Financial Constraints and Propagation of Shocks in Production Networks *

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This study examines the role of financing constraints in propagation of an unexpected supply shock through a country's production network. The analysis, motivated by a simple theoretical model, is based on data covering quasi-totality of supplier-customer links in Turkey during the 2010-14 period. The shock in question was the increase in the tax rate applying to imports *purchased on credit* from 3 to 6% in October 2011. As utilization of trade credit varied across product varieties, the shock had a heterogenous effect across importers. The results suggest that the shock was propagated and amplified by firms with limited access to external liquidity. Liquidity constrained importers, exposed to the shock, transmitted it to their liquidity constrained customers.

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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 of 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 stress 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.

More specifically, the paper focuses on a shock that increased 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 that are financed through trade credit. Since utilization of trade credit varied across imported varieties (i.e., product-source country combinations), the shock had a heterogenous impact across importers.

Our analysis is motivated by simple partial equilibrium framework. We extend an otherwise standard model that has been used by others (e.g., Halpern, Koren, and Szeidl (2015)) by allowing firms to choose between paying for imports immediately or delaying payment by using trade credit. The model 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.

In our analysis, we examine the extent to which the cost shock affected firms directly exposed to the tax. We then 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. Most importantly, we investigate the role of liquidity constraints in the transmission of the shock throughout the economy.

Our results can be summarized as follows. First, we find that all firms directly exposed to the tax saw an increase in their costs (relative to sales), but this increase was smaller for firms with an easy access to external liquidity. The exposed firms also experienced a decline in sales and imports. Their domestic purchases and the number of domestic suppliers went up. Second, we find that importing firms with no liquidity constraints appear to have absorbed the shock, while liquidity constrained importers passed the shock onto their liquidity constrained 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 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. These authors are, however, unable to use network data as they do not have access to inter-firm payment information. We add to this strand of the literature 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%.[1]

The tax is implemented by the Turkish Customs and Trade Ministry that 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 it 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 transactions (in which the importer pre-pays for the goods), transactions financed through a 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

[1] Google Trends statistics, presented in Figure 1, do not show a trend for the number of searches involving "KKDF" or "Kaynak Kullanımını Destekleme Fonu", which is the Turkish name of the tax, before the week of 9 October 2011, when the number of searches peaks. This supports our claim that the tax increase was unanticipated.

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:

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

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.[2]

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 $r_f \in [\underline{\mathrm{r}}, r^*]$ choose to pay immediately, and others use external financing to delay payment.

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

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

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 $\eta_{fj} = \frac{\left(\frac{P^F_{fj}}{B_{fj}}\right)^{1-\theta}}{\left(\frac{P^F_{fj}}{B_{fj}}\right)^{1-\theta} + \left(P^H_{fj}\right)^{1-\theta}}$ is related to share of imported varieties in the unit of intermediate

[2]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.

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:[3]

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

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.

[3] 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.

4 Data and Empirical Strategy

4.1 Data

To conduct our analysis, we combine data from three Turkish administrative datasets.[4] The first dataset, available at the Turkish Statistical Institute (TSI), is based on customs data. It allows us to trace all Turkish imports disaggregated by the importing firm, source country, 6-digit Harmonized System (HS6) product code and trade financing type (i.e., cash in advance, letter of credit, open account, etc.). The TSI imports data cover 150 source countries, roughly 4,700 HS6 product categories, and correspond to approximately 75,000 country-product pairs.

Due to confidentiality issues, we cannot transfer firm-level import data from the TSI and match them with the other two datasets that we describe below. However, we can augment the other datasets with the more aggregate figures obtained from TSI on the import financing used at the product-country-year-level for each year between 2010-2012.

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.

This dataset also 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. Therefore, we augment the dataset with the country-product financing information obtained from TSI and described above.

Finally, we combine the firm-to-firm transaction data with firm-level balance sheet and income

[4] 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.

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 which stand for 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-level exposure variable ($Exposure_{j,T-2}$) and import it into the MIST dataset:

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

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

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

where $\omega_{fj,T-2}$ denotes the share of imports of variety j in firm f's total costs (defined as the sum of labor costs, purchases from other domestic firms and imports) at time $t = T - 2$.

Figure 2 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:

$$Exposure^{Suppliers}_{f,T-2} \quad = \quad \sum_s \omega_{fs,T-2} \times Exposure_{s,T-2}, \tag{9}$$

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,:

$$Exposure^{Buyers}_{f,T-2} \quad = \quad \sum_b \omega_{fb,T-2} \times Exposure_{b,T-2}, \tag{10}$$

where $\omega^{B}_{fb,T-2}$ is the share of buyer b in firm f's total domestic sales in year 2010. In Figures 3 and 4, we present the distributions for direct and indirect firm-level exposures, respectively (after excluding zero exposure cases, as explained above).

We also construct additional variables to capture the firm's exposure to the RUSF levy increase through its second-degree vertical (*suppliers of suppliers* and *buyers of buyers*) and second-degree horizontal linkages (*buyers of suppliers* and *suppliers of buyers*):[5]

$$\begin{aligned}
Exposure^{Sup-of-Sup}_{f,T-2} &= \sum_s \omega_{fs,T-2} \times Exposure^{Suppliers}_{s,T-2} \\
Exposure^{Buy-of-Buy}_{f,T-2} &= \sum_b \omega_{fb,T-2} \times Exposure^{Buyers}_{b,T-2} \\
Exposure^{Buy-of-Sup}_{f,T-2} &= \sum_s \omega_{fs,T-2} \times Exposure^{Buyers}_{s,T-2} \\
Exposure^{Sup-of-Buy}_{f,T-2} &= \sum_b \omega_{fb,T-2} \times Exposure^{Suppliers}_{b,T-2}
\end{aligned} \tag{11}$$

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Using the exposure variable described in equation (8), we first estimate a difference-in-differences

[5] See Figure 5 for an illustration.

specification with a first-differenced dependent variable for the 2011-2014 period:

$$\Delta \ln Y_{fsrt} = \beta_0 + \sum_{l=2012}^{2014} \beta_l * I\{t=l\} * Exposure_{fsr,T-2} + \alpha_{srt} + \alpha_f + e_{fsrt}, \quad (12)$$

where Y is an outcome variable (e.g., unit costs) 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 industry-region 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 2, we focus on the change in the unit material costs, defined as the sum of imported and domestically purchases material inputs, 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 (12). We control only for industry-time, region-time, and industry-region unobservables and use data for the 2011-2012 period. The coefficient of interest (on the interaction of *Exposure* and year 2012 indicator variable) is positive and statistically significant at the 1%-level. The magnitude of the estimated effect is economically meaningful: a one-standard-deviation increase in exposure to the tax as of year 2010 leads to a 4% increase in the exposed firm's unit costs in the year following the shock.

