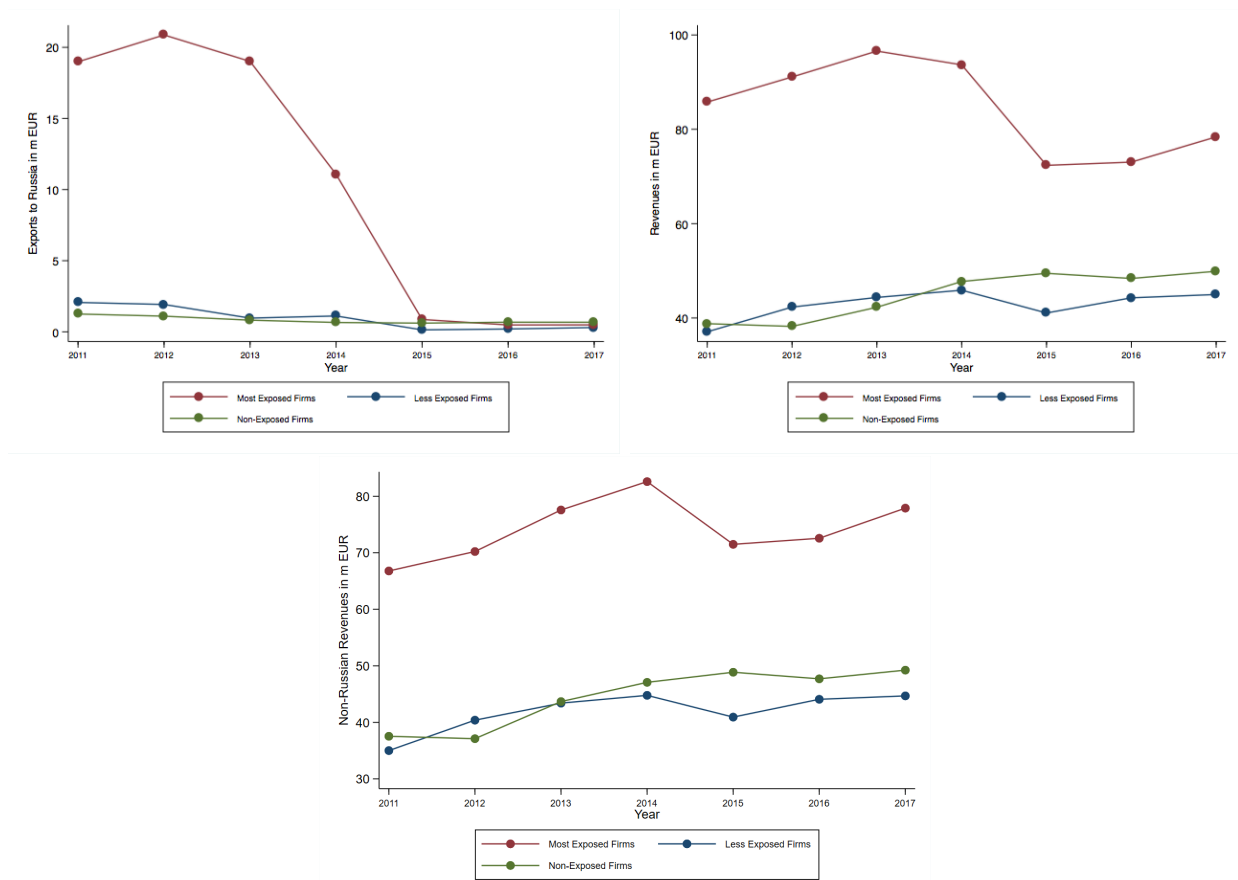
In estimating each firm’s direct exposure to this abrupt trade shock, for each Lithuanian firm we look at the pre-ban exports of the banned 8-digit level HS products to Russia. In particular, firm-level exposure to the trade shock is measured by the fraction of firm’s sales that were composed of the banned product exports to Russia in 2013, the year before the ban was imposed. Figure 1 shows the dynamics of exports to Russia for the most exposed firms (with exports to Russia constituting over 10% of revenues), less exposed firms (with exports to Russia constituting between 2-10% of revenues), and non-exposed firms (with exports to Russia constituting less than 2% of revenues).⁵

The top left panel of Figure 1 depicts total exports of all products (that include banned and non-banned products) to Russia for these firms. We see a significant drop of exports for the firms exposed to the shock. The partial effect is already observed in 2014, when the ban was imposed in August, while the full change can be seen in 2015. Moreover, these drops in exports are reflected in the overall decrease in the affected firms’ sales, suggesting that the demand shock for these firms was indeed considerable. As shown in the top right panel of Figure 1, affected food manufacturers experienced a sharp drop in the overall sales but later also showed some recovery. The drop in overall sales also suggests that the venting-in effect was limited, i.e., the drop in exports was not replaced by a respective increase in the domestic sales. We also confirm that in the bottom panel of Figure 1, which plots the dynamics of revenues from outside of Russia.

This observation of different exposure to the shock will be our key identifying variable in the empirical analysis and also one of the guiding inputs in building our theoretical framework.

⁵In our further empirical estimations, we consider the continuous treatment with both *more* and *less* exposed firms considered as treated firms and non-exposed firms considered as the control firms.

Figure 1: Exports to Russia, Total Revenues, and Revenues from Outside of Russia



Notes: The top left figure plots the dynamics of all exports to Russia by food manufacturing firms. The top right figure plots the dynamics of overall revenues by food manufacturing firms. The bottom figure plots the dynamics of revenues from outside of Russia by food manufacturing firms. The red lines represent the firms with high pre-2013 exposure of exports to Russia (with exports to Russia constituting over 10% of revenues), the blue lines represent the firms with low pre-2013 exposure of exports to Russia (with exports to Russia constituting between 2-10% of revenues), the green lines represent the average for all food manufacturing firms in the economy (with exports to Russia constituting less than 2% of revenues). The ban of exports to Russia is effective as of August 2014, therefore the annual value of exports to Russia in 2014 features a considerable fall but not an immediate drop to zero. The exports to Russia go down to nearly zero in 2015 and beyond.

3 Empirical Analysis

3.1 Reduced-form Identification

We start with the reduced-form analysis that provides causal evidence on the Russian ban's impact on Lithuanian food exporters. In particular, we match the export-level data to the

balance sheet data and employ a reduced-form difference-in-differences identification strategy to identify the effect of how these firms have adjusted to the negative trade shock.

We define the period of 2011-2013, which precedes the export ban, to be *pre-period*, and the period of 2014-2017, which follows the export ban, to be *post-period*. Our treatment group consists of firms that had banned-product exports to Russia in 2013. We have 25 such treated food manufacturers in Lithuanian economy.⁶ For each of these treated firms we choose a control firm (with replacement) that satisfies the following criteria: (a) the control firm is also in the food manufacturing sector; (b) it is an exporter but does not have banned-product exports to Russia in 2013; and (c) of all the candidate firms satisfying (a) and (b), it is the closest one in terms of size to the focal treated firm, as measured by total sales in 2013 (but limited to maximum 100% difference). By stable unit treatment value assumption, we consider that control firms are not affected by the treatment. That is, any spillover effects of, e.g., lower sales of control firms because treated firms now compete more aggressively in the domestic markets,⁷ only contributes to underestimating the effects of our interest.

Given likely heterogeneity across firms, we impose these criteria to make sure that before the event, the treated and control firms are as similar as possible. As reported in [Table 2](#), when we compare matched pairs in the pre-period of 2013, the treated firms appear smaller than control firms in terms of sales but larger in terms of the number of employees. Nevertheless, these differences are not statistically significant.

As firms are likely to vary in terms of their exposure to the sanctions, we rely on *Banned export share* to identify the exposure to Russia's ban. *Banned export share* is defined as the fraction of the firm's revenue from exports of the banned products to Russia in 2013 to the total revenues of the firm in 2013. We then study whether the food production firms that had a larger fraction of their sales exported to Russia in 2013 experienced changes across different adjustment margins in 2014-2017 as compared to 2011-2013, and whether

⁶While this number might appear small, it does correspond to the whole population of affected firms. If anything, low power sets us against establishing statistically significant effects.

⁷As per [Figure 1](#), such venting-in was, however, limited.

Table 2: Balance checks of matched pairs

	Treated	Control	Difference	Pairs
Sales, m EUR, 2013	55.5	60.8	-5.3	25
Full-time employees, 2013	393.2	286.6	106.6	25
Part-time employees, 2013	14.5	3.8	10.7	25
Fixed assets, m EUR, 2013	9.6	15.1	-5.5	25
Total exports, m EUR, 2013	25.9	29.8	3.9	25
Exports to Russia, m EUR, 2013	6.4	0.9	5.5***	25

This table shows the mean values of firm characteristics for the two groups of firms in 2013. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

such changes had larger magnitudes than those experienced by the corresponding firms with a smaller fraction of their sales exported to Russia in 2013.

We investigate the following adjustment margins: the number of part-time employees,⁸ the number of full-time employees, the dollar value of investment, measured as a change in fixed assets, and the change in exports to the rest of the world. We set up the specification at the firm-match \times year level. That is, we take differences between treated firm values and control firm values, and investigate whether these differences become larger after the Russian ban.⁹ The identifying parallel trends assumption is that in the absence of the Russia’s ban the differential in the outcomes of firms that exported to Russia and firms that did not export to Russia prior to 2013 would have trended similarly after 2013 (Olden and Møen 2022). We then estimate a reduced form triple-differences specification:

$$\Delta Y_{i,t} = \beta_1 \times \text{Banned export share}_i \times \text{Post2014}_t + \gamma_i + \tau_t + \epsilon_{i,t}. \quad (1)$$

In this specification, $\Delta Y_{i,t}$ refers to the difference in the adjustment margin $Y_{i,t}$, where the

⁸The standard full-time employment contract in Lithuania is 40 hours per week; and thus part-time employees are defined as those who have fewer than 40 weekly hours defined in their labor contract. The Structure of Earnings Survey for Lithuania reveals that in 2014 October part-time employees on average worked 17 hours a week while full-time employees worked 40 hours a week.

⁹Alternatively, we could set up an equivalent panel structure at the firm \times year level, and identify the effects via the triple interaction $Treated \times Banned\ export\ share_i \times Post$. For the ease of interpretation, we prefer the specification (1) at the firm-match \times year level that only requires us to have $Banned\ export\ share_i \times Post$. That lets us avoid quadruple interactions when we further explore the heterogeneity of our effects.

difference is taken between the values of a treated firm i and its matched control firm in a particular year t . *Banned export share_i* refers to the fraction of firm i 's sales of the banned products that it exported to Russia in 2013 over the total sales of firm i in 2013. *Post2014_t* refers to the dummy equal to 1 in the years 2014-2017 and equal to 0 in years 2011-2013. γ_i and τ_t denote the match- and year-fixed effects. The identification thus relies on the variation in *Banned export share_i* across treated firms in 2013.

In other words, we study whether the food producers that had a larger *Banned export share_i* experienced changes in adjustment margins $Y_{i,t}$ in 2014-2017 (a) as compared to their average $Y_{i,t}$ over 2011-2013, (b) as compared to the respective changes in $Y_{i,t}$ in control firms, and (c) as compared to the respective changes in changes in corresponding firms with a smaller *Banned export share_i*. This estimation thus not only controls for non-time-varying differences between firms but also controls for general sectoral-trends that might have varied across the firms of similar size.

In our analysis we also estimate a specification that studies dynamic adjustments:

$$\begin{aligned} \Delta Y_{i,t} = & \beta_1 \times \textit{Banned export share}_i \times \textit{Post2014}_t + \\ & \beta_2 \times \textit{Banned export share}_i \times \textit{Post2016}_t + \gamma_i + \tau_t + \epsilon_{i,t}. \end{aligned} \tag{2}$$

Compared to the specification (1), here we separately estimate the additional adjustment that happened in years 2016-2017, over the general adjustment in 2014-2017. That is, *Post2016_t* refers to the dummy equal to 1 in the years 2016-2017 and equal to 0 in years 2011-2015, while as before, *Post2014_t* refers to the dummy equal to 1 in the years 2014-2017 and equal to 0 in years 2011-2013. All other variables are defined as in specification (1).

3.2 Findings

In this section we report the results from the empirical analysis. We separately discuss the results on labor market, investment, and revenue-increasing strategies.

3.2.1 Labor Market

We start with the number of employees and report results in Table 3. We report the results separately for part-time and full-time employees, and also split our treatment effect into the overall effect after year 2014 and the additional effect after 2016.

Table 3: Number of employees

	(1)	(2)	(3)	(4)
	Part-time employees		Full-time employees	
Banned export share x Post 2014	-146.909*** (50.223)	-125.123** (48.105)	-384.578** (177.502)	-128.022 (159.867)
Banned export share x Post 2016		-56.133 (52.725)		-661.058** (314.478)
Constant	24.411*** (4.478)	24.378*** (4.474)	141.696*** (16.923)	141.306*** (17.150)
R ²	0.755	0.757	0.953	0.956
N	151	151	151	151

Notes: This table shows the effect of the Russian ban on the number of employees in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variable is then the difference in the number of either part-time employees (Columns 1-2) or full-time employees (Columns 3-4) between the treated and control firms. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

We see the statistically significant adjustment for both part-time and full-time employees. We see that for the part-time employees, the effect is immediate, i.e., there is no statistically significant effect after 2016. For an average exposed food manufacturing firm with 6.69% of revenues coming from the banned product exports to Russia in 2013, the number of part-time employees dropped by an average of 9.76 (compared to the change in control firms), which constituted a 67% drop over the sample mean of 14.48 part-time employees in treated food manufacturing firms in 2013. Such an economically large depletion in the number of employees suggests that the shock perceived by the firms was substantial as they had significantly depleted their most flexible margin.

When we look at the full-time employees, we see that the adjustment is delayed. That is, the effect is not immediate but rather appears in years 2016-2017. In terms of the

economic effect for an average exposed firm with 6.69% of revenues coming from the banned product exports to Russia in 2013, the number of employees dropped by an average of 25.9, constituting a 6.6% drop over the sample mean of 393.2 employees in treated firms in 2013. Taken together with our findings on the adjustment of part-time employees, these results suggest that firms lay off part-time employees first and then when they realize the actual magnitude of the shock, its permanence, or the lack of adjustment in terms of revenue-increasing strategies, they consequently reduce the number of full-time employees.

