Financial Constraints and Propagation of Shocks in Production Networks

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We examine the role of financing constraints in propagation of an unexpected supply shock through a country's production network. Working with a database that covers quasi-totality of supplier-customer links in an open economy, we find that even a small economic shock can be propagated and amplified by liquidity-constrained firms. Using a Bartik-type instrument for exposure to the shock, we find that liquidity constrained suppliers exposed to the shock transmit it to their downstream customers. This is not true of suppliers who are not liquidity constrained.

JEL Codes: Fxx; Gxx.
Keywords: production networks; shock transmission; financing constraints; liquidity; Turkey.

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1 Introduction

This paper examines the role of financing constraints in the propagation of economic shocks in a production network. Since the seminal work of Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi (2012) showing that amplification of sectoral shocks can be responsible for aggregate fluctuations, researchers have been trying to improve their understanding of the transmission channels for various shocks within economies. This paper adds to this line of work in a number of dimensions. First, we contribute by examining the propagation of a much smaller, yet unexpected, shock and show that it can have substantial consequences. Second, we focus on the role played by financing constraints in the transmission of an economic shock. Third, we are able to do so while observing the quasi-totality of an open economy's production network in the manufacturing sector.

Our analysis focuses on an unexpected increase in the cost of import financing. In October 2011, the Turkish Government unexpectedly doubled the rate of the Resource Utilization Support Fund (RUSF) tax from 3% to 6%. This tax applies to import transactions which are financed through trade credit and thus the shock had a heterogenous impact across importers. Our analysis proceeds in several steps. First, we examine to what extent the shock in question affected the directly exposed firms. Next, we examine whether the shock was transmitted to upstream and downstream firms in the production network. Since we observe the quasi-totality of the supplier-buyer pairs in the economy, we can examine the propagation of the shock in the entire production network. Third, we investigate the role of liquidity constraints in the transmission of the shock throughout the economy. Finally, we focus on whether the shock transformed the existing production network by inducing firm exit and altering the supplying relationships.

Our results can be summarized as follows. First, we find that all firms directly exposed to the tax were negatively affected in the year after the shock. However, only liquidity-constrained firms continued to be affected in the following year as well. Second, we find that not all importing firms that were directly affected by the shock transmitted it to their customers. Importing firms with no liquidity constraints appear to have absorbed the shock, while liquidity constrained importers passed the shock onto their customers. As such, our evidence extends the existing literature by pointing out the importance of liquidity constraints in the propagation and magnification of economic shocks.

Our paper is closely related to three strands of the existing research. First, our work contributes to the literature on the transmission of shocks through production networks, which originated with the work of Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi (2012) and has been extended by others. For example, Barrot and Sauvagnat (2016) show that large economic shocks caused by natural disasters, which affect publicly-listed suppliers, have economically important effects on their publicly-listed client-firms. Carvalho, Nirei, Saito, and Tahbaz-Salehi (2016), who focus on the 2011 East Japan Earthquake, provide more evidence on the propagation of shocks through production networks. We extend this literature by showing that even a relatively small financial shock can propagate through a production network and have a sizeable impact. Our results are also in line with the findings of Acemoglu, Akcigit, and Kerr (2016) who investigate the impact of various shocks on the U.S. economy using a simple model of sectoral network structure. They find sizeable network propagation effects for both demand and supply shocks. The demand shocks, such as increases in Chinese imports and changes in Federal government spending, propagate upstream, while the supply shocks, such as TFP and patenting shocks, tend to work downstream. In our analysis, we also find that a supply shock propagates to downstream firms.

Our paper is also closely related to the area of research that focuses on the role of financial constraints in production networks. For example, Bigio and La'O (2016) introduce reduced-form working capital constraints into the Acemoglu, Akcigit, and Kerr (2016) fixed network model to analyze the aggregate impact of firm-level financial constraints. As expected, financial constraints prevent firms from producing at the optimal scale and lead to misallocation of labor across sectors. Moreover, an inefficient discrepancy between labor and consumption, and the resulting employment choices, arises due to general equilibrium effects. Jacobson and von Schedvin (2015) study exposure of Swedish firms to bankruptcies through trade credit in production chains and find that trade creditors suffer 50% higher losses than banks lending to the corporate sector. Boissay and Gropp (2013) examine the transmission of trade-credit-related payment defaults. They find that credit constrained firms that are on the receiving end of payment defaults (whose causes cannot be observed in the data) are more likely to pass on a major portion of the shock and default through trade credit. In contrast, companies that are financially unconstrained help stop the payment default chain. Boissay and Gropp (2013) are unable, however, to use network data as they do not have access to inter-firm payment data. We complement these papers by examining transmission of an unexpected shock throughout an entire production network and show that the shock is initially transmitted by liquidity constrained firms, whereas financially unconstrained firms help absorb the shock.

Since the RUSF levy is in fact a tax on internationally provided trade credit, our paper is also related to the large trade credit literature. Relevant for our work, Petersen and Rajan (1997) note that credit constrained (small) firms obtain liquidity from their suppliers through (domestic) trade credit. Findings by Nilsen (2002), Choi and Kim (2005), and Love, Preve, and Sartia-Allende (2007) support the Meltzer (1960) idea that trade credit is a substitute for bank credit and may be a way of redistributing credit from entities that are financially stronger (and enjoy easier access to bank credit) to the ones that are not. These arguments could apply to internationally issued trade credit as well. Bams, Bos, and Pisa (2016) modify the Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi (2012) model and estimate the impact of trade credit in economic expansions and recessions on sales growth. Wilner (2000) provides a model where sellers help buyers in financial distress. As shown by Cunat (2007), trade credit would be offered in industries where switching costs – for example in sectors with differentiated goods – are high. In our context, this finding suggest that the overall impact of the tax shock is likely to be stronger if firms affected by the RUSF levy cannot easily switch to other suppliers. In line with this research, our paper investigates the role played by trade credit as a possible channel of shock transmission.

The rest of the paper is organized as follows. Section 2 describes the exogenous shock which we examine in the empirical analysis. Section 3 presents a simple partial equilibrium model that informs the empirical analysis. The following section details the data and the empirical approach. Section 5 presents the main results. Section 6 concludes the paper.

2 Institutional Context

We focus on the increase in the RUSF levy as an exogenous shock that affected certain types of imports. The import related RUSF contribution was instituted by the Council of Ministers on May 12, 1988. This particular tax, which is considered a statutory import duty by the U.S. Department of Commerce (e.g., ICF 201304), imposed a 3% levy on imports involving foreign credit. In the face of a growing current account deficit, on October 13, 2011, a new governmental decree unexpectedly increased the RUSF levy on imports from 3% to 6%. The tax is implemented by the Turkish Customs and Trade Ministry which checks the payment details during the customs clearing process for the imported goods. The Turkish Customs' Law no. 4458 imposes high penalties (at the order of three times the mandated payment) if the import duty is not paid as due or is avoided.

The RUSF levy applies to imports financed by open account (OA), acceptance credit (AC), and deferred-payment letter of credit (DC). In the case of OA, the payment to exporter is due 30 to 90 days after the receipt of the goods. AC is a type of letter of credit financing that involves a time draft for delayed payment after receipt of trade documents. DC is another type of letter of credit financing with deferred payment but one that does not involve a time draft. In contrast, the levy does not apply to cash in advance (in which the importer pre-pays for the goods), standard letter of credit (in which the payment is guaranteed by the importer's bank provided that the conditions stipulated in the trade contract are met), or documentary collection (which involves bank intermediation without a payment guarantee). The data allow us to distinguish between the various import financing types and hence to measure the exposure to import flows to the RUSF tax.

3 Conceptual Framework

In this section, we introduce an import payment choice decision to an otherwise standard framework which has been used by others, including Halpern, Koren, and Szeidl (2015). The model is cast in partial equilibrium. It presents a simple, yet useful, setting for understanding the propagation of a cost shock, such as an increase in the RUSF rate, in a production network. It also allows us to illustrate how liquidity constraints affect this propagation.