Another, and perhaps more appropriate, way of expressing the impact of the shock is to evaluate the RUSF-related elasticities of unit costs in 2012 at the mean of value of $Exposure$. This elasticity is equal to 0.0096: thus a 100% increase in the RUSF levy (from 3% to 6%) leads to a 0.96% increase in unit costs at the mean value of $Exposure$. 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 0.009. We obtain very similar coefficient estimates for β_1 and β_2 when we replace industry-time and region-time fixed effects with industry-region-time (α_{srt}) fixed effects in column 2.

In columns (3) and (4), we show the estimates of the baseline model specified in equation (12). We use the 2011-2014 panel of first-differenced data and control for industry-region-time fixed effects. In the last column, we also add firm fixed effects. The coefficient estimate on the interaction of $Exposure$ and year 2012 indicator variable is equal to 1.095. It is statistically significant at the 1%-level: a one standard deviation (0.036) increase in a firm's exposure in year 2010 leads to a 4% increase in exposed firms' unit costs in year 2012, after controlling for industry-region-time as well as firm-level unobservables. The RUSF-levy-related elasticity of unit costs at the mean of exposure is equal to 0.0099, suggesting that a 100% increase in tax leads to a 1% increase in unit costs. The results also indicate the reaction the unexpected 2011 doubling of the RUSF levy is long lived. In column 4, the coefficient estimates for the $I\{t = 2013\} * Exposure_{fsr,T-2}$ interaction is equal to 1.268 and the one for $I\{t = 2014\} * Exposure_{fsr,T-2}$ interaction is equal to 1.503, with both of them being statistically significant at the 1%-level. We fail to reject the equality of the coefficient estimates for the interaction terms across years.

We conduct a number of robustness checks. In column 1 of Table 9, we assign a placebo date (October 2010 instead of the actual date October 2011) to the shock. As expected, the estimate obtained for the interaction $I\{t = 2011\} * Exposure_{fsr,T-3}$ is not economically or statistically significant at conventional levels. In column 2, we run another 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 column 3, we add a dummy indicating whether the firm size (in terms of sales) was below the industry median as of $T-2$ ($I\{Size < \overline{Size}\}_{fsr,T-2}$) and its interactions with time dummies as additional controls to the baseline specification. The estimates of interest remain robust to those additional controls. In column 4, we add the ratio of total imports to sales as of $T-2$ ($(M/Sales)_{fsr,T-2}$) and its interactions with time dummies to check whether other import-related shocks (e.g., exchange rate movements) affect the baseline estimates. The estimates of interest remain robust . In the last column, we restricts the sample to surviving firms during the 2011-2014 period to check whether firm exit affects our coefficient estimates. The results show that they remain very close to the baseline estimates.

In Table 3, we consider the direct effect of the shock on firm-level sales. As with unit costs, we find that the tax increase has a large and statistically significant impact on the sales of affected firms. The effects is large and lasts beyond the year immediately following the tax increase. In the last column, the coefficient estimate for the $I\{t = 2012\} * Exposure_{f,T-2}$ interaction is equal to -0.385, and it is statistically significant at the 1%-level, implying that a one standard deviation increase in a firm's 2010 exposure (0.036) leads to a 1.4% decrease in exposed firms' sales growth in year 2012 following the shock.

Next, we examine the impact of the shock on other firm-level outcomes using equation (12). In column 1, the dependent variable is the change in the share of imports in the 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 1.2% decrease in import intensity. 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 column 2, we focus on the direct effect of the shock on domestic purchases. We consider the growth of domestic purchases scaled by sales. As anticipated, the interaction term for year 2012 is positive and statistically significant at the 5%-level. The estimate implies that a one standard deviation increase in firms' exposure as of 2010 leads to a 0.76% increase in its purchases. This effect persist in 2013 and 2014, albeit its magnitude halves. In the last column of the same table, we examine the change in the number of domestic suppliers following the RUSF levy increase. The results suggest that firms exposed to the tax increase the number of domestic suppliers. All estimates of interest are statistically significant with their magnitudes increasing over time. This pattern is intuitive because it takes time to find suitable domestic suppliers.

5.2 Network effects of the RUSF shock

In this section, we examine the propagation of the RUSF levy increase through the manufacturing network. In Table 5, we present the estimates obtained from estimating equation (12), augmented with variables that capture supplier and buyer exposure to the shock (as defined in equations (9) and (10)) as well as their interactions with the time dummies. In other words, 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 2 and being statistically significant at the 1%-level. A one standard deviation increase in firm's own-exposure to RUSF leads to a 3.8% increase in unit costs. Importantly, we find that RUSF levy increase has an indirect effect through firms suppliers. The coefficient estimate for the $I\{t = 2012\} * Exposure^{Suppliers}_{f,T-2}$ interaction is equal to 0.526 and is statistically significant at the 1%-level. A one standard deviation increase in the exposure (0.034) of the firm's suppliers to RUSF levy leads to an additional 1.8% increase in unit costs of the firm. We find no such effect for the firm's buyers: the coefficient estimate for the $I\{t = 2012\} * Exposure^{Buyers}_{f,T-2}$ interaction fails to reach the conventional significance levels. In sum, the tax shock appears to propagate only through the direct exposure and the exposure of suppliers.

In column 2, we consider a longer time period and trace the impact of the shock over time. Our previous conclusions are confirmed. The tax increase has a long-lasting negative effect on unit costs. The impact works through a firms direct exposure as well as through the exposure of a firms suppliers. As before, we find no evidence of the shock being propagated through exposed buyers. Column 3 shows that the results are robust to controlling for firm fixed effects, which in this setting (with the dependent variable defined as the first difference) capture firm-specific trends.

Finally, in column 4, we consider second-round effects. Namely, we allow for the impact to work through suppliers of a firm's suppliers being exposed or through buyers of a firm's buyers being exposed (recall Panel A of Figure 5). This does not appear to be the case. Neither is there evidence of horizontal propagation, that is propagation through other buyers of the firm‘s suppliers and through other suppliers of the firm‘s buyers (recall Panel B of Figure 5).