Note that while the number of treated firms, and thus the number of observations over which we estimate the effects, could appear small, the effects are estimated over the whole population of the directly affected food manufacturers in the Lithuanian economy. Further, the fact that we are able to get statistically significant results with limited power ascertains the precision of the effect.

We perform several robustness tests. First, in Appendix Table B1, we show that the results are consistent if we consider hours worked rather than the number of employees. Second, we provide robustness for our matching procedure of treated and control groups by following entropy balancing approach (see, e.g., Hainmueller (2012)). In particular, in Appendix Table B2, we re-weigh our sample by balancing the first two moments of distributions of firm sales across the treated and control group in 2012. Third, instead of a continuous variable as in Table 3, we consider a binary treatment *High banned export share*, based on the median value of *Banned export share*, which is 3%. We report the results in Appendix Table B3 and find stronger results in terms of statistical significance. Fourth, in the main analysis we do not condition on the firms surviving until 2017. In Appendix Table B4, we exclude two firms that do not survive until 2017.¹⁰ Fifth, we go further and leave out one firm at a time to investigate outlier effects but we do not find that excluding any single firm changes the statistical significance of the earlier effect on part-time employees and delayed effect on full-time employees (these results are available at request).

¹⁰These two firms have slightly higher *Banned export share_i* than the surviving firms, although differences are not statistically significant.

3.2.2 Investment

While part-time and full-time employees represent the adjustments of the labor input, we also look at the adjustment of capital. We proxy the adjustment of capital by the change in investment, which we define as the annual change in the fixed assets, adjusted for depreciation. As shown in Table 4, we see a drop in investment; the effect is immediate and does not reverse in the longer term.¹¹

Table 4: Investment

	(1)	(2)
Banned export share x Post 2014	-24.459** (11.235)	-26.798* (13.657)
Banned export share x Post 2016		6.103 (14.727)
Constant	-0.926 (1.609)	-1.274 (1.772)
R ²	0.596	0.597
N	126	126

Notes: This table shows the effect of the Russian ban on the investment in fixed assets in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that has exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variable is the difference in the investment between the treated and control firms (in 1 million euros). ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

3.2.3 Revenue-Increasing Strategies

Finally, we study revenue-increasing strategies. In particular, we look at whether the affected firms increased their sales from exports to countries outside of Russia. We report results in Table 5, where we see a rise in the dollar value of exports. While we document an immediate positive effect, the effect is only statistically significant with a longer lag, suggesting that when we split the effect into two periods, the later period effect dominates. These results could be interpreted as suggesting that reaching new export markets requires a longer time

¹¹Here and also in Section 3.2.3, we perform similar robustness checks as those reported for part-time and full-time employees in Appendix Tables B2-B4, and we find consistent results.

and larger trade costs.¹²

Table 5: Exports outside of Russia

	(1)	(2)
Banned export share x Post 2014	46.042** (20.687)	19.626 (24.308)
Banned export share x Post 2016		54.657* (30.436)
Constant	-9.581*** (1.799)	-9.566*** (1.807)
R ²	0.889	0.892
N	165	165

Notes: This table shows the effect of the Russian ban on dollar value of exports outside Russia in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that has exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variable is then the difference in the dollar value of exports, excluding Russia. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

4 Conceptual Mechanisms

In developing the theoretical mechanisms to rationalize our empirical findings, we conceptualize Russia’s trade ban as an exogenous shock to the variable trade costs and analyze its effects on various adjustment margins. Notice that an alternative way to model sanctions is via a decrease in Russian demand. However, since demand shifters enter multiplicatively, the two ways are isomorphic, and we stick to a more standard approach. The hit of sanctions varies across firms due to the different exposure to the banned production.

We use a stylized framework with a firm as the ultimate decision maker.¹³ We show that even without delving into a fully-fledged general equilibrium – due to very targeted sanctions — we can rationalize the empirical findings by highlighting the main role played

¹²Note that not only the Lithuanian food manufacturers but also the manufacturers from other EU countries were affected, and so such excess supply at the EU level might have contributed to larger search costs than those that would have otherwise materialized after the single-country-targeted sanctions.

¹³As in our dataset we do not observe the agents in other markets (e.g., employees, job searchers, suppliers), we limit the analysis to the firms’ choices.

by the part-time employment, a flexible shock absorption tier.¹⁴ We refer an interested reader to the Appendix D, where we describe our economic environment, and Appendix E, where we provide detailed derivations. In this Section, we sketch key open economy relationships and then discuss the resulting implications.

4.1 Primitives

We employ a simplified version of the economic environment similar to Helpman et al. (2010).¹⁵ We allow for J varieties overall, and index a particular one by j . As is usual, we use the constant elasticity of substitution (CES) preferences structure, where parameter σ governs the elasticity of substitution between varieties.

A firm takes consumers' choices as given and solves its profit maximization problem, also taking the technology into account. The production function for a variety j is given by:

$$q_t(j) = \left(K_t^\psi(j) (L_t^F(j))^{1-\psi} \right)^\phi (L_t^P(j))^{1-\phi}, \quad (3)$$

where the produced and demanded quantity $q_t(j)$ coincides in equilibrium. The functional form is assumed to be identical across all firms producing varieties $j \in J$; ϕ , ψ denote distribution (share) parameters. As is standard, $q_t(j)$ denotes quantity, $K_t(j)$ capital, $L_t^F(j)$ full-time employment and $L_t^P(j)$ part-time employment. A simplifying assumption of the unitary elasticity of substitution across inputs helps us clarify key channels and arrive at the closed-form solutions.¹⁶ We abstract away from interactions between full-time and part-time

¹⁴We consider that part-time workers have lower firing costs. In Lithuania, statutory severance pay differs between permanent and fixed-term contracts. According to the Eurostat's Structure of Earnings Survey in Lithuania, in 2014 part-time employees were three times more likely to hold the fixed-term contract as compared to the full-time employees.

¹⁵However, we abstract from the demand and fixed costs heterogeneity, unlike Roberts et al. (2018), who, in addition to prices and destination patterns, also exploit data on quantity, which we do not observe. Roberts et al. (2018) find that demand shifters and marginal costs are key drivers of observed variation in the revenue share and the intensive margin of trade, which also constitute our focus.

¹⁶Please see Appendix E.3 for a more general case with the two-part production function, $q_t(j) = (\psi K_t^\gamma(j) + (1-\psi)(L_t^F(j))^\gamma)^{\frac{\phi}{\gamma}} (L_t^P(j))^{1-\phi}$, $0 < \phi < 1$, $0 < \psi < 1$, $\gamma \leq 1$ (see, for instance, Goldin and Katz (1998), Krusell et al. (2000)). In such a case, the elasticity of substitution between full-time employment and capital is $\epsilon_{K,L^F} = \frac{1}{1-\gamma}$ but it is unitary between the part-time employment and the other two inputs, i.e., $\epsilon_{K,L^P} = \epsilon_{L^F,L^P} = 1$. Since the additional parameter, γ , capturing imperfect substitutability

labor markets, assuming that they are separate. Before turning to key mechanisms, we first clarify how trade impacts firm production.

4.2 Trade

In addition to selling to the domestic market, a firm exports a fraction of its good after covering a fixed cost of exporting, $f_x > 0$. Additionally, in order for one unit to arrive in the foreign market, a firm faces an iceberg variable trade cost, $\tau(j) > 1$, denominated in units of a variety. Again, variable trade costs are firm-specific, showing, for example, efficiency in transporting goods, accessing customs, or managing a distribution network. The total production is then split between the domestic market: $q_t^d(j)$ and the export market $q_t^x(j)$, so that the firm's marginal revenues are equated in the two markets. Note that unlike [Helpman et al. \(2010\)](#), where production shares for export and domestic markets within firms are identical, in our setting trade cost heterogeneity generates varying (firm-specific) proportions of export production.

We denote the firm's market access variable by $\Upsilon_t(j)$ or, more precisely, by $\Upsilon_t(j) - 1$. $\Upsilon_t(j) - 1$ captures the share of exports over domestic revenue:

$$\Upsilon_t(j) \equiv 1 + \tau_{RU,t}^{1-\sigma}(j) \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma + s_{RW,t}^x(j) \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \geq 1, \quad (4)$$

where trade partners are allowed to be Russia (RU) and the rest of the world (RW), and thus $A_{RU,t}$ and $A_{RW,t}$ correspond to the respective demand shifters. As we consider only those firms that are exporters to Russia (i.e., firms *conditional* on exporting to Russia), we model the rest of the world using the share function, $s_{RW,t}^x(j)$, which captures the coverage of all remaining world markets under a trade costs symmetry assumption and provides a close and transparent connection to the data (see [Appendix D](#) for details).

between part-time labor and the mix of full-time labor and capital, cannot be reliably inferred from our data and also some solutions would require approximations, we stick to the Cobb-Douglas specification to demonstrate the key mechanism for our baseline analysis.

4.3 Optimal Choices and Constraints

Since factor installment, legal environment, and contractual obligations entail time rigidities, a firm engages in a dynamic planning and optimizes by taking into account a constant discount rate ρ . A firm decides on the optimal level of full-time labor next period $L_{t+1}^F(j)$ (and thus a change in full-time employment stock this period, $H_t^F(j)$), part-time labor $L_t^P(j)$, capital stock next period $K_{t+1}(j)$ (and thus investment this period, $I_t(j)$), and the sales to other markets but Russia, $s_{RW,t}^x(j)$.

A firm faces full-time labor adjustment costs, embedded in the function $\Phi^L(L_t^F(j), H_t^F(j))$. Reflecting the institutional setup, we assume that hiring and firing costs per each full-time employee, h and f , respectively, are constant across all firms. Hence, $\Phi^L(L_t^F(j), H_t^F(j)) = hH_t^F(j)\mathbb{I}_{\Delta L_t^F(j)>0} - fH_t^F(j)\mathbb{I}_{\Delta L_t^F(j)<0}$, where an indicator function \mathbb{I} turns to one when the respective subscript condition is true (i.e., when a firm hires or fires full-time labor) and assumes value zero otherwise. As described earlier, part-time labor is cheaper to adjust for Lithuanian firms, and we simplify analysis by assuming costless adjustment. Regarding capital adjustment, we assume that capital takes time to be installed and become productive. It depreciates at a rate δ , i.e., it follows the standard law of motion, $I_t(j) = K_{t+1}(j) - (1 - \delta)K_t(j)$.¹⁷

We denote the shadow value of full-time labor by $\mu_t(j)$. It embodies an inter-temporal optimization where a current value of full-time employment is equal to the discounted value of the marginal value of full-time employment,¹⁸ discounted wage, and future value of full-time employment. Since a decision today realizes only next period due to the lengthy search for employees, discounting affects the current value (and thus the optimal action). As full-time labor can be hired or fired with a lag due to search and other frictions, the net variation in full-time employment, $H_t^F(j)$, can be positive, negative or zero, and result in the new

¹⁷Otherwise, we abstract from the adjustment costs of investment, thus marginal (revenue) product of capital refers to marginal product of capital and additional revenue, both evaluated next period and discounted, as well as depreciation rate.

¹⁸Marginal product tells how much output gets reduced by marginally reducing employment and then multiplying it by the price of (the last unit of) production.

labor stock $L_{t+1}^F(j)$ next period. This adjustment mechanism introduces non-convexities and thus intervals of optimal inaction, as covered in [Bentolila and Bertola \(1990\)](#). The part-time employment can be adjusted more quickly and costlessly, equating wage w_t^P with the marginal (revenue) product of part-time labor.

Lastly, since we analyze only those firms that exported to Russia before the shock, we obtain the optimal intensive margin of trade with the rest of the world, $s_{RW,t}^x(j)$, which also links the firm's openness and quantity. We can therefore get an expression for the share of the rest of the world's market using the openness variable, $\Upsilon_t(j)$:

$$s_{RW,t}^x(j) = \frac{q_t(j)}{\tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t}\right)^\sigma \frac{\tau_{RW,t}(j)^\sigma A_t^\sigma (A_{RW,t}^*)^{\frac{\sigma}{1-\sigma}}}{\sigma^{\frac{\sigma}{1-\sigma}} f_x^{\frac{\sigma}{1-\sigma}}}} - \tau_{RW,t}^{\sigma-1}(j) \left(\frac{A_{RW,t}^*}{A_t}\right)^{-\sigma} - \left(\frac{\tau_{RU,t}(j)}{\tau_{RW,t}(j)}\right)^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_{RW,t}^*}\right)^\sigma.$$

Based on the first-order condition for the flexible adjustment margin, namely part-time employment, we can express output as:

$$q_t(j) = [(1 - \phi) \left(\frac{\sigma-1}{\sigma}\right)]^{\frac{\sigma}{1-\sigma}} \Upsilon_t^{\frac{1}{1-\sigma}}(j) A_t^{\frac{\sigma}{1-\sigma}} (w_t^P L_t^P(j))^{\frac{\sigma}{\sigma-1}}.$$

Finally, combining the above expressions, the trade share can be written in an explicit form as:

$$s_{RW,t}^x(j) = (\sigma - 1)^{\frac{\sigma}{1-\sigma}} \left(\frac{w_t^P L_t^P(j)}{1-\phi}\right)^{\frac{\sigma}{\sigma-1}} f_x^{\frac{\sigma}{1-\sigma}} \tau_{RW,t}^{-1}(j) \left(\frac{A_t}{A_{RW,t}^*}\right)^{\frac{\sigma}{1-\sigma}} \Upsilon_t^{\frac{1}{1-\sigma}}(j) - \tau_{RW,t}^{\sigma-1}(j) \left(\frac{A_{RW,t}^*}{A_t}\right)^{-\sigma} - \left(\frac{\tau_{RU,t}(j)}{\tau_{RW,t}(j)}\right)^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_{RW,t}^*}\right)^\sigma. \quad (5)$$

The trade with the rest of the world thus depends on the choice variable, part-time labor, and openness, which is determined by firm-specific variable trade costs. In what follows, we show that even though part-time employment is endogenous, a change can be linked to exogenous factors and a change in trade costs. As long as the change in trade costs is exogenous, so will be the adjustment in part-time labor.

5 Testable Implications

We first discuss what happens with the intensive margin of trade and then turn to implications for the firms experiencing a large trade shock.