Assume a fixed number of firms, indexed by f, which combine labor, capital, and intermediate inputs to produce a final good according to the following production function:

$$Q_f = A_f K_f^{\alpha} L_f^{\beta} \prod_{j=1}^{N} X_{fj}^{\gamma_j}, \tag{1}$$

where A_f is firm-specific productivity shifter; K_f denotes capital input, L_f labor input, and X_{fj} the quantity of the composite intermediate input j used by firm f. Each firm minimizes its production costs, taking the input prices as given. Each intermediate good j is represented as a CES aggregate of domestic and imported varieties:

$$X_{fj} = \left[\left(B_{fj} X_{fj}^{F} \right)^{\frac{\theta-1}{\theta}} + \left(X_{fj}^{H} \right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{2}$$

where θ is the elasticity of substitution between domestic and imported varieties. Denoting the prices of foreign and domestic varieties by P_{fj}^{F} and P_{fj}^{H}, we can derive the price index associated with variety j as:

$$P_{fj} = \left[\left(P_{fj}^{F} / B_{fj} \right)^{1-\theta} + \left(P_{fj}^{H} \right)^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{3}$$

When firms import, they choose between paying immediately and delaying payment (i.e., using external financing). By paying immediately, firm f incurs a financing cost, $r_f > 1$ but saves the import tax $\tau_0 > 1$. Thus the cost of importing variety j is equal to $r_f P_j^F$, where P_j^F is the price of the imported variety excluding the cost of financing or taxes. If the firm delays payment by using external financing, the cost becomes $\tau_0 P_j^F$. The liquidity costs, r_f, are drawn from a common and known distribution $g(r)$ with positive support on the interval $(\underline{r}, \infty)$ and a continuous cumulative distribution $G(r)$.

We assume that firms already agreed on the optimal types of payment terms for each imported intermediate through bargaining with their international suppliers before the shock. This gives rise to an exogenous firm distribution of exposure to the RUSF shock at the time of the policy change. We denote the set of intermediates on which firm f initially pays the tax by N_f.[1]

The increase in the RUSF rate from τ_0 to τ_1 leaves firms with a choice: they can either switch (by incurring additional liquidity costs) to immediate payment for the imported goods or pay the increased tax. The firm compares its cost of liquidity (r_f) to the cost of external financing (τ_1) and chooses the method that is associated with a lower cost. Given that firms are heterogeneous in the cost of liquidity they are facing, we can define a marginal firm which is indifferent between paying immediately and delaying payment: $r^* = \tau_1$. Firms with $r_f \in [\underline{r}, r^*]$ choose to pay immediately,

[1] The choice of optimal payment terms in international trade is determined by various factors related to the source and destination countries as well as the characteristics of the goods traded (Schmidt-Eisenlohr (2013); Antràs and Foley (2015)). We are not modelling those factors explicitly in this paper.

and others use external financing to delay payment.

The model implies a constant marginal cost of production that is given by:

$$c_f = \frac{R^\alpha w^\beta \Pi_{j=1}^N (P_{fj})^{\gamma_j}}{A_f \Gamma}, \tag{4}$$

where R is the cost of capital, w is the wage and Γ is a collection of parameters. Taking the logarithm of both sides, we obtain:

$$\ln c_f = \alpha \ln R + \beta \ln w + \sum_{j=1}^N \gamma_j \ln P_{fj} - \ln A_f - \ln \Gamma.$$

Now, consider a firm with $r_f > r^* = \tau_1$, i.e., a firm that uses external financing when sourcing inputs from abroad even after the shock. The direct effect of a change in τ on the firm's unit costs is (approximately):

$$\frac{d \ln c}{d\tau} \Delta\tau = (\tau_1 - \tau_0) \sum_{j \in N_f} \gamma_j \frac{1}{\tau_0} \eta_{fj} \tag{5}$$

where $\eta_{fj} = \frac{\left(\frac{P_{fj}^F}{B_{fj}}\right)^{1-\theta}}{\left(\frac{P_{fj}^F}{B_{fj}}\right)^{1-\theta} + \left(P_{fj}^H\right)^{1-\theta}}$ is related to share of imported varieties in the unit of intermediate good j. The corresponding effect for a firm with $r_f < r^* = \tau_1$ is

$$(r_f - \tau_0) \sum_{j \in N_f} \gamma_j \frac{1}{\tau_0} \eta_{fj}. \tag{6}$$

In both expressions (5) and (6), the direct effect of a change in τ on firm f's unit (marginal) costs increases with the firm's exposure to external financing, which is represented by the summation $\sum_{j \in N_f} \gamma_j \frac{1}{\tau_0} \eta_{fj}$. Also, for a given exposure, firms that have low costs of liquidity will experience a lower increase in their costs as $(\tau_1 - \tau_0) > (r_f - \tau_0)$.

In the model, firms are affected by the change in the tax rate τ through two channels. First, a rise in τ affects firms directly by increasing the cost of imported inputs. Second, a rise in τ increases costs faced by firms' domestic suppliers, which affects firms' costs to the extent that the suppliers pass the increases onto their buyers. This indirect effect of the tax through domestic suppliers will be generated by the term P^H_{fj} in equation (4).

If the elasticity of substitution among domestic inputs for any input j is 1, we can define $P^H_{fj} = \prod_k p_{fjk}^{\frac{\phi_k}{\phi}}$ where $\phi = \sum_k \phi_k$. Then the indirect change in the cost of firm i is given by:[2]

$$\sum_{j=1}^{N} \gamma_j (1-\eta_{fj}) \left[\sum_{k \in \Theta_{fj}} \frac{\phi_k}{\phi} (\tau_1 - \tau_0) \left(\sum_{l \in N_k} \gamma_l \frac{1}{\tau_0} \eta_{kl} \right) + \sum_{k \notin \Theta_{fj}} (r_k - \tau_0) \left(\sum_{l \in N_k} \gamma_l \frac{1}{\tau_0} \eta_{kl} \right) \right] \tag{7}$$

where Θ_{fj} denotes, for firm f and intermediate j, the set of suppliers that face low liquidity costs, i.e., $r_f < \tau_1$. The indirect effect of changes in τ is increasing in the domestic input share of firm f, the imported input share of the firm's domestic suppliers, and the number of domestic suppliers that face high liquidity costs.

In the next section, we take the predictions of this simple model to the data. In particular, we test whether liquidity constraints matter for the direct effect of the rise in the RUSF rate on firms' costs as well as for the propagation of the shock through firms' domestic suppliers.

4 Data and Empirical Strategy

4.1 Data

To conduct our analysis, we combine data from three Turkish administrative datasets.[3] The first dataset, which is available at the Turkish Statistical Institute (TSI), is based on customs data and traces all Turkish imports at the firm, country, and 6-digit Harmonized System (HS6) product code level, and is disaggregated by international trade financing type (i.e., whether based on cash in advance, letter of credit, or open account). The TSI imports data cover 150 source countries, roughly 4,700 HS6 product categories, and correspond to approximately 75,000 country-product pairs. However, due to confidentiality issues, we cannot transfer firm-level imports data from the TSI and match them with the other two datasets that we describe below. That said, TSI provides us with the information on the distribution of Turkish imports at product-source-country-

[2] The expression below makes two simplifying assumptions: (i) changes in supplier costs are reflected fully in their prices, and (ii) secondary and further network effects, i.e., effects through suppliers of suppliers and so on, are negligible.

[3] The empirical analysis in this paper is based on confidential data accessed on the premises of the Ministry of Science, Industry and Technology (MSIT) of the Turkish Republic as well as the Turkish Statistical Institute. Similar to the US Census micro-data utilization requirements, access to these data requires a special permission involving a background check, and the results can only be exported upon approval by the authorized staff.

level disaggregated by the trade financing type for each year between 2010-2012. These data are matched with the Ministry of Industry imports database at the firm-product-country of origin (i.e., "variety") level.[4]

The second dataset is maintained by the MSIT for the purpose of calculating and collecting value added tax (VAT). This dataset covers all domestic firm-to-firm transactions as long as they are above 5,000 Turkish Liras (TLs), or roughly $2,650 (as of the year-end 2011 exchange rate) in a given month. As our identification is driven by the import duty increase, we limit ourselves to manufacturing firms. Between 2010 and 2014, we are able to trace, on average, roughly 600,000 firms, approximately 6,000,000 buyer-seller connections, with close to 20,000,000 transactions per year. In fact, we effectively observe almost all domestic supplier-buyer pairs, which provides us with the complete picture of the production network in the Turkish economy.