5.3 Effects of the RUSF shock on liquidity constrained firms

Next, we examine the effects of liquidity constraints on transmission of economic shocks through the economy. Firms that are not liquidity constrained might not be affected by the RUSF tax increase, as they might switch away from importing on trade credit and in this way avoid being subject to the levy. The model presented in Section 3 predicts that liquidity unconstrained firms will switch to cash-in-advance financing, while liquidity-constrained firms will continue to rely on external financing despite its high cost after the shock. Thus we expect to observe that liquidity constrained firms are more severely affected by the RUSF levy increase.[6]

We define liquidity unconstrained firms ($HighLiq_{f,T-2}$) as those that are above 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 ratio of inventories to gross sales. This proxy for access to liquidity has been used extensively in the literature (see, for instance, Raddatz (2006)).[7]

We augment our estimating equation (12) by adding a high-liquidity indicator variable ($HighLiq_{f,T-2}$). In this modified specification, $HighLiq_{f,T-2}$ is interacted with both year indicator variables as well as year-and-$Exposure$ double interactions. The stand-alone $HighLiq_{f,T-2}$ gets absorbed into the firm fixed-effects. The estimates of this empirical model are presented in Table 6. As before, we find that firms directly exposed to the shock experience a long-lasting increase in unit costs. More interestingly, we find that this increase is much smaller for liquidity unconstrained firms. The coefficient estimate on the triple interactions $HighLiq_{f,T-2} * I\{t = 2012\} * Exposure_{f,T-2}$ and $HighLiq_{f,T-2} * I\{t = 2013\} * Exposure_{f,T-2}$ are positive and statistically significant at the 10% and 5% level, respectively. They are equal to -0.667 and -0.634. The coefficient on $HighLiq_{f,T-2} * I\{t = 2014\} * Exposure_{f,T-2}$, although similar in magnitude (-0.428) does not reach conventional significance levels. A one-standard-deviation increase in $Exposure$ translates into a 5.9% increase in unit costs of liquidity constrained firms and a 3.3% increase in unit costs of liquidity unconstrained firms in 2012. In Appendix Table 10, we show that replacing our measure of liquidity constraints with the leverage ratio does not lead to similar conclusions. This boosts our confidence in the findings.

[6] 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.

[7] Our results are robust to using an alternative measure of access to liquidity defined as current assets divided by total liabilities.

In Table 7, we 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 ($LowLiq$) or liquidity unconstrained (($HighLiq$): $Exposure_{f,T-2}^{Suppliers,HighLiq}$, $Exposure_{f,T-2}^{Suppliers,LowLiq}$, $Exposure_{f,T-2}^{Buyers,HighLiq}$, and $Exposure_{f,T-2}^{Buyers,LowLiq}$. We present a specification estimated on the full sample as well as on the subsamples of liquidity constrained and liquidity unconstrained firms. To increase the readability of the table we report only groups of coefficients where we find some statistically significant effects. The full table is reported in the Appendix (see Table 11).

As before, we find that the coefficient estimates for the own exposure to the shock continue to be the most important. The effects are economically meaningful (though the magnitudes are smaller than in previous tables), statistically significant and persist over time. More interestingly, we find that the propagation of the shock through the networks takes place only when *both* the firm in question exposed to the shock and its suppliers exposed to the shock are liquidity constrained. In other words, the estimated coefficient on year interactions with $Exposure_{f,T-2}^{Suppliers,LowLiq}$ are statistically significant only in the liquidity constrained subsample (column 2) but not in the liquidity unconstrained subsample (column 3). In the former subsample, the estimates are statistically significant at the 1% level in 2012 and 2013. This pattern is intuitive. Suppliers that are not liquidity constrained may switch to a different form of financing to avoid the high tax. Similarly, firms that are not liquidity constrained may extend trade credit to their constrained suppliers thus allowing them to avoid the high tax. Thus the shock matters only for liquidity constrained firms with liquidity constrained suppliers.

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 the tax on import financing and detailed production network data from Turkey, we find evidence of a direct and indirect effects of the shock on firms' unit costs. The indirect effects are transmitted to liquidity constrained firms by their liquidity constrained suppliers. Thus the results indicate that liquidity constraints matters for propagation of the shock through the economy.

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Tables and Graphs

Table 1: **Summary Statistics**

	Variable				
	Exposure	$Exposure^{Suppliers}$	$Exposure^{Buyers}$	Number of suppliers	Number of buyers
2011-2012					
Mean	0.009	0.021	0.013	20.97	25.74
Standard deviation	0.036	0.034	0.027	42.28	53.70
Number of obs	106,066	106,066	106,066	106,066	106,066
2011-2014					
Mean	0.009	0.020	0.013	23.79	29.63
Standard deviation	0.036	0.033	0.027	46.74	59.32
Number of obs	185,449	185,449	185,449	185,449	185,449

Table 2: **Direct Effect of the Shock on Firm-level Costs**

Dependent variable: $\Delta \ln \left(\frac{InputCosts}{Sales}\right)_{fsrt}$	(1)	(2)	(3)	(4)
	2011-2012	2011-2012	2011-2014	2011-2014
$I\{t=2012\} * Exposure_{fsr,T-2}$	**1.068*****	**1.095*****	**1.095*****	**1.095*****
	(0.113)	(0.114)	(0.114)	(0.129)
$I\{t=2013\} * Exposure_{fsr,T-2}$			**1.252*****	**1.268*****
			(0.0923)	(0.118)
$I\{t=2014\} * Exposure_{fsr,T-2}$			**1.406*****	**1.503*****
			(0.109)	(0.138)
$Exposure_{fsr,T-2}$	-1.886***	-1.903***	-1.903***	
	(0.109)	(0.111)	(0.111)	
R^2	0.0326	0.0411	0.0420	0.385
N	106,066	106,066	185,449	185,449
Fixed effects	sxt,rxt,sxr	sxrxt	sxrxt	sxrxt,f

Notes: This table shows the results from estimating specification in equation (12) where the dependent variable is the annual change in unit material costs of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. Material inputs include imports and purchases from other domestic firms. $Exposure_{fsr,T-2}$ 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 industry-region level.

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

Dependent variable: $\Delta \ln Sales_{fsrt}$	(1)	(2)	(3)	(4)
	2011-2012	2011-2012	2011-2014	2011-2014
$I\{t = 2012\} * Exposure_{fsr,T-2}$	**-0.516*****	**-0.510*****	**-0.510*****	**-0.385*****
	(0.0625)	(0.0629)	(0.0629)	(0.0793)
$I\{t = 2013\} * Exposure_{fsr,T-2}$			**-0.300*****	**-0.134****
			(0.0504)	(0.0621)
$I\{t = 2014\} * Exposure_{fsr,T-2}$			**-0.208*****	-0.0493
			(0.0555)	(0.0662)
$Exposure_{fsr,T-2}$	0.379***	0.376***	0.376***	
	(0.0440)	(0.0441)	(0.0441)	
R^2	0.0502	0.0588	0.0531	0.393
N	106,066	106,066	185,449	185,449
Fixed effects	sxt,rxt,sxr	sxrxt	sxrxt	sxrxt,f

Notes: This table shows the results from estimating specification in equation (12) 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 industry-region level.