5.1 Flexible Adjustment Margin

Using the optimal trade share choice in combination with the optimal part-time employment, we can express the intensive margin of trade as:

$$\Upsilon_t(j) = \left(\frac{w^P L_t^P(j)}{1 - \phi} \right) (\sigma - 1)^{-1} \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma f_x^{-1}.$$

Therefore, $\Upsilon_t(j)$ is determined by the part-time labor, which acts as a choice variable in the face of an exogenous shock to trade with Russia. In other words, a change in an intensive margin of trade acts through a direct effect of trade costs and an indirect channel through the flexible adjustment margin, part-time labor. We can therefore conclude that:

$$\frac{\frac{\partial \Upsilon_t(j)}{\partial \tau_{RU,t}(j)}}{\frac{\partial \Upsilon_t(j)}{\partial L_t^P(j)}} = \frac{\partial L_t^P(j)}{\partial \tau_{RU,t}(j)} = \frac{(\sigma - 1)(1 - \sigma) \tau_{RU,t}^{-\sigma}(j) f_x \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma}{\left(\frac{w^P}{1 - \phi} \right) \tau_{RW,t}^{1-\sigma}(j)} < 0, \quad (6)$$

leading to the following result:

Proposition 1. *An exogenous increase in trade costs with Russia induces layoffs of part-time employees. Conditional on exporting to Russia prior to the ban, this effect is larger for larger fixed exporting costs¹⁹ and for lower variable exporting costs to Russia before a shock (in other words, the larger f_x and thus the larger export basket and/or the lower $\tau_{RU,t}(j)$ or the larger the revenue share of exports to Russia, $\mathcal{S}_t^{RU}(j) \equiv \frac{(\tau_{RU,t}(j))^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma}{\Upsilon_t(j)}$, for a given level of intensive margin $\Upsilon_t(j)$).*

Proof. Follows from the equation (6), which is in detail derived in Appendix E.4.1. \square

¹⁹We are conditioning on the firms that are exporters to Russia, therefore higher fixed exporting costs must be associated with larger pre-shock export share to Russia.

Our empirical strategy is thus based on the approximation:

$$\Delta L_t^P(j) \approx \frac{(\sigma - 1)(1 - \sigma) f_x}{\left(\frac{w^P}{1 - \phi}\right)} \left(\frac{A_{RU,t}^*}{A_{RW,t}^*}\right)^\sigma \underbrace{\left(\frac{\tau_{RU,t}(j)}{\tau_{RW,t}(j)}\right)^{1 - \sigma}}_{\text{Rel. trade costs: RU/RW; Rel. change in trade costs w RU}} \underbrace{\frac{\Delta \tau_{RU,t}(j)}{\tau_{RU,t}(j)}}_{\text{Rel. change in trade costs w RU}} \quad (7)$$

A change in part-time labor is solely driven by a change in trade costs, adjusted by the forces exogenous from the firm's perspective. What matters is not only the relative magnitude of a trade costs shock ($\Delta \tau_{RU,t}(j) / \tau_{RU,t}(j)$), but also how large trading costs with Russia are vis-a-vis the rest of the world ($\tau_{RU,t}(j) / \tau_{RW,t}(j)$). As a result, we should look not only at the change in trade costs but also how it affects the entire firm's portfolio, i.e., how small or large exports to Russia have been compared to all other countries. This observation justifies the use of the banned share defined as a ratio of sales of banned products to Russia, compared to the total sales to other destinations.

5.2 Trade Adjustment

Since the openness measure $\Upsilon_t(j)$ in equation (4) may be less intuitive than the immediately observable revenue share of openness, $\mathcal{S}_t^{RW}(j)$, we move on to analyze the key drivers in its adjustment to the Russian trade shock. The response in the revenue share is given by:

$$\begin{aligned} \frac{\partial \mathcal{S}_t^{RW}(j)}{\partial \tau_{RU,t}(j)} &= \frac{1}{(\Upsilon_t(j))^2} \frac{\partial \Upsilon_t(j)}{\partial \tau_{RU,t}(j)} \\ &\times \left[1 - (1 - \sigma) \tau_{RU,t}^{-\sigma}(j) \Upsilon_t(j) \left(\frac{A_{RU,t}^*}{A_t}\right)^\sigma \left(\frac{\partial \Upsilon_t(j)}{\partial \tau_{RU,t}(j)}\right)^{-1} + \tau_{RU,t}^{1 - \sigma}(j) \left(\frac{A_{RU,t}^*}{A_t}\right)^\sigma \right] \quad (8) \\ &= -\frac{\tau_{RU,t}(j)}{\Upsilon_t(j)} \frac{\partial \Upsilon_t(j)}{\partial \tau_{RU,t}(j)} \frac{\mathcal{S}_t^{RW}(j)}{\tau_{RU,t}(j)} > 0, \end{aligned}$$

where the last inequality follows since $\frac{\partial \Upsilon_t(j)}{\partial \tau_{RU,t}(j)} < 0$. We show in Appendix D.2 that the export revenue share collapses to $\mathcal{S}_t(j) = \frac{\Upsilon_t(j) - 1}{\Upsilon_t(j)}$ in a two-country world.

Therefore, notice that a two-country case only has a direct effect, which is negative, $\frac{1}{(\Upsilon_t(j))^2} \frac{\partial \Upsilon_t(j)}{\partial \tau_{RU,t}(j)} < 0$. As shown in equation (8), in a multi-country case, however, the sign switches to a positive one. All else equal, trade reallocation to the rest of the world is larger if a firm's openness sensitivity to trade costs was larger (i.e., a relative trade shock,

$\Delta\tau_{RU,t}(j)/\tau_{RU,t}(j)$, induced a larger adjustment in relative openness, $\Delta\Upsilon_t/\Upsilon_t$,²⁰ trade costs to export to Russia were smaller (lower $\tau_{RU,t}(j)$), and the firm had a larger revenue share of the rest of the world, \mathcal{S}_t^{RW} , to start with.

Proposition 2. *Elasticity of the revenue share of the rest of the world, after an increase in variable trade costs with Russia, is given by:*

$$\frac{\partial\mathcal{S}_t^{RW}(j)}{\partial\tau_{RU,t}(j)}\frac{\tau_{RU,t}(j)}{\mathcal{S}_t^{RW}(j)} = -\frac{\partial\Upsilon_t(j)}{\partial\tau_{RU,t}(j)}\frac{\tau_{RU,t}(j)}{\Upsilon_t(j)} > 0.$$

For each level of openness, the larger the relative trade shock, the larger the adjustment in the revenue share of the rest of the world.

Proof. Follows from the equation (8), which is derived in detail in Appendix E.4.2. \square

As summarized in Table 5, the dollar value of exports in fact increases after a shock to trade costs with Russia, suggesting a rise in revenue share of the rest of the world. Note that the full effect is a combination of a mechanical effect of lower or no trade with Russia and also export reorientation towards other markets. Table 5 reports only the latter effect as it looks at the pre-shock export revenue to non-Russian destinations.

5.3 Large Shock

We are now equipped with the required tools to analyze costly adjustment margins. Since a small and temporary shock could have been fully absorbed by the flexible adjustment margin and shifting exports to other destinations but Russia, we introduce a concept of a *large shock*, which necessitates costly adjustment margins by a firm. We start with clarifying the concept of a large shock.

According to the full-time labor adjustment cost function $\Phi^L(L_t^F(j), H_t^F(j))$, the full-time labor shadow value varies in the interval $h \geq \mu_t(j) \geq -f$, with the equality constraint

²⁰Recall that $\frac{\Delta\Upsilon_t(j)}{\Delta\tau_{RU,t}(j)} \approx (1 - \sigma)\tau_{RU,t}^{-\sigma}(j)\left(\frac{A_{RU,t}^*}{A_t}\right)^\sigma$. Hence, a change in openness is also caused by exogenous factors as long as a change in trade costs can be argued to be exogenous.

binding when hiring or firing occurs. To illustrate the mechanism and find a closed-form solution, we consider a state space reduction into two discrete states – good and bad. In the former case, a firm hires new full-time staff whereas in the latter – it lays off current full-time employees. Our definition of a large shock considers only those shocks that surpass the thresholds of hiring and firing. That is, due to non-convexities, if a shock is small and does not surpass a required threshold of hiring and firing, the optimal strategy in terms of full-time labor is inaction.

Let the transition probability of moving between good and bad states be p , whereas with probability $1 - p$ the state remains the same in the next period. For instance, a degenerate probability of no change implies $1 - p = 1$, and thus a firm is permanently stuck in the current state. Note that we do not explicitly model the probability parameter as a stochastic process or endogenize it, which can reflect firm’s capabilities in forecasting future events, past experience or severity of a shock.²¹

Using the first-order conditions for the full-time labor, describing marginal revenue and marginal costs, and summarized by the shadow values $\mu_t(j)$, we can find an implicit expression for the optimal full-time labor stock next period. In essence, we can exploit the two states since a shadow value in a bad state will be related to a shadow value in a good state and the other way round. Finally, using the production function and the relationship between part-time labor and openness variable, we end up with

$$\left(L_{t+1}^{F-}(j)\right)^{(1-\psi)\phi\frac{\sigma-1}{\sigma}-1} = \Psi_{t+1}\tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}(j)K_{t+1}(j)^{-\psi\phi\frac{\sigma-1}{\sigma}}\left(L_{t+1}^P(j)\right)^{-(1-\phi)\frac{\sigma-1}{\sigma}-\frac{1}{\sigma}}, \quad (9)$$

where L_{t+1}^{F-} stands for the optimal full-time labor under a negative shock (firing) and Ψ_{t+1} is a time-varying term, exogenous from the perspective of a firm.²²

²¹The persistence of the state can be explicitly modeled by an autoregressive process and richer state space but we merely treat it as one of the reasons behind an increase in the probability of a bad state remaining bad in the next period.

²²See Appendix D.4 for the description and Appendix E.4.3 for the precise expression and derivation. To simplify expressions, we normalized hiring costs to $h = 0$.

Before learning how full-time employment adjusts, we first solve for the capital choice. From the first-order conditions,²³ we get:

$$K_{t+1}(j) = \left(\frac{w^P}{1-\phi} \right) (\sigma-1)^{-1} f_x^{-1} \frac{\rho f_x \phi \psi (\sigma-1)}{1-\rho+\delta\rho} L_{t+1}^P(j), \quad (10)$$

thereby yielding

$$I_t(j) = \left(\frac{w^P}{1-\phi} \right) \frac{\rho}{1-\rho} \phi \psi \Delta L_{t+1}^P(j) \quad (11)$$

where, for exposition purposes, we assume depreciation to be equal to zero, $\delta = 0$.

Proposition 3. *A forward-looking firm reduces investment proportionally to a forthcoming drop in part-time employment.*

Proof. Follows from the investment equation (11), which is derived in Appendix E.4.4. See also equation (6) where the relationship between trade costs and part-time employment is established. \square

Table 4 provides empirical support for the Proposition 3: firms cut investment early on with no significant effect in later periods. A change in the part-time employment acts a measure of the shock severity. Since expansion to the new export markets is lengthy and costly, whereas full time labor and capital are costlier adjustment margins, a change in part-time labor becomes an indicator of investment plans.

Finally, taking into account capital adjustment in equation (10), we can re-express labor adjustment equation (9) in terms of the flexible adjustment margin, part-time employment, and exogenous (from the perspective of a firm) variables:

$$(L_{t+1}^{F-}(j))^{(1-\psi)\phi\left(\frac{\sigma-1}{\sigma}\right)-1} = \tilde{\Psi}_t \tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}(j) (L_{t+1}^P(j))^{-\frac{1}{\sigma}([1-\phi+\psi\phi](\sigma-1)+1)}, \quad (12)$$

where $\tilde{\Psi}_t$ is a mix of aggregate and exogenous terms (see Appendix E.4.5). A new (lower) level of full-time employees is driven by variable trade costs with other countries except for

²³See equation (E15) in the Appendix E.3.

Russia and part-time employees present with a firm at the time of full-time employment adjustment. As in Bertola (2004), under a strictly diminishing marginal productivity of inputs, an interior solution would require that firms have a higher full-time labor stock in a good state. It is clear that the larger the firing and hiring costs, the larger the opportunity costs, and thus the wedge between marginal values, making a strategy of hoarding labor more likely. We summarize this finding as follows:

Proposition 4. *Contingent on the decision to fire full-time employees, the layoffs are more likely to be larger (i.e., there is a decrease in $L_{t+1}^{F-}(j)$ or an increase in $(L_{t+1}^{F-}(j))^{(1-\psi)\phi\frac{\sigma-1}{\sigma}-1}$ since $(1-\psi)\phi\frac{\sigma-1}{\sigma} < 1$), the higher the firm's variable costs to trade with the rest of the world, the smaller the stock of part-time employment, and a bad state is more likely to persist (higher $1-p$).*

Proof. Follows from the equation (12), which is derived in Appendix E.4.3. As for the first claim, higher $\tau_{RW,t+1}$ leads to a larger full-time labor adjustment. To establish the second claim, notice that $(1-\psi)\phi\frac{\sigma-1}{\sigma} < 1$ as ψ , ϕ , and $\frac{\sigma-1}{\sigma}$ are all strictly between zero and one. The power of part-time employment is negative, i.e., $-\frac{1}{\sigma}([1-\phi+\psi\phi](\sigma-1)+1) < 0$ since $[1-\phi+\psi\phi](\sigma-1)+1 > 0$ or $(1-\psi)\phi < \frac{\sigma}{\sigma-1}$, which is always the case since ψ , ϕ are between zero and one, whereas $\sigma > 1$, hence, $\frac{\sigma}{\sigma-1} > 1$. As for the last claim, Ψ_{t+1} is an increasing function of $1-p$. □

Recall that, even though a level of part-time employment is an endogenous firm's choice, a change, for a given level of part-time workers, is driven by exogenous factors (e.g. an unexpected change in trade costs due to political reasons), as summarized in equation (7). This insight underlies our ensuing empirical strategy.

6 Discussion and Additional Empirical Results

6.1 Mechanism's Implications

Before moving to the additional empirical evidence, we take stock of the main theoretical implications. First, as Proposition 1 indicates, an exogenous increase in trade costs with Russia induces layoffs of part-time employees. This effect is larger, the larger the revenue share of exports to Russia had been before a shock. An implication is that if a shock is large relative to the flexible labor margin (part-time employment) and/or considered to be persistent (i.e., lost access to the Russian market in the future periods), it triggers other adjustments: further inputs reductions and export re-direction to other markets.