Finally, we combine the firm-to-firm transaction data with firm-level balance sheet and income statement data, also maintained by the Turkish Ministry of Science, Industry and Technology. The annual balance sheet and income statement data allow us to calculate our outcome variables, such as, growth in sales and unit costs.

4.2 Empirical strategy

We first describe the construction of a Bartik-type instrument that traces the firm-level exposure to the RUSF-levy shock. Ideally, we would like to construct a firm-level exposure variable of the following kind:

$$Exposure_{fj,T-2} = \frac{\sum_{m \in \{OA,AC,DLC\}} M_{fjm,T-2}}{\sum_m M_{fjm,T-2}}$$

where f indexes firms, j country-product "variety" pairs, and m trade financing types (OA, AC, and DLC being open account financing, acceptance credit facility, and delayed letter of credit, respectively). M denotes imports, and T the year following the unexpected RUSF increase, 2012. Due to confidentiality concerns, we cannot create and transfer out of TSI the firm-level exposure variable $Exposure_{fj,T-2}$. Instead, we use the TSI data to construct an aggregated country-product-

[4]Ministry of Industry dataset contains imports data with the country-product detail at the firm level, but does *not* include information on the types of trade financing used. We need the latter information in order to pinpoint to imports affected by the RUSF shock, which depends on the type of trade financing.

level exposure variable ($Exposure_{j,T-2}$) and import it into the Ministry of Industry data:

$$Exposure_{j,T-2} = \frac{\sum_{m\in\{OA,AC,DLC\}} M_{jm,T-2}}{\sum_m M_{jm,T-2}}.$$

Given that the variety j level of detail is also available in the the Ministry of Industry imports database, we create a firm-level Bartik-type exposure variable as follows:

$$Exposure_{f,T-2} = \sum_v \omega_{fj,T-2} \times Exposure_{j,T-2} \tag{8}$$

where $\omega_{fj,T-2}$ denotes the share of imports of variety j in firm f's total imports in year 2010.

Figure 1 presents the distribution of $Exposure_{jt}$ for $t = T-1, T$, which varies between 0 and 1 for firms in our sample (zeros are excluded from the figure, as including them would dominate the rest of the frequency distribution graph). As illustrated in the figure, the distribution shifted to the left after the increase in the RUSF rate. The average value of the share of imports with external financing decreased from about 21% before to 18% after the shock.

Later in the analysis, we will define additional exposure variables that will be based on a firm's domestic suppliers and domestic buyers. For example, to capture a firm's exposure to the RUSF levy increase through its supplier firms, expressed in equation (7), we will define:

$$Exposure^S_{f,T-2} = \sum_s \omega^S_{fs,T-2} \times Exposure_{s,T-2} \tag{9}$$

where $Exposure^S_{f,T-2}$ is the firm f's exposure to the shock through its suppliers; and $\omega^S_{fs,T-2}$ is the share of supplier s in firm f's total domestic purchases in year 2010. In a similar fashion, we also construct firm f's exposure to RUSF levy increase through its domestic buyers, indexed by b,:

$$Exposure^B_{f,T-2} = \sum_b \omega^B_{fs,T-2} \times Exposure_{b,T-2}, \tag{10}$$

where $\omega^B_{fb,T-2}$ is the share of buyer b in firm f's total domestic sales in year 2010. In Figures 2 and 3, we present the frequency distributions for direct and indirect firm-level exposures, respectively (after excluding zero exposure cases, as explained above).

Using the exposure variable described in equation (8), we first estimate a difference-in-differences specification with a first-differenced dependent variable for the 2011-2014 period:

$$\Delta \ln Y_{fsrt} = \beta_0 + \sum_{l=2012}^{2014} \beta_l * I\{t = l\} * Exposure_{fsr,T-2} + \alpha_{srt} + \alpha_f + e_{fsrt}, \tag{11}$$

where Y is an outcome variable (e.g., sales, unit costs, etc) for firm f operating in a two-digit NACE industry s and region r, with t={2011, 2012, 2013, 2014}. Region r corresponds to the 81 contiguous administrative districts into which Turkey is subdivided, with each district corresponding to a Turkish city (such as Ankara, Istanbul, Izmir, etc.) $\Delta \ln Y_{fsrt}$ is the annual change in the logarithm of Y. $I\{t = l\}$ is an indicator variable that is equal to one for year $t = l$, and zero otherwise.

We add industry-region-time fixed effects (α_{srt}) to account for time-varying unobservables at the industry-region-and-time level. These control for unobserved regional shocks at the industry level that vary over time, as well as economy-wide changes that might be due to exchange rate fluctuations, monetary or fiscal policies, etc. The specification also includes firm fixed effects (α_f), which soak up firm-level unobservables that might otherwise have an influence on our results. As our dependent variable is first-differenced, those fixed effects also control for firm-level trends. In all of our regressions, the standard errors are clustered at the firm level.

5 Results

5.1 Direct effect of the RUSF increase

We first examine the direct effect of the RUSF duty increase on the affected firms' performance. In Table 1, we focus on the change in the sales growth after the RUSF rate unexpectedly went up from 3% to 6% in October 2011. In column 1, we present the results from a less demanding specification than the baseline in equation (11). We control only for industry-time and region-time unobservables and use data for the 2011-2012 period. The coefficient of interest (on the interaction of exposure and year 2012 indicator variable) is negative and statistically significant at the 1%-level. The magnitude of the estimated effect is economically meaningful: a one-standard-deviation increase in exposure as of year 2010 leads to a 1.77% decrease in exposed firms' sales growth in year 2012 following the shock. Another, and perhaps more appropriate, way of expressing the impact of the shock is to evaluate the RUSF-related elasticities of sales growth in 2012 at the mean of value of exposure. This elasticity is equal to -0.0046: thus a 100% increase in the RUSF levy (from 3% to 6%) leads to a 0.46% drop in sales growth at the mean value of the exposure. These estimates reflect the fact that 29% firms in our sample were importers in 2010, and 18% of the sample of companies were exposed to the RUSF levy with an average exposure of 0.0172. We obtain very similar coefficient estimates for β_1 and β_2 when we add industry-region (α_{sr}) fixed effects in column 2 or replace industry-time and region-time fixed effects with industry-region-time (α_{srt}) fixed effects in column 3.

In column 4, we show the estimates of baseline model specified in equation (11). We use the 2011-2014 panel of first-differenced data and industry-region-time as well as firm fixed effects. The coefficient estimate on the interaction of exposure and year 2012 indicator variable is equal to -0.193 and statistically significant at the 1%-level: a one standard deviation (0.0662) increase in a firm's exposure in year 2010 leads to a 1.28% decrease in exposed firms' sales growth in year 2012, after controlling for industry-region-time as well as firm-level unobservables. The RUSF-levy-related elasticity of sales growth at the mean of exposure is equal to -0.0033, suggesting that a 100% increase in tax leads to a 0.33% drop in sales growth. The results in column 4 also indicate the reaction the unexpected 2011 doubling of the RUSF levy is short lived. The coefficient estimates for the $I\{t = 2013\} * Exposure_{fsr,T-2}$ interaction is equal to -0.0343 and the one for $I\{t = 2014\} * Exposure_{fsr,T-2}$ interaction is equal to 0.0189, with neither of them being statistically significant at conventional levels.

Table 2 shows the results from a falsification test where we construct $Exposure^P_{f,T-2}$ using data on processing imports. Since the RUSF tax does not apply to processing imports, we should not see any response of sales growth to this placebo exposure measure. The results are consistent with our expectations as the coefficients on the interaction terms between $Exposure^P_{f,T-2}$ and time dummies are economically and statistically insignificant.