Table 4: **Direct Effect of the Shock on Firm-level Input Purchases**

	(1)	(2)	(3)
Dependent variable:	$\Delta\left(\frac{M}{Sales}\right)_{fsrt}$	$\Delta\left(\frac{DomPurch}{Sales}\right)_{fsrt}$	$NewDomSupp_{fsrt}$
	2011-2014	2011-2014	2011-2014
$I\{t=2012\} * Exposure_{fsr,T-2}$	**-0.0314****	**0.210*****	**4.700*****
	(0.0149)	(0.0425)	(1.531)
$I\{t=2013\} * Exposure_{fsr,T-2}$	0.0118	**0.118*****	**9.702*****
	(0.0175)	(0.0455)	(2.240)
$I\{t=2014\} * Exposure_{fsr,T-2}$	0.00922	**0.107****	**15.13*****
	(0.0183)	(0.0449)	(3.026)
R^2	0.278	0.242	0.825
N	185,449	185,449	185,449
Fixed effects	sxrxt,f	sxrxt,f	sxrxt,f

Notes: This table shows the results from estimating specification in equation (12) where the dependent variable is the annual change in imports to sales ratio (column 1), annual change in domestic purchases to sales ratio (column 2) and new domestic supplier links 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 industry-region level.

Table 5: **Direct and Indirect Effects of the Shock on Firm-level Costs**

Dependent variable: $\Delta \ln \left(\frac{InputCosts}{Sales}\right)_{fsrt}$	(1)	(2)	(3)	(4)
	Baseline		Baseline w/ firm FEs	Second-round effects
	2011-2012	2011-2014	2011-2014	2011-2012
$I\{t=2012\} * Exposure_{fsr,T-2}$	**1.032*****	**1.032*****	**1.023*****	**0.851*****
	(0.117)	(0.117)	(0.131)	(0.156)
$I\{t=2013\} * Exposure_{fsr,T-2}$		**1.163*****	**1.172*****	
		(0.0953)	(0.117)	
$I\{t=2014\} * Exposure_{fsr,T-2}$		**1.333*****	**1.427*****	
		(0.113)	(0.136)	
$I\{t=2012\} * Exposure^{Suppliers}_{fsr,T-2}$	**0.526*****	**0.526*****	**0.701*****	**0.277***
	(0.184)	(0.184)	(0.176)	(0.168)
$I\{t=2013\} * Exposure^{Suppliers}_{fsr,T-2}$		**0.815*****	**0.935*****	
		(0.216)	(0.200)	
$I\{t=2014\} * Exposure^{Suppliers}_{fsr,T-2}$		**0.542*****	**0.739*****	
		(0.203)	(0.201)	
$I\{t=2012\} * Exposure^{Buyers}_{fsr,T-2}$	0.267	0.267	0.280	-0.191
	(0.279)	(0.279)	(0.265)	(0.288)
$I\{t=2013\} * Exposure^{Buyers}_{fsr,T-2}$		0.248	0.472	
		(0.259)	(0.292)	
$I\{t=2014\} * Exposure^{Buyers}_{fsr,T-2}$		0.128	0.461	
		(0.255)	(0.322)	
$I\{t=2012\} * Exposure^{Sup-of-Sup}_{fsr,T-2}$				-0.455
				(0.291)
$I\{t=2012\} * Exposure^{Buy-of-Buy}_{fsr,T-2}$				0.374
				(0.442)
$I\{t=2012\} * Exposure^{Buy-of-Sup}_{fsr,T-2}$				0.339
				(0.460)
$I\{t=2012\} * Exposure^{Sup-of-Buy}_{fsr,T-2}$				-0.332
				(0.310)
R^2	0.0445	0.0453	0.385	0.0428
N	106,066	185,449	185,449	106,066
Fixed effects	sxrxt	sxrxt	sxrxt,f	sxrxt

Notes: This table shows the results from estimating specification in equation (12) augmented with buyer and supplier exposure variables. The dependent variable is the annual change in unit material costs of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. Material inputs include imports and purchases from other domestic firms. Exposure variables are defined in equations (8), (9), (10), and (11)). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. In columns (1), (2) and (4), individual exposure terms are included but not reported. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the industry-region level.

Table 6: **Role of Financial Constraints: Baseline**

Dependent variable: $\Delta \ln \left(\frac{InputCosts}{Sales}\right)_{fsrt}$	(1)
	2011-2014
$I\{t = 2012\} * Exposure_{fsr,t=T-2}$	**1.580*****
	(0.313)
$I\{t = 2013\} * Exposure_{fsr,t=T-2}$	**1.472*****
	(0.287)
$I\{t = 2014\} * Exposure_{fsr,T-2}$	**1.480*****
	(0.410)
$HighLiq_{fsr,T-2} * I\{2012\} * Exposure_{fsr,T-2}$	**-0.667***
	(0.344)
$HighLiq_{fsr,T-2} * I\{2013\} * Exposure_{fsr,T-2}$	**-0.634****
	(0.304)
$HighLiq_{fsr,T-2} * I\{2014\} * Exposure_{fsr,T-2}$	-0.428
	(0.485)
R^2	0.416
N	185,449
Fixed effects	sxrxt,f

Notes: The dependent variable is the annual change in unit material costs of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. Material inputs include imports and purchases from other domestic firms. $Exposure_{fsr,T-2}$ 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. $HighLiq_{fsr,T-2}$ is a dummy variable indicating liquidity unconstrained firms, which have inventory-to-sales ratio above their industry median at $t = T - 2$. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the industry-region level.