Regarding the latter, we saw that export re-orientation to the rest of the world, i.e., an increase in the trade share with the rest of the world, is larger for a larger trade shock. In other words, a larger exposure to the Russian market makes producers search for alternative routes, other factors being held constant (see Proposition 2).

When it comes to timely and costly adjustment margins, Propositions 3 and 4 suggest that investment drops by more, the larger the part-time employment adjustment, whereas the layoffs of full-time labor are more likely the larger and more persistent was the shock and the larger was the part-time employment adjustment.

Starting by adjusting on the margin with no adjustment costs, i.e., part-time labor, larger shocks trigger forward-looking firms to pursue other adjustments, i.e., investment. When the shocks turn out to be large and persistent, firms also adjust the margin with non-convex adjustment costs, i.e., full-time labor. There are two types of firms that engage in costly adjustments. First, conditional on other actions such as new markets search, firms hit by a large shock engage in front-loading of future adjustments costs. Second, some firms engage in costly adjustments later since the original shock turns out to be more persistent than expected, thereby necessitating changes in capital and full-time labor. The non-action in the first period following the shock can be optimal from the perspective of a temporary shock, which

could have been sufficiently small to be absorbed by a flexible input in the first period, but could force a firm to recalculate its response in case of the unforeseen persistence of the bad shock. In fact, under such circumstances a firm faces more depleted part-time staff and is thus more likely to change its full-time labor and capital.

6.2 Further Empirical Evidence

Our conceptual framework suggests that the adjustments on other margins depend on such parameters as heterogeneity in the variable exporting costs to Russia and to the rest of the world, time preferences, expected probability of the shock persistence, and various adjustment costs. Thus, while our theoretical framework demonstrates that the firm’s response to the unanticipated shocks is likely to be heterogeneous depending on these parameters, such heterogeneity might be challenging to capture empirically for the econometrician with limited data.

At the same time, as the model implies, such heterogeneity can be expressed by how strongly the firm adjusts on its most flexible adjustment margin, the part-time labor. Thus, one way to test the theory is to track a change in part-time employment caused by an exogenous change in trade costs with Russia and see whether it is a relevant statistic of subsequent adjustments within a firm. Hence, we now present empirical results on whether the same firms that adjust part-time labor also follow other adjustments.

In particular, we add additional interaction of the change in part-time employees over 2014-2015 to our dynamic specification (2):

$$\begin{aligned} \Delta Y_{i,t} = & \beta_1 \times \text{Banned export share}_i \times \text{Post2014}_t + \\ & \beta_2 \times \text{Banned export share}_i \times \text{Post2016}_t + \\ & \beta_2 \times \text{Banned export share}_i \times \Delta \text{Part time change}_i \times \text{Post2016}_t + \gamma_i + \tau_t + \epsilon_{i,t} \end{aligned} \tag{13}$$

In this specification, $\Delta \text{Part time change}_i$ refers to the difference in the change of part-time

employees between 2013 and 2014, where the difference is taken between the values of a treated firm i and its matched control firm. All other variables are defined as in specifications (1) and (2).

We report the results in Table 6, where we show that the adjustment in full-time employees and investment over 2016-2017 was larger for firms that had a larger cut in part-time employees between 2013-2014, as compared to the respective change in the control firms. That is, firms that experienced larger trade shock and consequently laid off more part-time employees, as captured by the triple interaction term, also engaged in larger layoffs of full-time labor and reductions in investment.

Table 6: Interaction with the change in part-time employees

	(1)	(2)
	Full-time employees	Investment
Banned export share x Post 2014	-128.022 (154.568)	-26.798* (13.679)
Banned export share x Post 2016	-484.914* (271.284)	7.230 (15.670)
Delta Part Time (2014-2015) x Post 2016	-0.896 (1.379)	-0.097 (0.077)
Banned export share x Delta Part Time (2014-2015) x Post 2016	22.104*** (7.738)	0.744* (0.408)
Constant	142.967*** (15.420)	-1.056 (1.839)
R ²	0.963	0.603
N	149	125

Notes: This table shows the effect of the Russian ban on the number of employees in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that has exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variables are the difference in the number of full-time employees (Column 1) and investment (Column 2) between the treated and control firms. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

These findings suggest that the firms were facing heterogeneity in terms of their adjustment margins. They also bring a broader takeaway from our paper: that when the expected permanence of the shock and the adjustment margins are not fully observable, one proxy that

could capture the full extent of the shock exposure of the firm with perfect foresight is its adjustment on the most flexible margin. While *Banned export share* captures the observable part of the effect, the heterogeneity of the adjustments might differ across firms due to firm differences in their perceived permanence and persistence of the shock. Firm adjustments on the most flexible margin thus reveal their expectations of their own exposure to the shock.

This insight brings us to the policy implications. To prevent costly layoffs of full-time labor, firms could face lower shadow costs of keeping employees on the payroll if a government subsidized wage costs. Part-time labor acts as an important shock absorber but that requires smooth and fast reallocation across fired labor, effective and accessible training policies, and labor market regulation admitting different types of work contracts.

Finally, we conduct the same analysis as above but instead condition on the openness margin, as discussed in Section 5.1 and Proposition 2. In the spirit of the specification (13), we add an additional interaction term of the change in dollar value of exports outside of Russia between 2013 and 2014 to our dynamic specification. In line with our predictions in Section 4, in Appendix C we find that the adjustment in full-time employees over 2016-2017 was smaller for firms that had a larger increase in exports outside of Russia between 2013 and 2014, as compared to the respective change in the control firms. When the shock turns out to be severe in terms of its persistence and expected cumulative effect, firms lay off full-time labor. However, those firms that managed to increase the reach of export markets outside of Russia reduced full-time employment less. This suggests another policy implication: trade deregulation and setting up the infrastructure to direct exports to more diverse foreign markets can help absorb trade shocks.

7 Conclusions

We investigate how firms in a small open economy adjust to a sudden, unanticipated, and permanent negative demand shock coming from the economic sanctions. We explore a unique

event when, due to political reasons, unrelated to trade, the exporters lost access to a major export market. In particular, we look at an abrupt negative trade shock to the food production sector in Lithuania in 2014 after the Russian sanctions on imports from Europe, the US, and some other countries. We use a rich firm-level dataset, which covers all exporters in the country and which allows us to comprehensively quantify the adjustment margins.

We look at the sample of all Lithuanian firms over 2011-2017, and first show that indeed the exports to Russia and consequently the total revenues dropped after 2013 for those food manufacturers that had substantial exports to Russia prior to the trade ban. We then estimate reduced form difference-in-differences estimation, comparing the adjustments of the affected versus unaffected food exporters. We find that part-time employment drops first and we see further adjustments in full-time employment, capital investment, and the expansion to markets outside of Russia. This suggests that if flexible adjustment margins are limited, food manufacturers might embark on finding new markets.

Based on these observations, we sketch a theoretical framework which explicitly considers an important adjustment margin, the employment of part-time workers. We show that part-time employment, as the most flexible margin, adjusts first. The further adjustments depend on the size of the shock and the expectations of persistence. In case of a larger shock, the full-time employment and capital also adjust. Moreover, if the shock is large enough that flexible adjustment margins are exhausted, the firms might revert to revenue-increasing strategies.

This conceptual set-up suggests additional theoretical predictions that we confirm in the data. Indeed, we see that food manufacturing firms which were quick to reduce part-time employees first, also reduced their full-time employees later on and dropped investment. These results suggest that firm adjustment on the most flexible margin can capture its expected permanence of shock when such heterogeneity is not directly observable.

Understanding the full scale of adjustments that are implemented in response to cleanly identified exposure to the economic sanctions can guide economic policy makers in deciding which alterations to policy making should be done on their behalf. This is particularly

important because any adjustment is likely to result in aggregate economic effects and might even generate feedback loops with further uncertainty.

Our results thus contribute to the literature on the most efficient ways to react to such shocks, which may have implications for labor and trade market reforms. For instance, at times of global uncertainty, more flexible work contracts could help absorb unexpected demand shocks. Such contracts could also allow firms to be more confident in their ex ante hiring decisions. Ensuring access to wide exports markets could also mitigate the risks that result from the unexpected loss of a large trade partner.

One could be concerned about the external validity of our findings given a unique composition of Lithuanian economy and its institutional environment. Indeed, every sanctions' package might be different²⁴ and thus our paper contributes with the empirical evidence on how the firms respond to one particular set of sanctions in an environment with flexible labor policies. While this particular episode might be unique, one way to build a broader picture how firms react to external trade shocks would be to study a wide range situations and with this paper we provide one piece to this puzzle.

²⁴See, e.g., estimates of macroeconomic and political effects of trade restrictions with Iran ([Dizaji and van Bergeijk 2013](#)), the effects on Danish firms in the aftermath of the Danish cartoon crisis ([Hiller et al. 2014](#), [Friedrich and Zator 2019](#)), or the effects of Russia's sanctions on firms in Western European countries ([Crozet and Hinz 2020](#), [Klomp 2020](#), [Crozet et al. 2021](#)).

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A Appendix: Banned Product List

Table A1: Banned products

HS code	Description
0201	Meat of bovine animals, fresh or chilled
0202	Meat of bovine animals, frozen
0203	Meat of swine, fresh, chilled or frozen
0207	Meat and edible offal of fowls of the species <i>Gallus domesticus</i> , ducks, geese, turkeys and guinea fowls, fresh, chilled or frozen
0210	Meat and edible offal, salted, in brine, dried or smoked; edible flours and meals of meat or meat offal
03	Fish and crustaceans, molluscs and other aquatic invertebrates
0401	Milk and cream, not concentrated nor containing added sugar or other sweetening matter
0402	Milk and cream, concentrated or containing added sugar or other sweetening matter
0403	Buttermilk, curdled milk and cream, yogurt, kephir and other fermented or acidified milk and cream, whether or not concentrated or flavoured or containing added sugar or other sweetening matter, fruit, nuts or cocoa, and yogurt may additionally contain chocolate, spices, coffee, plants or cereals
0404	Whey, whether or not concentrated or containing added sugar or other sweetening matter; products consisting of natural milk constituents, whether or not containing added sugar or other sweetening matter, n.e.s.
0405	Butter, incl. dehydrated butter and ghee, and other fats and oils derived from milk; dairy spreads
0406	Cheese and curd
07	Edible vegetables and certain roots and tubers
08	Edible fruit and nuts; peel of citrus fruit or melons, except for 0812
1601	Sausages and similar products, of meat, meat offal, blood or insects; food preparations based on these products
19019011	Malt extract with a dry extract content of $i=90\%$
19019091	Food preparations of flour, groats, meal, starch or malt extract (...)
21069092	Food preparations, n.e.s., not containing milkfats, sucrose, isoglucose starch or glucose
21069098	Food preparations, n.e.s.

Notes: The table provides a list of agricultural products, raw materials and foodstuffs originating from the United States, European Union countries, Canada, Australia and, Norway, and that were banned for imports to the Russian Federation on August 6, 2014.

B Appendix: Robustness Tests

Table B1: Number of hours

	(1)	(2)	(3)	(4)
	Part-time hours		Full-time hours	
Banned export share x Post 2014	-112.657*** (42.458)	-81.330** (39.657)	-760.604** (332.419)	-364.107 (308.019)
Banned export share x Post 2016		-80.719 (56.313)		-1021.639* (560.785)
Constant	18.992*** (3.793)	18.944*** (3.784)	210.729*** (29.558)	210.126*** (29.733)
R ²	0.674	0.681	0.949	0.952
N	151	151	151	151

Notes: This table shows the effect of the Russian ban on the hours worked by employees in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variable is then the difference in the number of either part-time hours (Columns 1-2) or full-time hours (Columns 3-4) between the treated and control firms. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

Table B2: Entropy balancing

	(1)	(2)	(3)	(4)
	Part-time employees		Full-time employees	
Banned export share x Post 2014	-143.747** (55.925)	-122.597** (53.468)	-270.542* (160.962)	-41.540 (146.134)
Banned export share x Post 2016		-53.032 (54.577)		-574.221** (287.580)
Constant	25.741*** (4.913)	25.712*** (4.911)	107.988*** (16.285)	107.677*** (16.555)
R ²	0.732	0.734	0.937	0.941
N	151	151	151	151

Notes: This table shows the effect of the Russian ban on the number of employees in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variable is then the difference in the number of either part-time employees (Columns 1-2) or full-time employees (Columns 3-4) between the treated and control firms. The first-differences observations are reweighted by balancing the first two moments of distributions of firm sales across the treated and control group in 2012. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

Table B3: Dummy treatment

	(1)	(2)	(3)	(4)
	Part-time employees		Full-time employees	
High banned export share x Post 2014	-19.415*** (6.726)	-17.423*** (6.261)	-58.332** (27.378)	-10.816 (23.298)
High banned export share x Post 2016		-5.756 (8.490)		-137.309** (54.037)
Constant	24.327*** (4.643)	24.311*** (4.645)	141.528*** (16.963)	141.149*** (17.083)
R ²	0.742	0.743	0.952	0.957
N	151	151	151	151

Notes: This table shows the effect of the Russian ban on the number of employees in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variable is then the difference in the number of either part-time employees (Columns 1-2) or full-time employees (Columns 3-4) between the treated and control firms. Instead of a continuous variable as in Table 3, *High banned export share* is defined as a dummy equal to one if the *Banned export share* is larger than 3%. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

Table B4: Surviving firms

	(1)	(2)	(3)	(4)
	Part-time employees		Full-time employees	
Banned export share x Post 2014	-152.426*** (50.846)	-131.323*** (48.748)	-386.130** (182.749)	-117.405 (165.680)
Banned export share x Post 2016		-52.413 (52.868)		-667.427** (315.623)
Constant	23.841*** (4.766)	23.816*** (4.773)	149.633*** (18.222)	149.312*** (18.454)
R ²	0.756	0.758	0.953	0.956
N	141	141	141	141

Notes: This table shows the effect of the Russian ban on the number of employees in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variable is then the difference in the number of either part-time employees (Columns 1-2) or full-time employees (Columns 3-4) between the treated and control firms. In this analysis, we condition on the firm surviving until 2017. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

C Appendix: Further Empirical Evidence

In addition to the main channel discuss in the main text, another policy-relevant dimension is firms' ability to adjust towards finding new export markets. In the spirit of the specification (13), we add an additional interaction of the change in dollar value of exports outside of Russia between 2013 and 2014 to our dynamic specification:

$$\begin{aligned}\Delta Y_{i,t} = & \beta_1 \times \text{Banned export share}_i \times \text{Post2014}_t + \\ & \beta_2 \times \text{Banned export share}_i \times \text{Post2016}_t + \\ & \beta_2 \times \text{Banned export share}_i \times \Delta \text{NonRu export change}_i \times \text{Post2016}_t + \gamma_i + \tau_t + \epsilon_{i,t}.\end{aligned}\tag{C1}$$

In this specification, $\Delta \text{NonRu export change}_i$ refers to the difference in the change of exports outside of Russia between 2013 and 2014, where the difference is taken between the values of a treated firm i and its matched control firm. All other variables are defined as in specifications (1) and (2).