In another robustness check, we restrict the sample to the firms that have positive sales for the entire 2011-2014 period. As presented in Table 3, our baseline results are robust to firm survival. This result is consistent with our findings presented in the next exercise (Table 4) where we show that firm exit, immediately after the RUSF increase or later during the estimation period, is not affected by the firm-level exposure to external financing two years prior to the shock.

Next, we examine the impact of the shock on other firm-level outcomes using equation (11).

The results are presented in Table 5. In column 1, the dependent variable is the change in unit costs defined as the ratio of cost of goods sold to gross sales. The coefficient estimate for the $I\{t = 2012\} * Exposure_{f,T-2}$ interaction is equal to 0.0536, and it is statistically significant at the 1%-level. This result is consistent with the mechanism presented in Section 3: increase in the RUSF tax rate leads to an increase in the unit cost of production, and the effect is increasing in the firm's initial exposure to external financing. The estimate implies that a one standard deviation increase in a firm's 2010 exposure (which is equal to 0.0662) leads to a 0.35% greater increase in unit costs. The related RUSF levy elasticity of unit costs at the mean of $Exposure_{f,T-2}$ is equal to 0.0009. While the coefficient estimate for the $I\{t = 2013\} * Exposure_{f,T-2}$ interaction is not statistically significant, the one for the $I\{t = 2014\} * Exposure_{f,T-2}$ interaction is equal to 0.0280 and is statistically significant at the 1%-level.

In column 2 of Table 5, the dependent variable is the change in the share of exports in firm's total sales. The coefficient on the year 2012 interaction term is statistically significant at the 5%-level and implies that a one standard deviation increase in $Exposure_{f,T-2}$ leads to a 0.09% decrease in export growth relative to gross sales. The increase in the RUSF levy appears to have led to a small decrease in exposed firms' shipments to foreign destinations, probably because some of the imported goods are used as inputs in the manufacturing of goods that are then shipped abroad. But the effect is short-lived: the coefficient on the $I\{t = 2013\} * Exposure_{f,T-2}$ and the $I\{t = 2014\} * Exposure_{f,T-2}$ interactions are not statistically significant.

In Table 6, we focus on the direct effect of the shock on domestic purchases. As the first outcome, we consider the growth in (unscaled) domestic purchases and present the results in column 1. The interaction term for year 2012 is statistically significant at the 5%-level. The estimate implies that a one standard deviation increase in firms' exposure as of 2010 leads to a 0.83% decrease in its purchases. However, the effect is limited to 2012, as the coefficient estimates on the $I\{t = 2013\} * Exposure_{f,T-2}$ and the $I\{t = 2014\} * Exposure_{f,T-2}$ interactions are not statistically significant. This observed decrease in domestic purchases in 2012 appears to be driven by suppliers with whom the firm was already doing business prior to the shock. This is visible in column 2, where the dependent variable is defined as the change in the purchases from domestic suppliers from which the firm was already purchasing goods as of 2010 (i.e., two years prior to the shock). The coefficient estimate on the $I\{t = 2012\} * Exposure_{f,T-2}$ interaction is equal to -0.116 and statistically significant at the 5%-level, and the coefficient estimate on the $I\{t = 2013\} * Exposure_{f,T-2}$interaction is equal to -0.0968 and statistically significant at the 10%-level. Thus a one standard deviation increase in $Exposure_{f,T-2}$ leads to a 0.77% drop in 2012 and a 0.64% drop in 2013 in purchases from domestic suppliers with which the exposed firm already had a relationship in 2010. In the last column of the same table, we examine the change in the number of domestic suppliers following the RUSF levy increase. Here of the coefficients of interest only the coefficient on $I\{t = 2014\} * Exposure_{f,T-2}$ is statistically significant. This suggests that the increase in the import tax prompts firms to find new domestic suppliers, but they manage to do so only with a two-year delay.

5.2 Effects of the RUSF shock on liquidity constrained firms

The model presented in Section 3 predicts that the liquidity-constrained firms will continue to rely on external financing despite its high cost after the shock, while unconstrained firms will switch to cash-in-advance. Thus we expect to observe that liquidity-constrained firms are more severely affected by the RUSF levy increase.[5]

We define liquidity-constrained firms as those that are below the median liquidity ratio for their industry as of 2010 (i.e., two years prior to the shock). The liquidity ratio is in turn defined as the total cash, checks received, bank accounts, plus Treasury securities divided by total assets.[6] We augment our estimating equation (11) by adding a low-liquidity indicator variable ($LowLiq_{f,T-2}$). In this modified specification, $LowLiq_{f,T-2}$ is interacted with both year indicator variables as well as year-and-exposure double interaction. The stand-alone $LowLiq_{f,T-2}$ gets absorbed into the firm fixed-effects. The estimates of this empirical model are presented in Table 7.

In the first column of Table 7, we examine sales growth. The coefficient estimate for the triple interaction $LowLiq_{f,T-2} * I\{t = 2013\} * Exposure_{f,T-2}$ is equal to -0.143 and statistically significant at the 10%-level, whereas the triple interactions for years 2012 and 2014 are not statistically significant. These findings suggests that both liquidity constrained and unconstrained firms are equally adversely affected in 2012 by the unexpected RUSF levy increase. The effect of the shock dies out for the liquidity unconstrained firms in the years that follow 2012, whereas liquidity constrained

[5]Liquidity-unconstrained firms could also invest in finding new suppliers and switch away from imported inputs to their domestic substitutes. A more elaborate model could incorporate such mechanism.

[6]Bank lines of credit, typically included in liquidity ratios, are not observable in our dataset.

firms continue to experience a lower sales growth for an additional year. The triple interaction coefficient estimate for 2013 in column 1 suggest that low liquidity firms, when exposed to a one standard deviation increase in exposure have a -0.95% lower sales growth in two years after the shock.

In column 2, we examine how financial constraints might affect the unit costs of the firms affected by the import-levy increase. The coefficient estimates for the $LowLiq_{f,T-2} * I\{t = 2012\} * Exposure_{f,T-2}$, $LowLiq_{f,T-2} * I\{t = 2013\} * Exposure_{f,T-2}$, and $LowLiq_{f,T-2} * I\{t = 2014\} * Exposure_{f,T-2}$ interactions are equal to 0.0378, 0.0578, and 0.0460 and statistically significant at the 10%-, 1%-, and 5%-levels, respectively. These estimates suggest that post-RUSF, a one standard deviation in $Exposure_{f,t=2010}$, the exposed-low liquidity firms' unit costs increase by 0.26%, 0.39%, and 0.30% in 2012, 2013 and 2014, respectively, over and above the effects observed for firms that are not liquidity constrained. These results are consistent with the predictions of the model presented in Section 3, which imply that liquidity constraints matter for the direct effect of the rise in the RUSF rate on firms's costs. In particular, liquidity-constrained firms are predicted to be affected more severely by the tax increase.

5.3 Network effects of the RUSF shock

In this section, we examine the propagation of the RUSF levy increase in Turkish manufacturing network. In Table 8, we present the estimates obtained from estimating equation (11), augmented with variables that capture supplier and buyer exposure (as defined in equations (9) and (10)) as well as their interactions with the time dummies.

In the first column, we examine the impact of the RUSF levy increase through firm's own exposure as well as through the exposure of its suppliers and buyers. Firms' own direct exposures to the shock continues to matter, with coefficient estimates being roughly of the same magnitude as in column 1 of Table 1 and being statistically significant at the 1%-level. A one standard deviation increase in firm's own-exposure to RUSF leads to a 1.51% drop in gross sales. Importantly, we find that RUSF levy increase has an indirect effect through suppliers of the firms. The coefficient estimate for the $I\{t = 2012\} * Exposure^{S}_{f,T-2}$ interaction is equal to -0.173 and statistically significant at the 1%-level. A one standard deviation increase in the exposure (0.0417) of the firm's suppliers to RUSF levy leads to an additional 0.72% decrease in gross sales of the firm. We find no such effect for the firm's buyers: the coefficient estimate for the $I\{t = 2012\} * Exposure^{B}_{f,T-2}$ interaction is equal to -0.076 but not statistically significant at the conventional levels. It appears that the RUSF shock propagates through the production network only through the direct exposure and via suppliers' exposures.