Table 7: **Direct and Indirect Effects of the Shock on Firm-level Costs: Role of financial constraints**

Dependent variable: $\Delta \ln \left(\frac{InputCosts}{Sales}\right)_{fsrt}$	(1)	(2)	(3)
	All	$LowLiq$ firms	$HighLiq$ firms
	2011-2014	2011-2014	2011-2014
$I\{t = 2012\} * Exposure_{fsr,T-2}$	**0.610*****	**0.859*****	**0.522*****
	(0.139)	(0.300)	(0.145)
$I\{t = 2013\} * Exposure_{fsr,T-2}$	**0.674*****	**1.362*****	**0.518*****
	(0.112)	(0.355)	(0.108)
$I\{t = 2014\} * Exposure_{fsr,T-2}$	**0.729*****	**0.660****	**0.708*****
	(0.129)	(0.306)	(0.144)
[1em] $I\{t = 2012\} * Exposure^{Suppliers,LowLiq}_{fsr,T-2}$	**0.493****	**1.309*****	0.179
	(0.201)	(0.428)	(0.247)
$\{t = 2013\} * Exposure^{Suppliers,LowLiq}_{fsr,T-2}$	0.270	**1.371*****	-0.0692
	(0.239)	(0.433)	(0.301)
$I\{t = 2014\} * Exposure^{Suppliers,LowLiq}_{fsr,T-2}$	-0.0443	0.582	-0.234
	(0.275)	(0.460)	(0.343)
R^2	0.383	0.421	0.385
N	185,449	89,015	96,434
Fixed effects	sxrxt,f	sxrxt,f	sxrxt,f

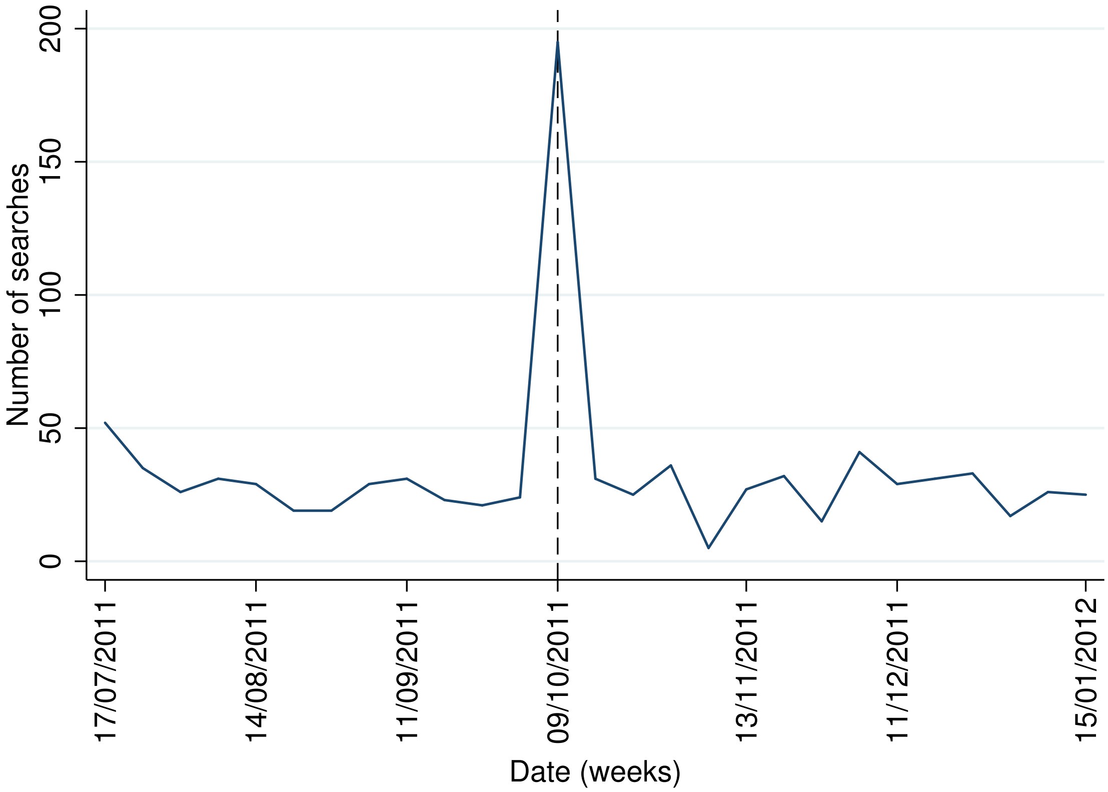
Notes: Dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. Exposure variables are defined in equations (8), (9) and (10). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $Exposure^{Suppliers,HighLiq}_{fsr,T-2}$ ($Exposure^{Buyers,HighLiq}_{fsr,T-2}$) denotes the weighted average of liquidity-unconstrained suppliers' (buyers') exposure (i.e. suppliers (buyers) with inventory to sales ratio above the industry median as of $T-2$) of firm f. $Exposure^{Suppliers,LowLiq}_{fsr,T-2}$ ($Exposure^{Buyers,LowLiq}_{fsr,T-2}$) denotes the weighted average of liquidity-constrained suppliers' (buyers') exposure (i.e. suppliers (buyers) with inventory to sales ratio below the industry median as of $T-2$) of firm f. Full results are presented in Table 11. $^{*}, ^{**}, ^{***}$ represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the industry-region level.

Table 8: **Direct and Indirect Effects of the Shock on Firm-level Costs: Is it about liquidity or size?**

Dependent variable: $\Delta \ln \left(\frac{InputCosts}{Sales}\right)_{fsrt}$	(1)
	2011-2014
$I\{t=2012\} * Exposure_{fsr,T-2}$	**0.607*****
	(0.138)
$I\{t=2013\} * Exposure_{fsr,T-2}$	**0.674*****
	(0.114)
$I\{t=2014\} * Exposure_{fsr,T-2}$	**0.728*****
	(0.130)
$I\{t=2012\} * Exposure^{Suppliers,Small}_{fsr,T-2}$	-0.887
	(1.513)
$I\{t=2013\} * Exposure^{Suppliers,Small}_{fsr,T-2}$	-0.467
	(1.360)
$I\{t=2014\} * Exposure^{Suppliers,Small}_{fsr,T-2}$	-0.516
	(1.537)
$I\{t=2012\} * Exposure^{Suppliers,Large}_{fsr,T-2}$	0.193
	(0.151)
$I\{t=2013\} * Exposure^{Suppliers,Large}_{fsr,T-2}$	0.0426
	(0.189)
$I\{t=2014\} * Exposure^{Suppliers,Large}_{fsr,T-2}$	-0.349
	(0.215)
$I\{t=2012\} * Exposure^{Buyers,Small}_{fsr,T-2}$	-1.147
	(1.500)
$I\{t=2013\} * Exposure^{Buyers,Small}_{fsr,T-2}$	-1.103
	(1.717)
$I\{t=2014\} * Exposure^{Buyers,Small}_{fsr,T-2}$	-1.046
	(1.657)
$I\{t=2012\} * Exposure^{Buyers,Large}_{fsr,T-2}$	-0.240
	(0.287)
$I\{t=2013\} * Exposure^{Buyers,Large}_{fsr,T-2}$	-0.176
	(0.289)
$I\{t=2014\} * Exposure^{Buyers,Large}_{fsr,T-2}$	-0.194
	(0.304)
R^2	0.383
N	185,449
Fixed effects	sxrxt,f