We report the results in Table C1, where we show that the adjustment in full-time employees over 2016-2017 was smaller for firms that had a larger increase in exports outside of Russia between 2013 and 2014, as compared to the respective change in the control firms. See the main text for the discussion of the main policy implications from this finding.

Table C1: Interaction with the change in exports outside of Russia

	(1) Full-time employees
Banned export share x Post 2014	-128.022 (163.557)
Banned export share x Post 2016	-546.798** (261.905)
Banned export share x Delta Non-Ru Exports (2013-2014) x Post 2016	25.454* (13.311)
Delta Non-Ru Exports (2013-2014) x Post 2016	-0.951 (1.053)
Constant	142.975*** (16.655)
R ²	0.958
N	149

Notes: This table shows the effect of the Russian ban on the number of employees in Lithuanian food manufacturing firms over 2011-2017. For each *treated* firm that has exported any banned products to Russia in 2013, we assign one *control* firm that is a food exporter, and is closest in size (as measured by total sales). The dependent variable is the difference in the number of full-time employees between the treated and control firms. ***, **, and * refer to the statistical significance at 1%, 5%, and 10%, respectively.

D Appendix: Conceptual Framework

The objective of this section is to set out a theoretical framework at a more conceptual level, leaving more technical details for the Appendix E. The theory helps us interpret empirical results as well as elucidate assumptions, channels, and implications consistent with the empirical findings.

D.1 Preferences and Technology

The real consumption index (Q_t) is defined as follows:

$$Q_t = \left[\int_{j \in J} q_t(j)^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1, \quad (\text{D1})$$

where j indexes varieties; J is the set of all varieties; $q_t(j)$ denotes consumption of variety j ; and σ governs the elasticity of substitution between varieties. The dual price index for the differentiated sector (P_t) is given by:

$$P_t = \left[\int_{j \in J} p_t(j)^{1-\sigma} dj \right]^{\frac{1}{1-\sigma}}. \quad (\text{D2})$$

Then it follows that the domestic demand for variety j is:

$$q_t(j) = \left(\frac{p_t(j)}{P_t} \right)^{-\sigma} Q_t = \left(\frac{A_t}{p_t(j)} \right)^{\sigma}, \quad (\text{D3})$$

where $A_t \equiv Q_t^{\frac{1}{\sigma}} P_t$ is a demand-shifter, similarly to [Helpman et al. \(2010\)](#). Refer below to the Appendix E.1 for a more detailed derivation.

A firm takes consumers' choices as given. Given the specification of the demand, the equilibrium revenues of a firm are:

$$r_t(j) \equiv p_t(j) q_t(j) = A_t q_t(j)^{\frac{\sigma-1}{\sigma}} = p_t(j)^{1-\sigma} A_t^{\sigma}. \quad (\text{D4})$$

The production function is given by:

$$q_t(j) = \left(K_t^{\psi}(j) (L_t^F(j))^{1-\psi} \right)^{\phi} (L_t^P(j))^{1-\phi}, \quad (\text{D5})$$

where the functional form is assumed to be identical across all firms producing varieties $j \in J$; ϕ, ψ denote distribution (share) parameters. As is standard, $q_t(j)$ denotes quantity, $K_t(j)$ capital, $L_t^F(j)$ full-time employment and $L_t^P(j)$ part-time employment. A simplifying assumption of the unitary elasticity of substitution across inputs helps us clarify key channels and arrive at the closed-form solutions.

D.2 Openness

Building on the above economic structure of preferences and technology, we move to the firm's choice to trade. Based on equation (D3), the domestic quantity satisfies $q_t(j) = \left(\frac{A_t}{p_t(j)}\right)^\sigma$ and it follows that a foreign consumer faces a price $\tau(j) p_t(j)$, whereas a domestic producer has to produce $\tau(j) > 1$ units for $\left(\frac{A_t^*}{\tau(j) p_t(j)}\right)^\sigma$ quantity to arrive to the foreign market:

$$q_t^x(j) = \tau(j) \left(\frac{A_t^*}{\tau(j) p_t(j)}\right)^\sigma,$$

where A_t^* is the foreign demand shifter, $A_t^* \equiv Q_t^{*\frac{1}{\sigma}} P_t^*$.

This expression yields $\left(\frac{q_t^x(j)}{q_t^d(j)}\right)^{\frac{1}{\sigma}} = \tau_t^{\frac{1-\sigma}{\sigma}}(j) \left(\frac{A_t^*}{A_t}\right)$. And, lastly, we can express total quantity as:

$$\begin{aligned} q_t(j) &\equiv q_t^d(j) + \mathbb{I}_t^x(j) q_t^x(j) = q_t^d(j) + \mathbb{I}_t^x(j) \left[\tau_t^{\frac{1-\sigma}{\sigma}}(j) \left(\frac{A_t^*}{A_t}\right)\right]^\sigma q_t^d(j) \\ &= \left[1 + \mathbb{I}_t^x(j) \left(\tau_t^{\frac{1-\sigma}{\sigma}}(j) \left(\frac{A_t^*}{A_t}\right)\right)^\sigma\right] \left(\frac{A_t}{p_t(j)}\right)^\sigma = \Upsilon_t(j) \left(\frac{A_t}{p_t(j)}\right)^\sigma, \end{aligned}$$

and the total revenues of a firm as follows:

$$\begin{aligned} r_t(j) &\equiv p_t(j) q_t(j) \\ &= \left[1 + \mathbb{I}_t^x(j) \tau_t^{1-\sigma}(j) \left(\frac{A_t^*}{A_t}\right)^\sigma\right]^{\frac{1}{\sigma}} A_t q_t^{\frac{\sigma-1}{\sigma}}(j) = \Upsilon_t^{\frac{1}{\sigma}}(j) A_t q_t^{\frac{\sigma-1}{\sigma}}(j). \end{aligned} \tag{D6}$$

The variable $\Upsilon_t(j) - 1$ denotes the market access by a firm, and captures the share of exports over domestic revenue:

$$\Upsilon_t(j) \equiv 1 + \mathbb{I}_t^x(j) \tau_t^{1-\sigma}(j) \left(\frac{A_t^*}{A_t}\right)^\sigma \geq 1, \tag{D7}$$

where $\mathbb{I}_t^x(j)$ is an indicator variable equal to one (zero) if firm j chooses to serve a foreign

market. It is straightforward to extend this setting to more than two foreign countries²⁵ but it suffices to consider two trade partners.

In our case, we refer to them as Russia (RU) and the rest of the world (RW):

$$\Upsilon_t(j) \equiv 1 + \tau_{RU,t}^{1-\sigma}(j) \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma + s_{RW,t}^x(j) \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \geq 1. \quad (\text{D8})$$

We consider only those firms that are exporters to Russia, so there is no indicator function (in other words, we consider firms *conditional* on exporting to Russia). The rest of the world is captured by the share function, $s_{RW,t}^x(j)$, an extensive margin of trade. Unlike a binary choice ($\mathbb{I}_t^x(j)$), and to provide as close and transparent connection as possible to the data, $s_{RW,t}^x(j)$ captures the coverage of all remaining world markets under a trade costs symmetry assumption.²⁶ We denote a share of export revenues (an intensive margin) as:

$$\mathcal{S}_t^{RU}(j) = \frac{\Upsilon_t(j)-1}{\Upsilon_t(j)} - \frac{s_{RW,t}^x(j) \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma}{\Upsilon_t(j)}$$

and

$$\mathcal{S}_t^{RW}(j) = \frac{r_t^{RW}(j)}{r_t^d(j) + r_t^{RU}(j) + r_t^{RW}(j)} = \frac{\Upsilon_t(j)-1}{\Upsilon_t(j)} - \frac{\tau_{RU,t}^{1-\sigma}(j) \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma}{\Upsilon_t(j)}. \quad (\text{D9})$$

In a standard two-country setting, export revenue share collapses to $\mathcal{S}_t(j) = \frac{\Upsilon_t(j)-1}{\Upsilon_t(j)}$. For full details regarding the derivation of quantity, prices and revenues in this three-country setting, please refer to the Appendix E.2 below.

D.3 Optimal Choices

Given the structure outlined above, we summarize firm's optimal choices. Recall that since the focus of our empirical analysis is on the exporters to Russia, we only consider those firms

²⁵If each firm reaches a set of foreign markets, we can generalize: $\Upsilon_t(j) \equiv 1 + \sum_{\ell} \mathbb{I}_{\ell,t}^x(j) \tau_{\ell,t}^{1-\sigma}(j) \left(\frac{A_{\ell,t}^*}{A_t} \right)^\sigma \geq 1$, where $\ell = 1, \dots, \mathcal{L}$.

²⁶One can think of the (normalized) sum as: $\sum_{\ell=1}^{\mathcal{L}} \mathbb{I}_{\ell,t}^x(j) \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma = \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \sum_{\ell} \mathbb{I}_{\ell,t}^x(j)$, where symmetry across foreign markets was assumed. In such a case, $\mathcal{L} \times s_{RW,t}^x(j) = \sum_{\ell} \mathbb{I}_{\ell,t}^x(j)$, and we can thus normalize $\mathcal{L} = 1$.

that have been trading with Russia. As in the data, these firms have a choice to increase exporting to the rest of the world. The per-period profit of a firm is then:

$$\begin{aligned} \pi_t(j) = & \left\{ \left[1 + \tau_{RU,t}^{1-\sigma}(j) \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma + s_{RW,t}^x(j) \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \right]^{\frac{1}{\sigma}} \times \right. \\ & A_t \left((\psi K_t^\gamma(j) + (1-\psi)(L_t^F(j))^\gamma)^{\frac{\phi}{\gamma}} (L_t^P(j))^{1-\phi} \right)^{\frac{\sigma-1}{\sigma}} \\ & \left. - w_t^F L_t^F(j) - w_t^P L_t^P(j) - I_t(j) - \Phi^L(L_t^F(j), H_t^F(j)) - s_{RW,t}^x(j) f_x \right\}, \end{aligned} \quad (D10)$$

where Φ^L stands for a full-time labor adjustment costs function. The other notation is standard: $I_t(j)$ stands for the firm j investment, $H_t^F(j)$ denotes a change in full-time labor stock, and $\Phi^L(L_t^F(j), H_t^F(j))$ takes full-time labor adjustment costs into account. We will assume that hiring and firing costs per each full-time employee, h and f , respectively, are constant across all firms.

A firm engages in a dynamic planning and optimizes by taking into account a constant discount rate ρ :

$$\begin{aligned} & \max_{L_{t+1}^F(j), H_t^F(j), L_t^P(j),} \mathbb{E}_t \sum_{s=t}^{+\infty} \rho^s \pi_s(j) = \\ & \max_{L_{t+1}^F(j), H_t^F(j), L_t^P(j),} \mathbb{E}_t \sum_{s=t}^{+\infty} \rho^s \left\{ \left[1 + \tau_{RU,s}^{1-\sigma}(j) \left(\frac{A_{RU,s}^*}{A_s} \right)^\sigma + s_{RW,s}^x(j) \tau_{RW,s}^{1-\sigma}(j) \left(\frac{A_{RW,s}^*}{A_s} \right)^\sigma \right]^{\frac{1}{\sigma}} \right. \\ & \left. K_{t+1}(j), I_t(j), s_{RW,t}^x(j) \right. \\ & \left. \times A_s \left((\psi K_s^\gamma(j) + (1-\psi)(L_s^F(j))^\gamma)^{\frac{\phi}{\gamma}} (L_s^P(j))^{1-\phi} \right)^{\frac{\sigma-1}{\sigma}} \right. \\ & \left. - w_s^F L_s^F(j) - w_s^P L_s^P(j) - I_s(j) \right. \\ & \left. - \Phi^L(L_s^F(j), H_s^F(j)) - s_{RW,s}^x(j) f_x \right\}, \end{aligned} \quad (D11)$$

subject to the following constraints:

$$I_t(j) = K_{t+1}(j) - (1 - \delta) K_t(j), \quad (\text{D12})$$

$$L_{t+1}^F(j) = L_t^F(j) + H_t^F(j), \quad (\text{D13})$$

$$\Phi^L(L_t^F(j), H_t^F(j)) = hH_t^F(j) \mathbb{I}_{\Delta L_t^F(j) > 0} - fH_t^F(j) \mathbb{I}_{\Delta L_t^F(j) < 0}. \quad (\text{D14})$$

The firm's optimal choices, ignoring variety-specific notation, can be summarized as follows:

$$\begin{aligned} \mu_t &= \rho \left(\Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) q_{t+1}^{\frac{\sigma-1}{\sigma}} (1 - \psi) \phi(L_{t+1}^F)^{\gamma-1} (\Phi_{t+1}^\gamma)^{-1} - w_{t+1}^F + \mu_{t+1} \right), \\ \mu_t &= h \mathbb{I}_{H_t^F > 0} - f \mathbb{I}_{H_t^F < 0}, \\ w_t^P &= \Upsilon_t^{\frac{1}{\sigma}} A_t \left(\frac{\sigma-1}{\sigma} \right) q_t^{-\frac{1}{\sigma}} \frac{\partial q_t}{\partial L_t^P}, \\ \frac{1-\rho+\delta\rho}{\rho} &= \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) q_{t+1}^{-\frac{1}{\sigma}} \frac{\partial q_{t+1}}{\partial K_{t+1}}, \\ q_t^{\frac{1}{\sigma}} &= \frac{\tau_{RW,t} A_t (A_{RW,t}^*)^{\frac{1-\sigma}{\sigma}}}{\sigma^{\frac{1}{1-\sigma}} f_x^{\frac{1}{1-\sigma}}} \Upsilon_t^{\frac{1}{\sigma}} (s_{RW,t}^x; \tau_{RU,t}, \tau_{RW,t}). \end{aligned} \quad (\text{D15})$$

As usual, capital takes time to be installed and become productive and depreciates at a rate δ (see equation (D12)). Otherwise, we abstract from the adjustment costs of investment, thus marginal (revenue) product of capital refers to marginal product of capital and additional revenue, both evaluated next period and discounted, as well as depreciation rate.