In column 2, we further examine the role of liquidity constraints within the framework of the production network. To do so, we consider additional exposure variables for the firm's suppliers and buyers given on whether the latter are liquidity constrained (LC) or liquidity unconstrained (LU): $Exposure^{S,LC}_{f,T-2}$, $Exposure^{S,LU}_{f,T-2}$, $Exposure^{B,LC}_{f,T-2}$, and $Exposure^{S,LU}_{f,T-2}$. Then, we introduce these new exposure variables by themselves as well as through interactions with $I\{t = 2012\}$ (but we only report the interactions to conserve space). The coefficient estimate for the own-exposure continues to be the most important: $I\{t = 2012\} * Exposure_{f,T-2}$ interaction's coefficient estimate is equal to -0.230 and statistically significant at the 1%-level. But now, we observe an equally large (if not larger) effect of liquidity constrained suppliers' exposure to RUSF increase: $I\{t = 2012\} * Exposure^{S,LC}_{f,T-2}$ interaction's coefficient estimate is equal to -0.287 and statistically significant at the 1%-level. A one standard deviation increase (0.0417) in the firm's suppliers' exposure to RUSF leads to a 1.20% drop in gross sales in 2012. It turns out that even the liquidity-unconstrained suppliers pass on the RUSF shock that they have received: $I\{t = 2012\} * Exposure^{S,LU}_{f,T-2}$ interaction's coefficient estimate is equal to -0.127, which is statistically significant at the 10%-level. A one standard deviation increase in unconstrained suppliers' exposure results in a 0.43% decrease in firm's gross sales. In contrast, we find no evidence of transmission through the buyers of the firm: $I\{t = 2012\} * Exposure^{B,LC}_{f,T-2}$ and $I\{t = 2012\} * Exposure^{B,LU}_{f,T-2}$ interactions' coefficient estimates are negative, but not statistically significant.

In column 3, we use the four-year panel from 2011 to 2014 and estimate a version of equation (11) with firm's own, supplier and buyer exposures interacted with the year indicators. As before, this specification accounts for firm-level time invariant unobservables through firm fixed effects. The estimates of the firm's own-exposure effects are now statistically significant for 2012 and 2013. The coefficient estimates for the interactions $I\{t = 2012\} * Exposure_{f,T-2}$ and $I\{t = 2013\} * Exposure_{f,T-2}$ are equal to -0.181 and -0.0985, respectively, and statistically significant at the 1%-level. The coefficient estimate for$I\{t = 2014\} * Exposure_{f,T-2}$ is negative but not statistically significant. The propagation of the RUSF shock is still observable through the firm's suppliers: the coefficients on $I\{t = 2012\} * Exposure^{S,LC}_{f,T-2}$ is equal to -0.240 and statistically significant at the 5%-level. However, this transmission through the firm's suppliers is short-lived: the coefficients on $I\{t = 2013\} * Exposure^{S,LC}_{f,T-2}$ and $I\{t = 2014\} * Exposure^{S,LC}_{f,T-2}$ are negative but not statistically significant. The shock appears to be only transmitted through liquidity constrained suppliers of the firm: the coefficient on the interactions for the unconstrained suppliers (i.e., $I\{t = 2012\} * Exposure^{S,LU}_{f,T-2}$, $I\{t = 2013\} * Exposure^{S,LU}_{f,T-2}$, and $I\{t = 2014\} * Exposure^{S,LU}_{f,T-2}$) are not statistically significant. Similarly, we do not observe any evidence of the shock being transmitted through the RUSF-exposed buyers: the coefficient estimates for involving the interactions of liquidity constrained or unconstrained buyers of the firm has no significant impact on the firm's sale growth.

In Table 9, we present a robustness check where we split the firm's suppliers and buyers according to their size relative to the industry median, instead of splitting them according to their liquidity ratio. If the results presented in Table 8 reflect the impact of the supplier size rather than the degree of their liquidity constraints, then estimating a similar regression after replacing the supplier (and buyer) exposure based on liquidity with the exposure based on size would yield similar results. The estimates show that the interactions of suppliers' exposure based on size with time indicators are not statistically significant. This increases our confidence in the results, discussed in the previous paragraph, which indicate the importance of the liquidity channel in the propagation of cost shocks in a production network.

In Table 10, we present another robustness check where we restrict the sample to surviving firms in column (1) and to non-importers in column (2). The results remain qualitatively unchanged. In column 2, we see that even firms are not exposed to the shock directly are negatively affected through their liquidity constrained suppliers. This shows the importance of liquidity as a channel for the propagation of cost shocks in a production network.

6 Conclusions

This paper presents evidence suggesting that even relatively small economic shocks propagate through production networks and that such shocks are transmitted and magnified by liquidity constraints firms. Using an unexpected increase in an import duty and detailed production network data from Turkey, we find evidence of a direct and indirect effects of the shock on firms' sales and unit costs. The indirect effects are transmitted by suppliers. The effects are relatively short-lived, typically lasting for a year after the shock and in some cases for two years. The results also indicate that the liquidity of the firms in the network matters for the propagation of the shock.

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Tables and Graphs

Table 1: **Direct Effect of the Shock on Firm-level Sales**

Dep vrb:$\Delta \ln GrossSales_{fsrt}$	(1)	(2)	(3)	(4)
	2011-2012	2011-2012	2011-2012	2011-2014
$I\{t = 2012\} * Exposure_{fsr,T-2}$	**-0.268*****	**-0.266*****	**-0.256*****	**-0.193*****
	(0.0400)	(0.0402)	(0.0409)	(0.0429)
$I\{t = 2013\} * Exposure_{fsr,T-2}$				-0.0343
				(0.0418)
$I\{t = 2014\} * Exposure_{fsr,T-2}$				0.0189
				(0.0404)
$Exposure_{fsr,T-2}$	0.123***	0.121***	0.115***	
	(0.0287)	(0.0291)	(0.0295)	
R^2	0.0432	0.0585	0.0693	0.369
N	73645	73645	73645	128484
Fixed effects	sxt,rxt	sxt,rxt,sxr	sxrxt	sxrxt,f

Notes: This table shows the results from estimating specification in equation (11) where the dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. $Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $^{*}, ^{**}, ^{***}$ represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Table 2: **Placebo Test Using *Exposure* based on Processing Imports**

Dep vrb: $\Delta \ln GrossSales_{fsrt}$	(1)	(2)	(3)	(4)
	2011-2012	2011-2012	2011-2012	2011-2014
$I\{t = 2012\} * Exposure^P_{fsr,T-2}$	-0.0741	-0.0749	-0.0751	-0.0421
	(0.0678)	(0.0686)	(0.0695)	(0.0777)
$I\{t = 2013\} * Exposure^P_{fsr,T-2}$				0.105
				(0.0761)
$I\{t = 2014\} * Exposure^P_{fsr,T-2}$				0.177**
				(0.0756)
$Exposure^P_{fsr,T-2}$	0.123***	0.121***	0.115***	
	(0.0287)	(0.0291)	(0.0295)	
R^2	0.0432	0.0585	0.0693	0.369
N	73645	73645	73645	128484
Fixed effects	sxt,rxt	sxt,rxt,sxr	sxrxt	sxrxt,f

Notes: This table shows the results from estimating specification in equation (11) where the dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. $Exposure^P_{fsr,T-2}$ denotes the direct exposure of firm f importing under processing regime to external financing as of 2010, as defined in equation (8). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $^{*}, ^{**}, ^{***}$ represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Table 3: **Direct Effect of the Shock on Firm-level Sales: Surviving firms only**