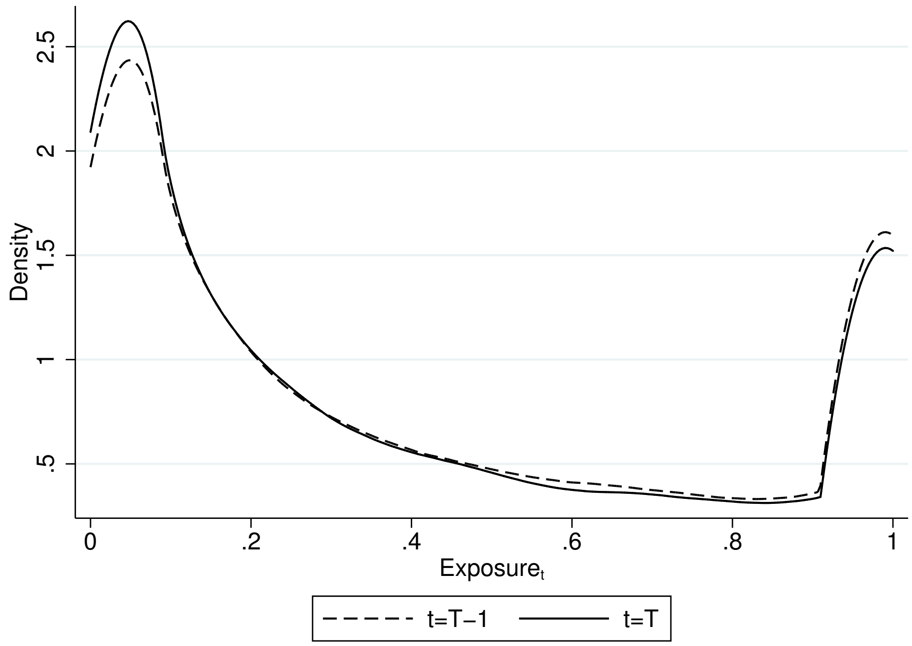
Notes: Dependent variable is the annual growth rate of gross sales of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. Exposure variables are defined in equations (8), (9) and (10). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $Exposure^{Suppliers,Small}_{fsr,T-2}$ ($Exposure^{Buyers,Small}_{fsr,T-2}$) denotes the weighted average of small suppliers' (buyers') exposure (i.e. suppliers (buyers) with sales below the industry median as of $T-2$) of firm f. $Exposure^{Suppliers,Large}_{fsr,T-2}$ ($Exposure^{Buyers,Large}_{fsr,T-2}$) denotes the weighted average of large suppliers' (buyers') exposure (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 industry-region level.

Figure 1: Number of Searches for RUSF on Google



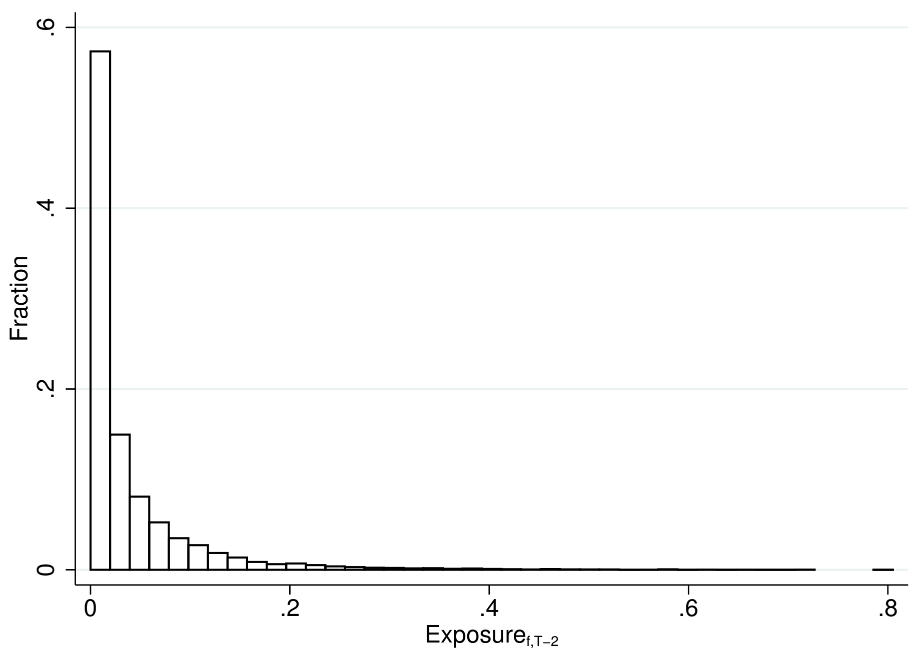
Notes: This figure shows the number of weekly searches involving "KKDF" or "Kaynak Kullanımını Destekleme Fonu" on Google before and after the increase in the RUSF rate on October 13, 2011. The vertical line marks the week of the policy change.

Figure 2: Distribution of Share of Imports with External Financing at the Product-Country Level



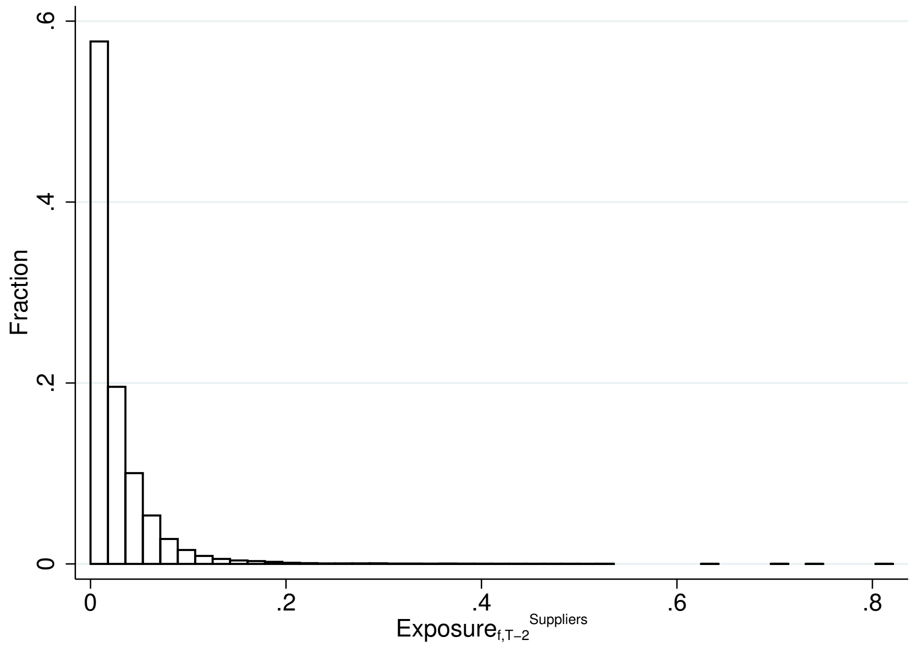
Notes: This figure illustrates the distribution of the share of ordinary imports with external financing in 2011 and 2012. It covers 4,700 6-digit HS products imported from 150 source countries, amounting to a total number of approximately 75,000 country-product pairs.