D.4 Full-time Labor Adjustment

As covered in the main text, we introduce a concept of a large shock, which necessitates costly adjustment margins by a firm. Recall that we consider a state space reduction into two discrete states – good and bad. Let the transition probability of moving between good and bad states be p , whereas with probability $1 - p$ that the state remains the same in the next period. In the good state change case, a firm hires new full-time staff whereas in the case when a bad state happens – it lays off current full-time employees. Given the full-time labor adjustment cost function in the equation (D14), the full-time labor shadow value varies in the interval $h \geq \mu_t(j) \geq -f$, with the equality constraint binding when hiring or firing

occurs. Whenever a firm hits an action interval, then $\mu_t(j)$ is equal to $-f$ under the adverse shock and h under a favorable shock.

Using the first-order conditions for the full-time labor, summarized by the first two equations of the shadow value $\mu_t(j)$ in Section D.3, we get:

$$-f = \rho \left(\Upsilon_{t+1}^{\frac{1}{\sigma}}(j) A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \underline{q}_{t+1}^{-\frac{1}{\sigma}}(j) \frac{\partial \underline{q}_{t+1}(j)}{\partial L_{t+1}^F(j)} - w_{t+1}^F - (1-p)f + ph \right), \quad (\text{D16})$$

where $\underline{q}_{t+1}(j) \equiv q(L_{t+1}^{F-}(j), L_{t+1}^P(j))$ denotes *reduced* employment levels (thereby implying a negative $H_t^F(j)$). This means that firing is optimal rather than waiting. That coincides with our definition of a large shock, i.e., a situation when the trade disruption is so large that paying firing costs is preferred.²⁷ In a good state:

$$h = \rho \left(\Upsilon_{t+1}^{\frac{1}{\sigma}}(j) A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \bar{q}_{t+1}^{-\frac{1}{\sigma}}(j) \frac{\partial \bar{q}_{t+1}(j)}{\partial L_{t+1}^F(j)} - w_{t+1}^F - pf + (1-p)h \right), \quad (\text{D17})$$

where $\bar{q}_{t+1}(j) \equiv q(L_{t+1}^{F+}(j), L_{t+1}^P(j))$ denotes *increased* employment levels (implying positive $H_t^F(j)$). Manipulating these two expressions and simplifying by the normalization of hiring costs to $h = 0$, we end up with:

$$(L_{t+1}^{F-}(j))^{(1-\psi)\phi\frac{\sigma-1}{\sigma}-1} = \Psi_{t+1} \tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}(j) K_{t+1}(j)^{-\psi\phi\frac{\sigma-1}{\sigma}} (L_{t+1}^P(j))^{-(1-\phi)\frac{\sigma-1}{\sigma}-\frac{1}{\sigma}}, \quad (\text{D18})$$

where Ψ_{t+1} is a time-varying term, exogenous from the perspective of a firm (see Appendix E.4.3 below for the precise expression and derivation).²⁸

²⁷Technically, when μ_t drops below $-f$, an optimizing firm must fire full-time workers and do so until $\mu_t \geq -f$ is restored. That is why we only consider marginal values with equality.

²⁸The term is given by $\Psi_{t+1} \equiv \frac{(-\frac{1}{\rho}f + (1-p(j))f + w_{t+1}^F)(\sigma-1)\frac{1}{\sigma}f x^{\frac{1}{\sigma}}}{A_{RW,t+1}^* \left(\frac{\sigma-1}{\sigma}\right) \left(\frac{w^P}{1-\phi}\right)^{\frac{1}{\sigma}} (1-\psi)\phi}$.

E Appendix: Detailed Derivations

E.1 Demand Derivation

$$\max \left[\int_{j \in J} q_t(j)^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}}, \text{ s.t. } \int_{j \in J} p_t(j) q_t(j) = E_t = P_t Q_t.$$

The first order conditions (FOCs), after setting a Lagrangian, are

$$\begin{aligned} \frac{\sigma}{\sigma-1} \left[\int_{j \in J} q_t(j)^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}-1} \frac{\sigma-1}{\sigma} q_t(j)^{\frac{\sigma-1}{\sigma}-1} - \lambda p_t(j) &= 0 \\ Q_t^{\frac{1}{\sigma}} q_t(j)^{-\frac{1}{\sigma}} - \lambda p_t(j) &= 0 \\ Q_t^{\frac{1}{\sigma}} q_t(j')^{-\frac{1}{\sigma}} - \lambda p_t(j') &= 0 \end{aligned}$$

So, $Q_t^{\frac{1}{\sigma}} q_t(j)^{-\frac{1}{\sigma}} = \lambda p_t(j)$ or $q_t(j)^{-\frac{1}{\sigma}} = \frac{p_t(j)}{Q_t^{\frac{1}{\sigma}}} q_t(j)^{-\frac{1}{\sigma}}$. It follows that $Q_t^{\frac{1}{\sigma}} q_t(j')^{-\frac{1}{\sigma}} = \lambda p_t(j')$

$$\begin{aligned} \int_{j \in J} q_t(j)^{-\frac{1}{\sigma}} p_t(j') q_t(j')^{\frac{1}{\sigma}} q_t(j) dj &= p_t(j') q_t(j')^{\frac{1}{\sigma}} \int_{j \in J} q_t(j)^{\frac{\sigma-1}{\sigma}} dj \\ &= p_t(j') q_t(j')^{\frac{1}{\sigma}} Q_t^{\frac{\sigma-1}{\sigma}} = P_t Q_t \end{aligned}$$

and $q_t(j)^{\frac{1}{\sigma}} = p_t(j)^{-1} P_t Q_t^{\frac{1}{\sigma}}$ or $q_t(j) = p_t(j)^{-\sigma} P_t^{\sigma} Q_t$. An inverse demand function follows immediately:

$$p_t(j) = A_t (q_t(j))^{-\frac{1}{\sigma}}.$$

E.2 Extension to Multiple Countries

For the two foreign countries, the additivity is useful when it comes to expressing a total quantity for an exporter as:

$$\begin{aligned} q_t(j) &\equiv q_t^d(j) + q_t^{RU}(j) + q_t^{RW}(j) \\ &= (p_t(j))^{-\sigma} A_t^{\sigma} \left[1 + \left(\frac{A_{RU,t}^*}{A_t} \right)^{\sigma} \tau_{RU,t}^{1-\sigma}(j) + s_{RW,t}^x(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^{\sigma} \tau_{RW,t}^{1-\sigma}(j) \right] \end{aligned}$$

and inverse demand

$$\begin{aligned} p_t(j) &= (q_t(j))^{-\frac{1}{\sigma}} A_t \left(1 + \left(\frac{A_{RU,t}^*}{A_t} \right)^{\sigma} \tau_{RU,t}^{1-\sigma}(j) + s_{RW,t}^x(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^{\sigma} \tau_{RW,t}^{1-\sigma}(j) \right)^{\frac{1}{\sigma}} \\ &= (q_t(j))^{-\frac{1}{\sigma}} A_t \Upsilon_t(j)^{\frac{1}{\sigma}}, \end{aligned}$$

thereby yielding

$$\begin{aligned}
r_t(j) &\equiv p_t(j) q_t^d(j) + p_t(j) q_t^{RU}(j) + p_t(j) q_t^{RW}(j) = p_t(j) q_t^d(j) \left[1 + \frac{q_t^{RU}(j)}{q_t^d(j)} + \frac{q_t^{RW}(j)}{q_t^d(j)} \right] \\
&= (p_t(j))^{1-\sigma} A_t^\sigma \left[1 + \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \tau_{RU,t}^{1-\sigma}(j) + s_{RW,t}^x(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \tau_{RW,t}^{1-\sigma}(j) \right] \\
&= (q_t(j))^{\frac{\sigma-1}{\sigma}} A_t \left[1 + \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \tau_{RU,t}^{1-\sigma}(j) + s_{RW,t}^x(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \tau_{RW,t}^{1-\sigma}(j) \right]^{\frac{1}{\sigma}}.
\end{aligned}$$

We will denote a share of export revenues (an intensive margin) as

$$\begin{aligned}
\mathcal{S}_t^{RU}(j) &= \frac{\tau_{RU,t}^{RU}(j)}{\tau_{RU,t}^{RU}(j) + \tau_{RU,t}^{RW}(j) + \tau_{RU,t}^{RW}(j)} = \frac{\tau_{RU,t}^{RU}(j) \left(\frac{A_{RU,t}^*}{\tau_{RU,t}^{RU}(j)} \right)^\sigma p_t^{1-\sigma}(j)}{(q_t(j))^{\frac{\sigma-1}{\sigma}} A_t \left[1 + \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \tau_{RU,t}^{1-\sigma}(j) + s_{RW,t}^x(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \tau_{RW,t}^{1-\sigma}(j) \right]^{\frac{1}{\sigma}}} \\
&= \frac{\tau_{RU,t}^{RU}(j) \left(\frac{A_{RU,t}^*}{\tau_{RU,t}^{RU}(j)} \right)^\sigma (q_t(j))^{-\frac{1-\sigma}{\sigma}} A_t^{1-\sigma} \Upsilon_t(j)^{\frac{1-\sigma}{\sigma}}}{(q_t(j))^{\frac{\sigma-1}{\sigma}} A_t \Upsilon_t(j)^{\frac{1}{\sigma}}} = \frac{\tau_{RU,t}^{RU}(j) \left(\frac{A_{RU,t}^*}{\tau_{RU,t}^{RU}(j)} \right)^\sigma A_t^{-\sigma}}{\Upsilon_t(j)} \\
&= \frac{\Upsilon_t(j) - 1 - s_{RW,t}^x(j) \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma}{\Upsilon_t(j)} = \frac{\Upsilon_t(j) - 1}{\Upsilon_t(j)} - \frac{s_{RW,t}^x(j) \tau_{RW,t}^{1-\sigma}(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma}{\Upsilon_t(j)}
\end{aligned}$$

and

$$\begin{aligned}
\mathcal{S}_t^{RW}(j) &= \frac{\tau_{RW,t}^{RW}(j)}{\tau_{RU,t}^{RU}(j) + \tau_{RU,t}^{RW}(j) + \tau_{RW,t}^{RW}(j)} = \frac{s_{RW,t}^x(j) \tau_{RW,t}^{RW}(j) \left(\frac{A_{RW,t}^*}{\tau_{RW,t}^{RW}(j)} \right)^\sigma p_t^{1-\sigma}(j)}{(q_t(j))^{\frac{\sigma-1}{\sigma}} A_t \left[1 + \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \tau_{RU,t}^{1-\sigma}(j) + s_{RW,t}^x(j) \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \tau_{RW,t}^{1-\sigma}(j) \right]^{\frac{1}{\sigma}}} \\
&= \frac{s_{RW,t}^x(j) \tau_{RW,t}^{RW}(j) \left(\frac{A_{RW,t}^*}{\tau_{RW,t}^{RW}(j)} \right)^\sigma (q_t(j))^{-\frac{1-\sigma}{\sigma}} A_t^{1-\sigma} \Upsilon_t(j)^{\frac{1-\sigma}{\sigma}}}{(q_t(j))^{\frac{\sigma-1}{\sigma}} A_t \Upsilon_t(j)^{\frac{1}{\sigma}}} = \frac{s_{RW,t}^x(j) \tau_{RW,t}^{RW}(j) \left(\frac{A_{RW,t}^*}{\tau_{RW,t}^{RW}(j)} \right)^\sigma A_t^{-\sigma}}{\Upsilon_t(j)} \\
&= \frac{\Upsilon_t(j) - 1 - \tau_{RU,t}^{1-\sigma}(j) \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma}{\Upsilon_t(j)} = \frac{\Upsilon_t(j) - 1}{\Upsilon_t(j)} - \frac{\tau_{RU,t}^{1-\sigma}(j) \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma}{\Upsilon_t(j)}.
\end{aligned}$$

It is clear that when $\tau_{RU,t}(j) \rightarrow \infty$, $\mathcal{S}_t^{RU}(j) \rightarrow 0$ and $\mathcal{S}_t^{RW}(j) \rightarrow \frac{\Upsilon_t(j)-1}{\Upsilon_t(j)}$, thereby replicating a two-country world, as in [Helpman et al. \(2010\)](#) (see their footnote 15).