Dep vrb:$\Delta \ln GrossSales_{fsrt}$	(1)	(2)	(3)	(4)
	2011-2012	2011-2012	2011-2012	2011-2014
$I\{t = 2012\} * Exposure_{fsr,T-2}$	**-0.182*****	**-0.182*****	**-0.169*****	**-0.169*****
	(0.0448)	(0.0453)	(0.0463)	(0.0463)
$I\{t = 2013\} * Exposure_{fsr,T-2}$				-0.0427
				(0.0444)
$I\{t = 2014\} * Exposure_{fsr,T-2}$				0.0416
				(0.0417)
$Exposure_{fsr,T-2}$	0.0450	0.0440	0.0372	
	(0.0307)	(0.0315)	(0.0320)	
R^2	0.0819	0.103	0.116	0.317
N	73645	73645	73645	128484
Fixed effects	sxt,rxt	sxt,rxt,sxr	sxrxt	sxrxt,f

Notes: This table shows the results from estimating specification in equation (11) where the dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. The sample only includes firms that survive during the entire period. $Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Table 4: **Direct Effect of the Shock on Firm Exit**

	(1)	(2)
Dep vrb:	$Pr(Sales_{fsr,t=T} = 0 \mid$	$Pr(Sales_{fsr,t=T+2} = 0 \mid$
	$Sales_{fsr,t=T-1} > 0)$	$Sales_{fst,t=T-1} > 0)$
$Exposure_{fsr,T-2}$	0.00323	-0.0375
	(0.0233)	(0.0352)
$Size_{fsr,T-2}$	-0.0189***	-0.0490***
	(0.00125)	(0.00173)
R^2	0.0993	0.127
N	37836	37836
Fixed effects	sxr	sxr

Notes: Dependent variable is the probability that an active firm in 2011 survives in the following year in column (1) and in 2014 in column (2).$Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $Size_{fsr,T-2}$ is the logarithm of firm-level sales in 2010. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the industry-region level.

Table 5: **Direct Effect of the Shock on Other Firm-level Outcomes**

	(1)	(2)
Dep vrb:	$\Delta\left(\frac{COGS}{GrossSales}\right)_{fsrt}$	$\Delta\left(\frac{Exports}{GrossSales}\right)_{fsrt}$
	2011-2014	2011-2014
$I\{t=2012\} * Exposure_{fsr,T-2}$	**0.0536*****	**-0.0129****
	(0.0109)	(0.00504)
$I\{t=2013\} * Exposure_{fsr,T-2}$	-0.000311	-0.00128
	(0.0101)	(0.00530)
$I\{t=2014\} * Exposure_{fsr,T-2}$	**0.0280*****	0.00269
	(0.0102)	(0.00522)
R^2	0.276	0.328
N	128484	128484
Fixed effects	sxrxt,f	sxrxt,f

Notes: This table shows the results from estimating specification in equation (11) where the dependent variable is the annual change in unit costs, defined as the ratio of cost of goods sold to gross sales, in column (1) and the ratio of exports to gross sales in column (2) of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. $Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $^{*}, ^{**}, ^{***}$ represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Table 6: **Direct Effect of the Shock on Domestic Purchases**

	(1)	(2)	(3)
Dep vrb:	$\Delta \ln DomPurch_{fsrt}$	$\Delta \ln DomPurch^{Exist}_{fsrt}$	$\Delta NumSupp_{fsrt}$
	2011-2014	2011-2014	2011-2014
$I\{t=2012\} * Exposure_{fsr,T-2}$	**-0.126****	**-0.116****	-0.0307
	(0.0574)	(0.0549)	(0.0461)
$I\{t=2013\} * Exposure_{fsr,T-2}$	-0.0483	**-0.0968***	0.0261
	(0.0576)	(0.0547)	(0.0423)
$I\{t=2014\} * Exposure_{fsr,T-2}$	-0.0285	-0.0274	**0.0740***
	(0.0585)	(0.0586)	(0.0433)
R^2	0.349	0.339	0.294
N	128484	128484	128484
Fixed effects	sxrxt,f	sxrxt,f	sxrxt,f

Notes: This table shows the results from estimating specification in equation (11). $DomPurch$ denotes the total value of total domestic purchases, $DomPurch^{Exist}$ the value of purchases from existing suppliers as of $T-2$, and $NumSupp$ the number of domestic suppliers. $Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $^{*}, ^{**}, ^{***}$ represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Table 7: **Direct Effect of the Shock on Firm-level Sales: The role of liquidity constraints**

	(1)	(2)
	2011-2014	2011-2014
	$\Delta \ln GrossSales_{fsrt}$	$\Delta \left(\frac{COGS}{GrossSales}\right)_{fsrt}$
$I\{t = 2012\} * Exposure_{fsr,t=T-2}$	**-0.208*****	**0.0390*****
	(0.0554)	(0.0139)
$I\{t = 2013\} * Exposure_{fsr,t=T-2}$	0.0337	**-0.0229***
	(0.0540)	(0.0128)
$I\{t = 2014\} * Exposure_{fsr,T-2}$	-0.0107	0.00962
	(0.0514)	(0.0131)
$LowLiq_{fsr,T-2} * I\{2012\} * Exposure_{fsr,T-2}$	0.0769	**0.0378***
	(0.0902)	(0.0218)
$LowLiq_{fsr,T-2} * I\{2013\} * Exposure_{fsr,T-2}$	**-0.143***	**0.0578*****
	(0.0863)	(0.0200)
$LowLiq_{fsr,T-2} * I\{2014\} * Exposure_{fsr,T-2}$	0.0685	**0.0460****
	(0.0843)	(0.0202)
$LowLiq_{fsr,T-2} * I\{2012\}$	-0.0187***	0.0390***
	(0.00684)	(0.0139)
$LowLiq_{fsr,T-2} * I\{2013\}$	-0.00692	-0.00162
	(0.00680)	(0.00134)
$LowLiq_{fsr,T-2} * I\{2014\}$	-0.0199***	-0.000978
	(0.00688)	(0.00137)
R^2	0.381	0.276
N	128484	128484
Fixed effects	sxrxt,f	sxrxt,f

Notes: Dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. $Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $LowLiq_{fsr,T-2}$ is a dummy variable indicating liquidity constrained firms, i.e. firms with liquid to asset ratio below the industry median as of $T-2$, where liquid assets are defined as the sum of cash, checks received, bank accounts-written checks and payments order, Turkish Treasury bills, notes, and bills. $^{*}, ^{**}, ^{***}$ represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Table 8: **Direct and Indirect Effects of the Shock on Firm-level Sales**

Dep vrb: $\Delta \ln GrossSales_{fsrt}$	(1)	(2)	(3)
	2011-2012	2011-2012	2011-2014
$I\{t=2012\} * Exposure_{fsr,T-2}$	**-0.229*****	**-0.230*****	**-0.181*****
	(0.0331)	(0.0331)	(0.0343)
$I\{t=2013\} * Exposure_{fsr,T-2}$			**-0.0985*****
			(0.0340)
$I\{t=2014\} * Exposure_{fsr,T-2}$			-0.00888
			(0.0338)
$I\{t=2012\} * Exposure^{S}_{fsr,t=T-2}$	**-0.173*****		
	(0.0599)		
$I\{t=2012\} * Exposure^{B}_{fsr,T-2}$	-0.0760		
	(0.0508)		
$I\{t=2012\} * Exposure^{S,LC}_{fsr,T-2}$		**-0.287*****	**-0.240****
		(0.100)	(0.117)
$I\{t=2013\} * Exposure^{S,LC}_{fsr,T-2}$			-0.105
			(0.103)
$I\{t=2014\} * Exposure^{S,LC}_{fsr,T-2}$			-0.122
			(0.122)
$I\{t=2012\} * Exposure^{S,LU}_{fsr,T-2}$		**-0.127***	-0.0668
		(0.0733)	(0.0839)
$I\{t=2013\} * Exposure^{S,LU}_{fsr,T-2}$			0.0784
			(0.0847)
$I\{t=2014\} * Exposure^{S,LU}_{fsr,T-2}$			-0.0392
			(0.0835)
$I\{t=2012\} * Exposure^{B,LC}_{fsr,T-2}$		-0.0631	-0.00375
		(0.0648)	(0.0743)
$I\{t=2013\} * Exposure^{B,LC}_{fsr,T-2}$			0.0592
			(0.0719)
$I\{t=2014\} * Exposure^{B,LC}_{fsr,T-2}$			-0.00234
			(0.0767)
$I\{t=2012\} * Exposure^{B,LU}_{fsr,T-2}$		-0.0887	-0.124
		(0.0769)	(0.0917)
$I\{t=2013\} * Exposure^{B,LU}_{fsr,T-2}$			-0.0828
			(0.0967)
$I\{t=2014\} * Exposure^{B,LU}_{fsr,T-2}$			0.0665
			(0.105)
R^2	0.0677	0.0679	0.395
N	73645	73645	128484
Fixed effects	sxrxt	sxrxt	sxrxt,f