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

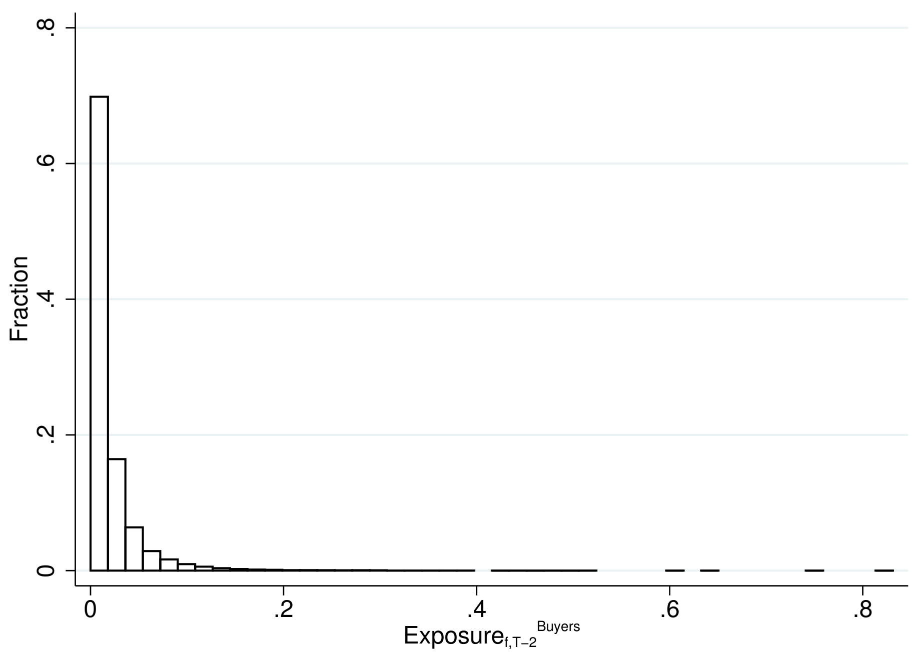


Notes: This figure illustrates the distribution of the firm-level direct exposure variable defined in equation (8).

Figure 4: Distribution of Indirect Firm-level Exposure to External Financing as of 2010



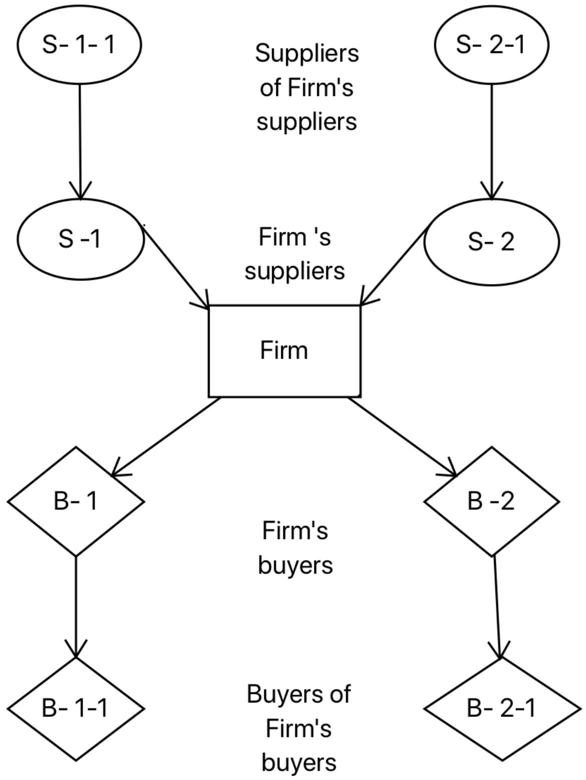
Panel A: Indirect exposure through suppliers



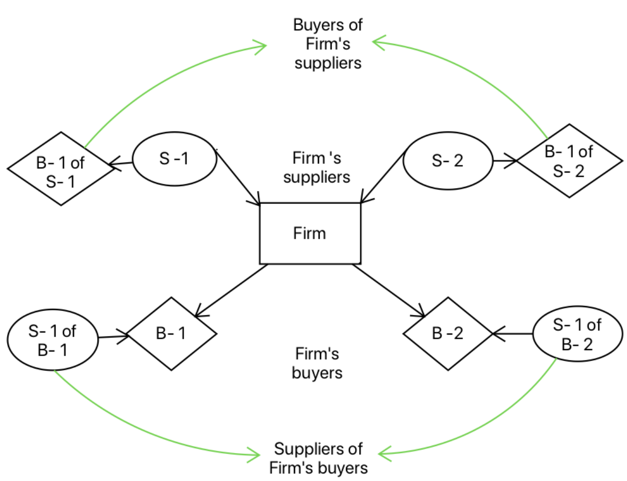
Panel B: Indirect exposure through buyers

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

Figure 5: Illustration of Network Structure



Panel A: Second-degree vertical linkages



Panel B: Second-degree horizontal linkages

Notes: This figure illustrates the buyer-supplier linkages in a production network.

Additional Tables

Table 9: **Direct Effect of the Shock on Firm-level Costs: Robustness checks**

Dependent variable: $\Delta \ln \left(\frac{InputCosts}{Sales}\right)_{fsrt}$	(1)	(2)	(3)	(4)	(5)
	Placebo	Processing	Size	Import int.	Survivors
	2010-2011	2011-2014	2011-2014	2011-2014	2011-2014
$I\{t=2011\} * Exposure_{fsr,T-3}$	-0.0335				
	(0.160)				
$I\{t=2012\} * Exposure_{fsr,T-2}$		0.309	**0.989*****	**0.964*****	**1.118*****
		(1.844)	(0.131)	(0.141)	(0.149)
$I\{t=2013\} * Exposure_{fsr,T-2}$		-0.001	**1.162****	**0.790*****	**1.158*****
		(1.490)	(0.123)	(0.144)	(0.119)
$I\{t=2014\} * Exposure_{fsr,T-2}$		-0.201	**1.371*****	**0.743*****	**1.220*****
		(0.980)	(0.144)	(0.201)	(0.126)
$I\{t=2012\} * I\{Size < \overline{Size}\}_{fsr,T-2}$			0.180***		
			(0.0350)		
$I\{t=2013\} * I\{Size < \overline{Size}\}_{fsr,T-2}$			0.181***		
			(0.0317)		
$I\{t=2014\} * I\{Size < \overline{Size}\}_{fsr,T-2}$			0.227***		
			(0.0322)		
$I\{t=2012\} * (M/Sales)_{fsr,T-2}$				0.0513	
				(0.0313)	
$I\{t=2013\} * (M/Sales)_{fsr,T-2}$				0.206***	
				(0.0515)	
$I\{t=2014\} * (M/Sales)_{fsr,T-2}$				0.336***	
				(0.0880)	
R^2	0.0473	0.403	0.386	0.385	0.249
N	104,314	114,352	185,449	185,449	148,480
Fixed effects	sxrxt	sxrxt,f	sxrxt,f	sxrxt,f	sxrxt,f