E.3 Optimal Choices

Setting up a Lagrangian in a perfect foresight environment with firm symmetry (to save on notation for each firm j , we abstract from variety/firm-specific notation from now on) yields:

$$\begin{aligned}
\mathcal{L} = \sum_{s=t}^{+\infty} \rho^s \left\{ \left[1 + \tau_{RU,s}^{1-\sigma} \left(\frac{A_{RU,s}^*}{A_s} \right)^\sigma + s_{RW,s}^x \tau_{RW,s}^{1-\sigma} \left(\frac{A_{RW,s}^*}{A_s} \right)^\sigma \right]^{\frac{1}{\sigma}} \times \right. \\
A_s \left(\left(\psi K_s^\gamma + (1-\psi) (L_s^F)^\gamma \right)^{\frac{\phi}{\gamma}} (L_s^P)^{1-\phi} \right)^{\frac{\sigma-1}{\sigma}} \\
-w_s^F L_s^F - w_s^P L_s^P - I_s - h H_s^F \mathbb{1}_{\Delta L_s^F > 0} \\
+f H_s^F \mathbb{1}_{\Delta L_s^F < 0} - s_{RW,s}^x f_x \\
+ \mathbf{q}_s (I_s + (1-\delta) K_s - K_{s+1}) \\
\left. + \mu_s (H_s^F + L_s^F - L_{s+1}^F) \right\}.
\end{aligned}$$

The optimality conditions read as follows:

$$\frac{\partial \mathcal{L}}{\partial L_{t+1}^F} = 0 \Rightarrow -\rho^{t+1} w_{t+1}^F - \rho^t \mu_t + \rho^{t+1} \mu_{t+1} + \rho^{t+1} \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) q_{t+1}^{-\frac{1}{\sigma}} \frac{\partial q_{t+1}}{\partial L_{t+1}^F}$$

$$\mu_t = \rho \left(\Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) q_{t+1}^{-\frac{1}{\sigma}} \frac{\partial q_{t+1}}{\partial L_{t+1}^F} - w_{t+1}^F + \mu_{t+1} \right) \quad (\text{E1})$$

$$\mu_t = \rho \left(\Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) q_{t+1}^{\frac{\sigma-1}{\sigma}} (1-\psi) \phi (L_{t+1}^F)^{\gamma-1} (\psi K_{t+1}^\gamma + (1-\psi) (L_{t+1}^F)^\gamma)^{-1} \right. \\
\left. - w_{t+1}^F + \mu_{t+1} \right) \quad (\text{E2})$$

$$-w_{t+1}^F + \mu_{t+1} \quad (\text{E3})$$

$$\mu_t = \rho \left(\Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) q_{t+1}^{\frac{\sigma-1}{\sigma}} (1-\psi) \phi (L_{t+1}^F)^{\gamma-1} (\Phi_{t+1}^\gamma)^{-1} - w_{t+1}^F + \mu_{t+1} \right) \quad (\text{E4})$$

$$\frac{\partial \mathcal{L}}{\partial H_t^F} = 0 \Rightarrow h \mathbb{1}_{H_t^F > 0} - f \mathbb{1}_{H_t^F < 0} = \mu_t, \quad (\text{E5})$$

$$\frac{\partial \mathcal{L}}{\partial L_{it}^P} = 0 \Rightarrow w_t^P = \Upsilon_t^{\frac{1}{\sigma}} A_t \left(\frac{\sigma-1}{\sigma} \right) q_t^{-\frac{1}{\sigma}} \frac{\partial q_t}{\partial L_{it}^P}, \quad (\text{E6})$$

$$\frac{\partial \mathcal{L}}{\partial K_{t+1}} = 0 \Rightarrow \mathbf{q}_{t+1} (1 - \delta) \rho^{t+1} - \rho^t \mathbf{q}_t \quad (\text{E7})$$

$$+ \rho^{t+1} \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma - 1}{\sigma} \right) q_{t+1}^{-\frac{1}{\sigma}} \frac{\partial q_{t+1}}{\partial K_{t+1}} = 0,$$

$$\frac{1}{\rho} \mathbf{q}_t = \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma - 1}{\sigma} \right) q_{t+1}^{-\frac{1}{\sigma}} \frac{\partial q_{t+1}}{\partial K_{t+1}} + \mathbf{q}_{t+1} (1 - \delta), \quad (\text{E8})$$

$$\frac{\partial \mathcal{L}}{\partial s_{RW,t}^x} = 0 \Rightarrow \frac{1}{\sigma} \left[1 + \tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma + s_{RW,t}^x \tau_{RW,t}^{1-\sigma} \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma \right]^{\frac{1-\sigma}{\sigma}} \tau_{RW,t}^{1-\sigma} \left(\frac{A_{RW,t}^*}{A_t} \right)^\sigma A_t q_t^{\frac{\sigma-1}{\sigma}} = f_x, \quad (\text{E9})$$

$$\sigma^{-\frac{1}{\sigma-1}} \Upsilon_t^{-\frac{1}{\sigma}} (s_{RW,t}^x; \tau_{RU,t}, \tau_{RW,t}) \tau_{RW,t}^{-1} \left(\frac{A_{RW,t}^*}{A_t} \right)^{\frac{\sigma}{\sigma-1}} A_t^{\frac{1}{\sigma-1}} q_t^{\frac{1}{\sigma}} = f_x^{\frac{1}{\sigma-1}} \quad (\text{E10})$$

$$q_t^{\frac{1}{\sigma}} = \frac{\tau_{RW,t} A_t (A_{RW,t}^*)^{\frac{\sigma}{1-\sigma}}}{\sigma^{\frac{1}{1-\sigma}} f_x^{\frac{1}{1-\sigma}}} \Upsilon_t^{\frac{1}{\sigma}} (s_{RW,t}^x; \tau_{RU,t}, \tau_{RW,t}), \quad (\text{E11})$$

$$\frac{\partial \mathcal{L}}{\partial I_t} = 0 \Rightarrow \mathbf{q}_t = 1, \quad (\text{E12})$$

$$\frac{1 - \rho + \delta \rho}{\rho} = \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma - 1}{\sigma} \right) q_{t+1}^{-\frac{1}{\sigma}} \frac{\partial q_{t+1}}{\partial K_{t+1}} \quad (\text{E13})$$

$$= \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma - 1}{\sigma} \right) q_{t+1}^{\frac{\sigma-1}{\sigma}} \phi \psi K_{t+1}^{\gamma-1} (\psi K_{t+1}^\gamma + (1 - \psi) (L_{t+1}^F)^\gamma)^{-1} \quad (\text{E14})$$

$$= \Upsilon_{t+1} (\sigma - 1) \tau_{RW,t+1}^{\sigma-1} \left(\frac{A_{t+1}}{A_{RW,t+1}^*} \right)^\sigma f_x \phi \psi K_{t+1}^{\gamma-1} (\Phi_{t+1}^\gamma)^{-1} = \frac{1 - \rho + \delta \rho}{\rho}. \quad (\text{E15})$$

Notice that output can be split into flexible and non-flexible parts, $q_t = \Phi_t^\phi (L_t^P)^{1-\phi}$, where the non-flexible part of production is summarized by $\Phi_t^\gamma \equiv (\psi K_t^\gamma + (1 - \psi) (L_t^F)^\gamma)$. In the main text, we consider a special case when γ approaches zero, the elasticity of substitution becomes unitary, and the production function becomes (D5).

Note that next period's capital requires adjusting investment in the current period, whereas full-time labor entails hiring and firing costs on top of temporal rigidities (a firm cannot hire or fire full-time employees contemporaneously).

E.4 Implications

E.4.1 Intensive Margin of Trade

We can use the trade share choice (E11) in combination with the part-time employment expression (E6) to pin down the relationship between openness and firm adjustment in the face of a shock. From (E11), we have:

$$q_t = \frac{\tau_{RW,t}^\sigma A_t^\sigma (A_{RW,t}^*)^{1-\sigma}}{\sigma^{1-\sigma} f_x^{\frac{\sigma}{1-\sigma}}} \Upsilon_t,$$

and equating to (E6), we obtain

$$\begin{aligned} \Upsilon_t^{\frac{1}{1-\sigma} \frac{\sigma-1}{\sigma}} A_t^{\frac{\sigma}{1-\sigma} \frac{\sigma-1}{\sigma}} \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\sigma}{1-\sigma} \frac{\sigma-1}{\sigma}} \left(\frac{w^P L_t^P}{1-\phi}\right)^{\frac{\sigma}{\sigma-1} \frac{\sigma-1}{\sigma}} \\ = \frac{\tau_{RW,t}^{\frac{\sigma}{\sigma-1}} A_t^{\frac{\sigma}{\sigma-1}} (A_{RW,t}^*)^{\frac{\sigma}{1-\sigma} \frac{\sigma-1}{\sigma}}}{\sigma^{\frac{\sigma}{1-\sigma} \frac{\sigma-1}{\sigma}} f_x^{\frac{\sigma}{1-\sigma} \frac{\sigma-1}{\sigma}}} \Upsilon_t^{\frac{\sigma-1}{\sigma}}. \end{aligned}$$

We can therefore express intensive margin as:

$$\Upsilon_t = \left(\frac{w^P L_t^P}{1-\phi}\right) (\sigma-1)^{-1} \tau_{RW,t}^{1-\sigma} \left(\frac{A_{RW,t}^*}{A_t}\right)^\sigma f_x^{-1}.$$

It is clearly determined by the part-time labor, which acts as a choice variable in the face of an exogenous shock to trade to Russia. To see the full effect, notice that

$$\frac{\partial \Upsilon_t}{\partial L_t^P} = \left(\frac{w^P}{1-\phi}\right) (\sigma-1)^{-1} \tau_{RW,t}^{1-\sigma} \left(\frac{A_{RW,t}^*}{A_t}\right)^\sigma f_x^{-1}$$

and

$$\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} = (1-\sigma) \tau_{RU,t}^{-\sigma} \left(\frac{A_{RU,t}^*}{A_t}\right)^\sigma < 0,$$

thereby yielding

$$\frac{\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}}}{\frac{\partial \Upsilon_t}{\partial L_t^P}} = \frac{\partial L_t^P}{\partial \tau_{RU,t}} = \frac{(\sigma-1)(1-\sigma) \tau_{RU,t}^{-\sigma} f_x}{\left(\frac{w^P}{1-\phi}\right) \tau_{RW,t}^{1-\sigma}} \left(\frac{A_{RU,t}^*}{A_{RW,t}^*}\right)^\sigma < 0,$$

as reported in the main text.

E.4.2 Revenue Share

Making use of the revenue share function, we get:

$$\mathcal{S}_t^{RW} = \frac{r_t^{RW}}{r_t^d + r_t^{RU} + r_t^{RW}} = \frac{\Upsilon_t - 1}{\Upsilon_t} - \frac{\tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma}{\Upsilon_t}.$$

It then follows that

$$\begin{aligned} \frac{\partial \mathcal{S}_t^{RW}}{\partial \tau_{RU,t}} &= \frac{\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \Upsilon_t - \Upsilon_t \frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} (\Upsilon_t - 1)}{(\Upsilon_t)^2} - \left[\frac{(1-\sigma) \tau_{RU,t}^{-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \Upsilon_t - \frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma}{(\Upsilon_t)^2} \right] \\ &= \frac{\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}}}{(\Upsilon_t)^2} - \left[\frac{(1-\sigma) \tau_{RU,t}^{-\sigma} \Upsilon_t - \frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \tau_{RU,t}^{1-\sigma}}{(\Upsilon_t)^2} \right] \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \\ &= \frac{1}{(\Upsilon_t)^2} \left[\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} - (1-\sigma) \tau_{RU,t}^{-\sigma} \Upsilon_t \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma + \frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \right] \\ &= \frac{1}{(\Upsilon_t)^2} \frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \left[1 - (1-\sigma) \tau_{RU,t}^{-\sigma} \Upsilon_t \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \left(\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \right)^{-1} + \tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \right]. \end{aligned}$$

Recall that

$$\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} = (1-\sigma) \tau_{RU,t}^{-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma,$$

therefore,

$$\frac{\partial \mathcal{S}_t^{RW}}{\partial \tau_{RU,t}} = \frac{1}{(\Upsilon_t)^2} \frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \left[1 - \Upsilon_t + \tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma \right].$$

From the definition of the revenue share:

$$-\mathcal{S}_t^{RW} \Upsilon_t = 1 - \Upsilon_t + \tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t} \right)^\sigma,$$

we obtain

$$\frac{\partial \mathcal{S}_t^{RW}}{\partial \tau_{RU,t}} = -\frac{\mathcal{S}_t^{RW}}{\Upsilon_t} \frac{\partial \Upsilon_t}{\partial \tau_{RU,t}}$$

or

$$\frac{\partial \mathcal{S}_t^{RW}}{\partial \tau_{RU,t}} \frac{\tau_{RU,t}}{\mathcal{S}_t^{RW}} = -\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \frac{\tau_{RU,t}}{\Upsilon_t},$$

just as stated in Proposition 2.

For completeness, note that the openness margin can be expressed as:

$$\begin{aligned} \frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \frac{\tau_{RU,t}}{\Upsilon_t} &= \frac{(1-\sigma)\tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t}\right)^\sigma}{\Upsilon_t} = \frac{(1-\sigma)\tau_{RU,t}^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_t}\right)^\sigma}{\left(\frac{w^P L_t^P}{1-\phi}\right) (\sigma-1)^{-1} \tau_{RW,t}^{1-\sigma} \left(\frac{A_{RW,t}^*}{A_t}\right)^\sigma f_x^{-1}} \\ &= -\frac{(\sigma-1)^2}{\left(\frac{w^P L_t^P}{1-\phi}\right)} \left(\frac{\tau_{RU,t}}{\tau_{RW,t}}\right)^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_{RW,t}^*}\right)^\sigma f_x. \end{aligned}$$

Making use of

$$\frac{\partial L_t^P}{\partial \tau_{RU,t}} \frac{\tau_{RU,t}}{L_t^P} = \frac{(\sigma-1)(1-\sigma)}{\left(\frac{w^P L_t^P}{1-\phi}\right)} \left(\frac{\tau_{RU,t}}{\tau_{RW,t}}\right)^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_{RW,t}^*}\right)^\sigma f_x,$$

we obtain

$$\frac{\partial \Upsilon_t}{\partial \tau_{RU,t}} \frac{\tau_{RU,t}}{\Upsilon_t} = -\frac{(\sigma-1)^2}{\left(\frac{w^P L_t^P}{1-\phi}\right)} \left(\frac{\tau_{RU,t}}{\tau_{RW,t}}\right)^{1-\sigma} \left(\frac{A_{RU,t}^*}{A_{RW,t}^*}\right)^\sigma f_x = \frac{\partial L_t^P}{\partial \tau_{RU,t}} \frac{\tau_{RU,t}}{L_t^P}.$$

Therefore, this analysis justifies the use of part-time employment as a proxy for the trade shock hit by the firm.