Notes: Dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. $Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $I\{t=l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $Exposure^{S,LC}_{fsr,T-2}$ ($Exposure^{B,LC}_{fsr,T-2}$) denotes the weighted average of liquidity-constrained suppliers' (buyers') exposure (i.e. suppliers (buyers) with liquid to asset ratio below the industry median as of $T-2$) of firm f. $Exposure^{S,LU}_{fsr,T-2}$ ($Exposure^{B,LU}_{fsr,T-2}$) denotes the weighted average of liquidity-unconstrained suppliers' (buyers') exposure (i.e. suppliers (buyers) with liquid to asset ratio above the industry median as of $T-2$) of firm f. Individual exposure terms in the first two columns are added but not reported to save space. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Table 9: **Direct and Indirect Effects of the Shock on Firm-level Sales: Is it about liquidity or size?**

Dep vrb: $\Delta \ln GrossSales_{fsrt}$	(1)
	2011-2014
$I\{t=2012\} * Exposure_{fsr,t=T-2}$	**-0.183*****
	(0.0342)
$I\{t=2013\} * Exposure_{fsr,t=T-2}$	**-0.0966*****
	(0.0340)
$I\{t=2014\} * Exposure_{fsr,t=T-2}$	-0.00932
	(0.0337)
$I\{t=2012\} * Exposure^{S,small}_{fsr,t=T-2}$	-0.0212
	(0.560)
$I\{t=2013\} * Exposure^{S,small}_{fsr,t=T-2}$	-0.112
	(0.143)
$I\{t=2014\} * Exposure^{S,small}_{fsr,t=T-2}$	-0.510
	(0.560)
$I\{t=2012\} * Exposure^{S,large}_{fsr,t=T-2}$	-0.122
	(0.0777)
$I\{t=2013\} * Exposure^{S,large}_{fsr,t=T-2}$	-0.00177
	(0.0783)
$I\{t=2014\} * Exposure^{S,large}_{fsr,t=T-2}$	-0.0455
	(0.0784)
$I\{t=2012\} * Exposure^{B,small}_{fsr,t=T-2}$	0.327
	(0.959)
$I\{t=2013\} * Exposure^{B,small}_{fsr,t=T-2}$	0.143
	(0.924)
$I\{t=2014\} * Exposure^{B,small}_{fsr,t=T-2}$	0.582
	(0.971)
$I\{t=2012\} * Exposure^{B,large}_{fsr,t=T-2}$	-0.00429
	(0.0749)
$I\{t=2013\} * Exposure^{B,large}_{fsr,t=T-2}$	0.000773
	(0.0740)
$I\{t=2014\} * Exposure^{B,large}_{fsr,t=T-2}$	0.0302
	(0.0763)
R^2	0.395
N	128484
Fixed effects	sxrxt,f

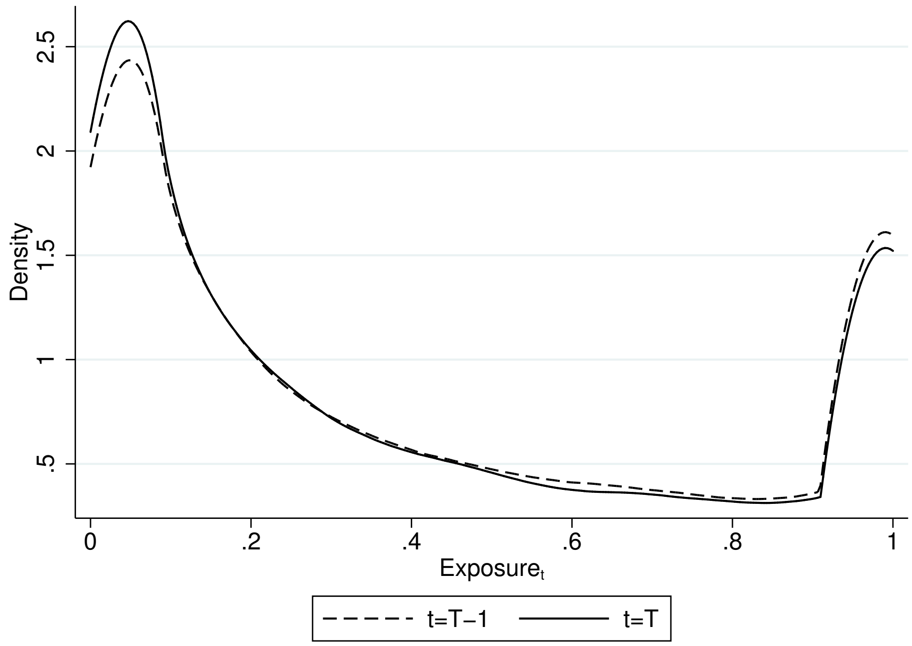
Notes: Dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. $Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $I\{t=l\}$ is a dummy variable that takes on the value one for the year $t=l$, and zero otherwise. $Exposure^{S,small}_{fsr,T-2}$ ($Exposure^{B,small}_{fsr,T-2}$) denotes the weighted average of small suppliers' (buyers') (i.e. suppliers (buyers) with sales below the industry median as of $T-2$) of firm f. $Exposure^{S,large}_{fsr,T-2}$ ($Exposure^{B,large}_{fsr,T-2}$) denotes the weighted average of large suppliers' (buyers') (i.e. suppliers (buyers) with sales above the industry median as of $T-2$) of firm f. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Table 10: **Direct and Indirect Effects of the Shock on Firm-level Sales: Alternative samples**

Dep vrb: $\Delta \ln GrossSales_{fsrt}$	(1)	(2)
	2011-2014	2011-2014
	Surviving firms	Non-importers
$I\{t=2012\} * Exposure_{fsr,t=T-2}$	**-0.198*****	
	(0.0355)	
$I\{t=2013\} * Exposure_{fsr,t=T-2}$	**-0.119*****	
	(0.0347)	
$I\{t=2014\} * Exposure_{fsr,t=T-2}$	-0.0234	
	(0.0337)	
$I\{t=2012\} * Exposure^{S,LC}_{fsr,t=T-2}$	**-0.362****	**-0.264***
	(0.143)	(0.136)
$I\{t=2013\} * Exposure^{S,LC}_{fsr,t=T-2}$	0.170	-0.143
	(0.126)	(0.117)
$I\{t=2014\} * Exposure^{S,LC}_{fsr,t=T-2}$	**-0.283****	-0.155
	(0.135)	(0.141)
$I\{t=2012\} * Exposure^{S,LU}_{fsr,t=T-2}$	-0.0541	-0.0442
	(0.0993)	(0.101)
$I\{t=2013\} * Exposure^{S,LU}_{fsr,t=T-2}$	0.0969	0.128
	(0.0951)	(0.103)
$I\{t=2014\} * Exposure^{S,LU}_{fsr,t=T-2}$	-0.0549	0.0133
	(0.0884)	(0.104)
$I\{t=2012\} * Exposure^{B,LC}_{fsr,t=T-2}$	-0.0120	-0.0139
	(0.0893)	(0.0864)
$I\{t=2013\} * Exposure^{B,LC}_{fsr,t=T-2}$	0.0419	0.0183
	(0.0827)	(0.0835)
$I\{t=2014\} * Exposure^{B,LC}_{fsr,t=T-2}$	0.00538	0.0281
	(0.0827)	(0.0919)
$I\{t=2012\} * Exposure^{B,LU}_{fsr,t=T-2}$	-0.0998	0.00184
	(0.105)	(0.117)
$I\{t=2013\} * Exposure^{B,LU}_{fsr,t=T-2}$	-0.112	0.0117
	(0.106)	(0.117)
$I\{t=2014\} * Exposure^{B,LU}_{fsr,t=T-2}$	0.111	0.0512
	(0.118)	(0.120)
R^2	0.364	0.397
N	75244	68205
Fixed effects	sxrxt	sxrxt

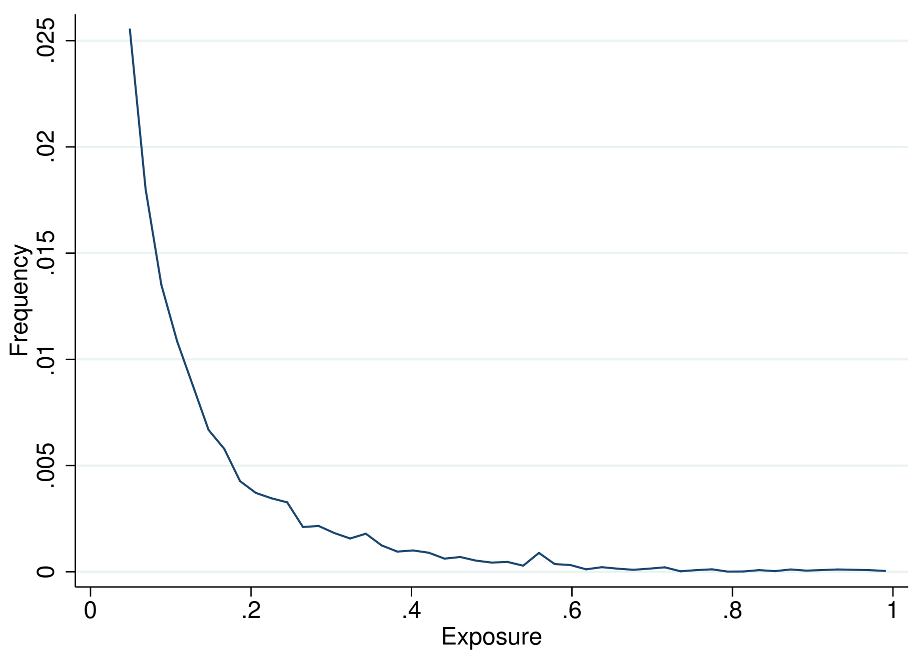
Notes: Dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. $Exposure_{fsr,T-2}$ denotes the direct exposure of firm f to external financing as of 2010, as defined in equation (8). $I\{t=l\}$ is a dummy variable that takes on the value one for the year $t=l$, and zero otherwise. $Exposure^{S,LC}_{fsr,T-2}$ ($Exposure^{B,LC}_{fsr,T-2}$) denotes the weighted average of liquidity-constrained suppliers' (buyers') exposure (i.e. suppliers (buyers) with liquid to asset ratio below the industry median as of $T-2$) of firm f. $Exposure^{S,LU}_{fsr,T-2}$ ($Exposure^{B,LU}_{fsr,T-2}$) denotes the weighted average of liquidity-unconstrained suppliers' (buyers') exposure (i.e. suppliers (buyers) with liquid to asset ratio above the industry median as of $T-2$) of firm f. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the firm level.

Figure 1: Distribution of Share of Imports with External Financing at the Product-Country Level



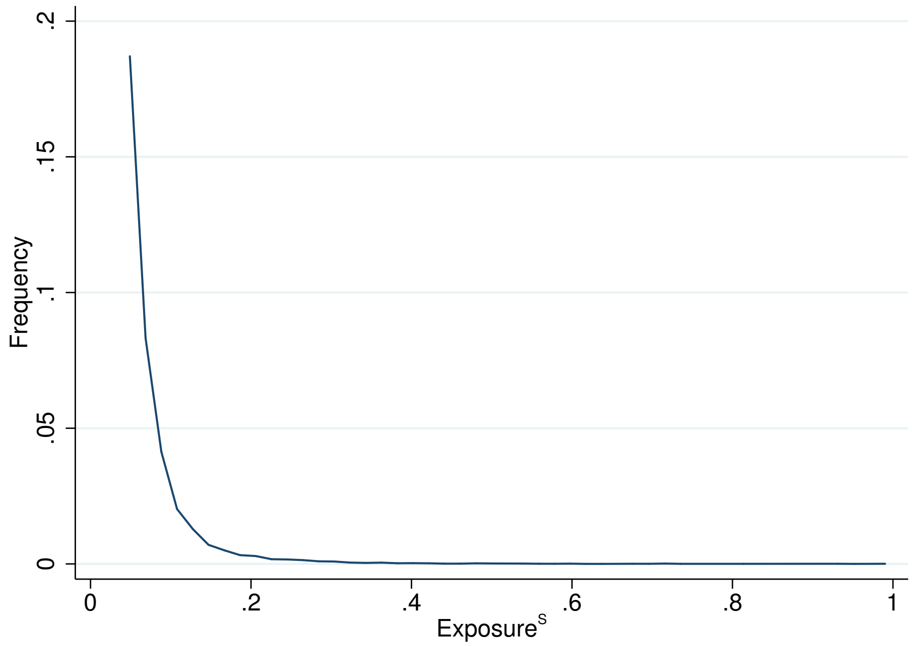
Notes: This figure illustrates the distribution of the share of ordinary imports with external financing in 2011 and 2012. It covers 4,700 6-digit HS products imported from 150 source countries, amounting to a total number of approximately 75,000 country-product pairs.

Figure 2: Distribution of Direct Firm-level Exposure to External Financing as of 2010

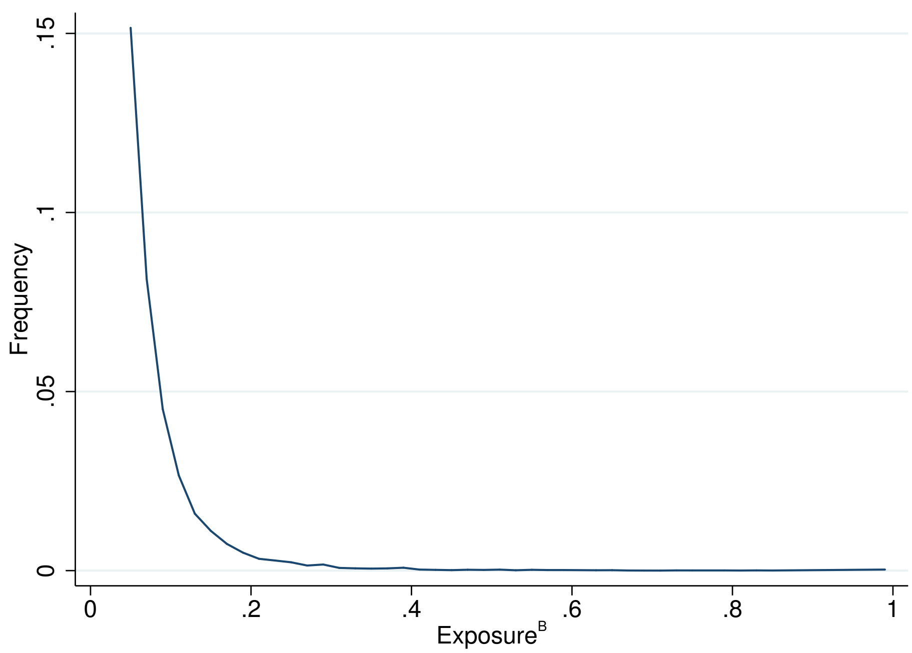


Notes: This figure illustrates the distribution of the firm-level direct exposure variable defined in equation (8).

Figure 3: Distribution of Indirect Firm-level Exposure to External Financing as of 2010



Panel A: Indirect exposure through suppliers



Panel A: Indirect exposure through buyers

Notes: This figure illustrates the distribution of the indirect firm-level exposure variables defined in equations (9) and (10).