E.4.3 Large Shock and Full-time Labor Adjustment

To shed light on key drivers of full-time labor layoffs, we focus on a closed-form solution for the production function (D5), as reported in the main text. The following expression for the next period's (lower) level of full-time labor emerges:

$$\left(L_{t+1}^{F-}\right)^{(1-\psi)\phi\frac{\sigma-1}{\sigma}-1} = \frac{\left(-\frac{1}{\rho}f + (1-p)f + w_{t+1}^F\right) (\sigma-1)^{\frac{1}{\sigma}} f_x^{\frac{1}{\sigma}} \tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}}{A_{RW,t+1}^* \left(\frac{\sigma-1}{\sigma}\right) \left(L_{t+1}^P\right)^{(1-\phi)\frac{\sigma-1}{\sigma} + \frac{1}{\sigma}} \left(\frac{w^P}{1-\phi}\right)^{\frac{1}{\sigma}} K_{t+1}^{\psi\phi\frac{\sigma-1}{\sigma}} (1-\psi)\phi}.$$

To derive this result, we combine equations (E1) and (E5) and obtain:

$$-f = \rho \left(\Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma}\right) \underline{q}_{t+1}^{-\frac{1}{\sigma}} \frac{\partial \underline{q}_{t+1}}{\partial L_{t+1}^F} - w_{t+1}^F - (1-p)f + ph \right), \quad (\text{E16})$$

where $\underline{q}_{t+1} \equiv q(L_{t+1}^{F-}, L_{t+1}^P)$ denotes *reduced* employment levels (thereby implying a negative H_t^F). This means that firing is optimal rather than waiting. That coincides with our definition of a large shock, i.e., a situation when the trade disruption is so large that paying firing

costs is preferred.²⁹ In a good state:

$$h = \rho \left(\Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \bar{q}_{t+1}^{-\frac{1}{\sigma}} \frac{\partial \bar{q}_{t+1}}{\partial L_{t+1}^F} - w_{t+1}^F - pf + (1-p)h \right), \quad (\text{E17})$$

where $\bar{q}_{t+1} \equiv q(L_{t+1}^{F+}, L_{t+1}^P)$ denotes *increased* employment levels (implying positive H_t^F).

These two equations deliver the following result:

$$\begin{aligned} -\frac{1}{\rho}f + (1-p)f + w_{t+1}^F - ph &= \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \underline{q}_{t+1}^{-\frac{1}{\sigma}} \frac{\partial \underline{q}_{t+1}}{\partial L_{t+1}^F} \\ \frac{1}{\rho}h - (1-p)h + w_{t+1}^F + pf &= \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \bar{q}_{t+1}^{-\frac{1}{\sigma}} \frac{\partial \bar{q}_{t+1}}{\partial L_{t+1}^F}. \end{aligned}$$

Since we are dealing with a negative shock, we normalize $h = 0$ to simplify expressions (we are not concern with costly hiring decisions). We can summarize the new level of full-time employment under the large sanctions shock as follows:

$$\begin{aligned} -\frac{1}{\rho}f + (1-p)f + w_{t+1}^F &= \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \underline{q}_{t+1}^{\frac{\sigma-1}{\sigma}} (1-\psi) \phi (L_{t+1}^{F-})^{\gamma-1} \Phi_{t+1}^{-\gamma} \\ w_{t+1}^F + pf &= \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \bar{q}_{t+1}^{\frac{\sigma-1}{\sigma}} (1-\psi) \phi (L_{t+1}^{F+})^{\gamma-1} \Phi_{t+1}^{\gamma}. \end{aligned}$$

or

$$\begin{aligned} -\frac{1}{\rho}f + (1-p)f + w_{t+1}^F &= \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \Phi_{t+1}^{\phi \frac{\sigma-1}{\sigma}} (L_{t+1}^P)^{(1-\phi)\frac{\sigma-1}{\sigma}} (1-\psi) \phi (L_{t+1}^{F-})^{\gamma-1} \Phi_{t+1}^{-\gamma} \\ w_{t+1}^F + pf &= \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) \bar{q}_{t+1}^{\frac{\sigma-1}{\sigma}} (1-\psi) \phi (L_{t+1}^{F+})^{\gamma-1} \Phi_{t+1}^{\gamma}. \end{aligned}$$

To follow the steps, we collect required elements:

$$\begin{aligned} q_t &= \left(K_t^\psi (L_t^F)^{1-\psi} \right)^\phi (L_t^P)^{1-\phi} \\ \frac{\partial \underline{q}_{t+1}}{\partial L_{t+1}^F} &= (1-\psi) \phi K_{t+1}^{\psi\phi} (L_{t+1}^{F-})^{(1-\psi)\phi-1} (L_{t+1}^P)^{1-\phi} \\ \underline{q}_{t+1}^{-\frac{1}{\sigma}} &= K_{t+1}^{-\frac{\phi}{\sigma}\psi} (L_{t+1}^{F-})^{-\frac{\phi}{\sigma}(1-\psi)} (L_{t+1}^P)^{-\frac{(1-\phi)}{\sigma}} \end{aligned}$$

Hence,

$$\begin{aligned} &-\frac{1}{\rho}f + (1-p)f + w_{t+1}^F \\ &= (1-\psi) \phi \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) K_{t+1}^{\psi\phi - \frac{\phi}{\sigma}\psi} (L_{t+1}^{F-})^{((1-\psi)\phi-1) - \frac{\phi}{\sigma}(1-\psi)} (L_{t+1}^P)^{(1-\phi) - \frac{(1-\phi)}{\sigma}} \\ &= (1-\psi) \phi \Upsilon_{t+1}^{\frac{1}{\sigma}} A_{t+1} \left(\frac{\sigma-1}{\sigma} \right) K_{t+1}^{\psi\phi \left(\frac{\sigma-1}{\sigma} \right)} (L_{t+1}^{F-})^{(1-\psi)\phi \left(\frac{\sigma-1}{\sigma} \right) - 1} (L_{t+1}^P)^{(1-\phi) \left(\frac{\sigma-1}{\sigma} \right)} \end{aligned}$$

The above expression allows us re-expressing:

²⁹Technically, when μ_t drops below $-f$, an optimizing firm must fire full-time workers and do so until $\mu_t \geq -f$ is restored. That is why we only consider marginal values with equality.

$$(L_{t+1}^{F-})^{(1-\psi)\phi\left(\frac{\sigma-1}{\sigma}\right)-1} = \frac{-\frac{1}{\rho}f+(1-p)f+w_{t+1}^F}{(1-\psi)\phi\Upsilon_{t+1}^{\frac{1}{\sigma}}A_{t+1}\left(\frac{\sigma-1}{\sigma}\right)K_{t+1}^{\psi\phi\left(\frac{\sigma-1}{\sigma}\right)}(L_{t+1}^P)^{(1-\phi)\left(\frac{\sigma-1}{\sigma}\right)}.$$

To get rid of the openness variable, we make use of

$$\Upsilon_{t+1}^{\frac{1}{\sigma}} = \left(\frac{w^P L_{t+1}^P}{1-\phi}\right)^{\frac{1}{\sigma}} (\sigma-1)^{-\frac{1}{\sigma}} \tau_{RW,t+1}^{\frac{1-\sigma}{\sigma}} \frac{A_{RW,t+1}^*}{A_{t+1}} f_x^{-\frac{1}{\sigma}},$$

which leads to

$$(L_{t+1}^{F-})^{(1-\psi)\phi\left(\frac{\sigma-1}{\sigma}\right)-1} = \frac{\left(-\frac{1}{\rho}f+(1-p)f+w_{t+1}^F\right)(\sigma-1)^{\frac{1}{\sigma}} f_x^{\frac{1}{\sigma}}}{(1-\psi)\phi\left(\frac{w^P}{1-\phi}\right)^{\frac{1}{\sigma}} \tau_{RW,t+1}^{\frac{1-\sigma}{\sigma}} A_{RW,t+1}^* \left(\frac{\sigma-1}{\sigma}\right) K_{t+1}^{\psi\phi\left(\frac{\sigma-1}{\sigma}\right)} (L_{t+1}^P)^{(1-\phi)\left(\frac{\sigma-1}{\sigma}\right)+\frac{1}{\sigma}}.$$

A closed-form solution for the production function (D5), therefore, follows:

$$(L_{t+1}^{F-})^{(1-\psi)\phi\frac{\sigma-1}{\sigma}-1} = \Psi_{t+1} \tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}} K_{t+1}^{-\psi\phi\frac{\sigma-1}{\sigma}} (L_{t+1}^P)^{-(1-\phi)\frac{\sigma-1}{\sigma}-\frac{1}{\sigma}}, \quad (\text{E18})$$

where we used $q_t = \left(K_t^\psi (L_t^F)^{1-\psi}\right)^\phi (L_t^P)^{1-\phi}$, and denoted by $\Psi_{t+1} \equiv \frac{\left(-\frac{1}{\rho}f+(1-p)f+w_{t+1}^F\right)(\sigma-1)^{\frac{1}{\sigma}} f_x^{\frac{1}{\sigma}}}{A_{RW,t+1}^* \left(\frac{\sigma-1}{\sigma}\right) \left(\frac{w^P}{1-\phi}\right)^{\frac{1}{\sigma}} (1-\psi)\phi}$ a time-varying term, exogenous from the perspective of a firm. This is an expression just as reported in the main text's equation (9).

Before learning how full-time employment adjusts, we have to first solve for the capital choice. From the first-order conditions, (E15), and under the production function (D5), we obtain:

$$K_{t+1} = \left(\frac{w^P}{1-\phi}\right) (\sigma-1)^{-1} f_x^{-1} \frac{\rho f_x \phi \psi (\sigma-1)}{1-\rho+\delta\rho} L_{t+1}^P, \quad (\text{E19})$$

yielding

$$I_t = \left(\frac{w^P}{1-\phi}\right) \frac{\rho}{1-\rho} \phi \psi \Delta L_{t+1}^P \quad (\text{E20})$$

where, for exposition purposes, we assume depreciation to be equal to zero. This result is what we report in the main text equations (10) and (11).

E.4.4 Investment

Our starting position is the capital equation

$$K_{t+1} = \Upsilon_{t+1} \tau_{RW,t+1}^{\sigma-1} \left(\frac{A_{t+1}}{A_{RW,t+1}^*} \right)^\sigma \frac{\rho f_x \phi \psi (\sigma - 1)}{1 - \rho + \delta \rho}.$$

Making use of

$$\Upsilon_{t+1} = \left(\frac{w^P L_{t+1}^P}{1 - \phi} \right) (\sigma - 1)^{-1} \tau_{RW,t+1}^{1-\sigma} \left(\frac{A_{RW,t+1}^*}{A_{t+1}} \right)^\sigma f_x^{-1},$$

we find that

$$K_{t+1} = \left(\frac{w^P}{1 - \phi} \right) (\sigma - 1)^{-1} f_x^{-1} \frac{\rho f_x \phi \psi (\sigma - 1)}{1 - \rho + \delta \rho} L_{t+1}^P.$$

It therefore follows that

$$\Delta K_{t+1} = I_t = \left(\frac{w^P}{1 - \phi} \right) \frac{\rho}{1 - \rho} \phi \psi \Delta L_{t+1}^P,$$

when $\delta = 0$.

E.4.5 Full-time Labor and Capital

We can re-express labor adjustment (E18) in terms of the flexible adjustment margin, part-time employment, and exogenous (from the perspective of a firm) variables:

$$(L_{t+1}^{F-})^{(1-\psi)\phi\left(\frac{\sigma-1}{\sigma}\right)-1} = \tilde{\Psi}_t \tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}} (L_{t+1}^P)^{-\frac{1}{\sigma}([1-\phi+\psi\phi](\sigma-1)+1)},$$

where $\tilde{\Psi}_t$ is a mix of aggregate and exogenous terms. In fact, it is equal to:

$$\tilde{\Psi}_t \equiv \Psi_t \left(\left(\frac{w^P}{1 - \phi} \right) (\sigma - 1)^{-1} f_x^{-1} \frac{\rho f_x \phi \psi (\sigma - 1)}{1 - \rho + \delta \rho} \right)^{-\psi \phi \frac{\sigma - 1}{\sigma}}.$$

We combine an expression for $(L_{t+1}^{F-})^{(1-\psi)\phi\left(\frac{\sigma-1}{\sigma}\right)^{-1}}$ with K_{t+1} above:

$$\begin{aligned}
(L_{t+1}^{F-})^{(1-\psi)\phi\left(\frac{\sigma-1}{\sigma}\right)^{-1}} &= \frac{\left(-\frac{1}{\rho}f+(1-p)f+w_{t+1}^F\right)(\sigma-1)^{\frac{1}{\sigma}}f_x^{\frac{1}{\sigma}}}{(1-\psi)\phi\left(\frac{w^P}{1-\phi}\right)^{\frac{1}{\sigma}}\tau_{RW,t+1}^{\frac{1-\sigma}{\sigma}}A_{RW,t+1}^*\left(\frac{\sigma-1}{\sigma}\right)K_{t+1}^{\psi\phi\left(\frac{\sigma-1}{\sigma}\right)}(L_{t+1}^P)^{(1-\phi)\left(\frac{\sigma-1}{\sigma}\right)+\frac{1}{\sigma}}} \\
&= \Psi_{t+1}\tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}K_{t+1}^{-\psi\phi\frac{\sigma-1}{\sigma}}(L_{t+1}^P)^{-(1-\phi)\frac{\sigma-1}{\sigma}-\frac{1}{\sigma}} \\
&= \Psi_{t+1}\tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}\left(\left(\frac{w^P}{1-\phi}\right)(\sigma-1)^{-1}f_x^{-1}\frac{\rho f_x\phi\psi(\sigma-1)}{1-\rho+\delta\rho}L_{t+1}^P\right)^{-\psi\phi\frac{\sigma-1}{\sigma}}(L_{t+1}^P)^{-(1-\phi)\frac{\sigma-1}{\sigma}-\frac{1}{\sigma}} \\
&= \Psi_{t+1}\left(\left(\frac{w^P}{1-\phi}\right)(\sigma-1)^{-1}f_x^{-1}\frac{\rho f_x\phi\psi(\sigma-1)}{1-\rho+\delta\rho}\right)^{-\psi\phi\frac{\sigma-1}{\sigma}}\tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}(L_{t+1}^P)^{-\psi\phi\frac{\sigma-1}{\sigma}-(1-\phi)\frac{\sigma-1}{\sigma}-\frac{1}{\sigma}} \\
&= \tilde{\Psi}_t\tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}(L_{t+1}^P)^{-\frac{1}{\sigma}(\psi\phi(\sigma-1)+(1-\phi)(\sigma-1)+1)} = \tilde{\Psi}_t\tau_{RW,t+1}^{\frac{\sigma-1}{\sigma}}(L_{t+1}^P)^{-\frac{1}{\sigma}([1-\phi+\psi\phi](\sigma-1)+1)}.
\end{aligned}$$