Notes: This table shows the results obtained from a number of robustness checks for the baseline results. The dependent variable is the annual change in unit material costs of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. Material inputs include imports and purchases from other domestic firms. First column assigns a placebo date (October 2011) to the shock. Second column uses a placebo sample: processing imports, which have not been subject to RUSF. Third column adds the ratio of total imports to sales as of $T-2$ ($(M/Sales)_{fsr,T-2}$) and its interactions with time dummies. Fourth column adds a dummy indicating whether the firm size (in terms of sales) was below the industry median as of $T-2$ ($I\{Size < \overline{Size}\}_{fsr,T-2}$) and its interactions with time dummies as additional controls to the baseline specification. Last column restricts the sample to surviving firms during the 2011-2014 period. $Exposure^{P}_{fsr,T-2}$ 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 industry-region level.

Table 10: **Role of Financial Constraints: Robustness checks**

Dependent variable: $\Delta \ln \left(\frac{InputCosts}{Sales}\right)_{fsrt}$	(1)
	Leverage interactions
	2011-2014
$I\{t = 2012\} * Exposure_{fsr,t=T-2}$	**1.236*****
	(0.194)
$I\{t = 2013\} * Exposure_{fsr,t=T-2}$	**1.112*****
	(0.188)
$I\{t = 2014\} * Exposure_{fsr,T-2}$	**1.267*****
	(0.166)
$HighLev_{fsr,T-2} * I\{2012\} * Exposure_{fsr,T-2}$	-0.275
	(0.222)
$HighLev_{fsr,T-2} * I\{2013\} * Exposure_{fsr,T-2}$	-0.161
	(0.256)
$HighLev_{fsr,T-2} * I\{2014\} * Exposure_{fsr,T-2}$	-0.114
	(0.242)
R^2	0.415
N	185,449
Fixed effects	sxrxt,f

Notes: The dependent variable is the annual change in unit material costs of firm f operating in industry s and located in region r at time $t = \{2011, 2012, 2013, 2014\}$. Material inputs include imports and purchases from other domestic firms. $Exposure_{fsr,T-2}$ 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. $HighLev$ is a dummy variable indicating highly leveraged firms, i.e. firms with the ratio of total debt to assets exceeding the industry median as of $T - 2$. $^{*}, ^{**}, ^{***}$ represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the industry-region level.

Table 11: **Direct and Indirect Effects of the Shock on Firm-level Costs: Role of financial constraints**

Dependent variable: $\Delta \ln\left(\frac{InputCosts}{Sales}\right)_{fsrt}$	(1)	(2)	(3)
	All	$LowLiq$ firms	$HighLiq$ firms
	2011-2014	2011-2014	2011-2014
$I\{t=2012\} * Exposure_{fsr,T-2}$	**0.610*****	**0.859*****	**0.522*****
	(0.139)	(0.300)	(0.145)
$I\{t=2013\} * Exposure_{fsr,T-2}$	**0.674*****	**1.362*****	**0.518*****
	(0.112)	(0.355)	(0.108)
$I\{t=2014\} * Exposure_{fsr,T-2}$	**0.729*****	**0.660****	**0.708*****
	(0.129)	(0.306)	(0.144)
$I\{t=2012\} * Exposure^{Suppliers,HighLiq}_{fsr,T-2}$	-0.426	-0.00803	-0.554
	(0.404)	(0.761)	(0.450)
$I\{t=2013\} * Exposure^{Suppliers,HighLiq}_{fsr,T-2}$	-0.413	-0.145	-0.549
	(0.363)	(0.732)	(0.402)
$I\{t=2014\} * Exposure^{Suppliers,HighLiq}_{fsr,T-2}$	-0.449	-0.735	-0.846
	(0.346)	(0.763)	(0.722)
$I\{t=2012\} * Exposure^{Suppliers,LowLiq}_{fsr,T-2}$	**0.493****	**1.309*****	0.179
	(0.201)	(0.428)	(0.247)
$\{t=2013\} * Exposure^{Suppliers,LowLiq}_{fsr,T-2}$	0.270	**1.371*****	-0.0692
	(0.239)	(0.433)	(0.301)
$I\{t=2014\} * Exposure^{Suppliers,LowLiq}_{fsr,T-2}$	-0.0443	0.582	-0.234
	(0.275)	(0.460)	(0.343)
$I\{t=2012\} * Exposure^{Buyers,HighLiq}_{fsr,T-2}$	-0.582	-1.006	-0.331
	(0.424)	(0.959)	(0.420)
$I\{t=2013\} * Exposure^{Buyers,HighLiq}_{fsr,T-2}$	-0.628	-1.144	-0.314
	(0.404)	(0.976)	(0.459)
$I\{t=2014\} * Exposure^{Buyers,HighLiq}_{fsr,T-2}$	-0.617	-0.478	-0.448
	(0.396)	(1.146)	(0.407)
$I\{t=2012\} * Exposure^{Buyers,LowLiq}_{fsr,T-2}$	-0.101	-0.409	0.151
	(0.335)	(0.540)	(0.369)
$I\{t=2013\} * Exposure^{Buyers,LowLiq}_{fsr,T-2}$	0.0459	-0.839	0.513
	(0.355)	(0.928)	(0.364)
$I\{t=2014\} * Exposure^{Buyers,LowLiq}_{fsr,T-2}$	-0.00755	-0.278	0.244
	(0.392)	(0.596)	(0.467)
R^2	0.383	0.421	0.385
N	185,449	89,015	96,434
Fixed effects	sxrxt,f	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 variables are defined in equations (8), (9) and (10). $I\{t = l\}$ is a dummy variable that takes on the value one for the year $t = l$, and zero otherwise. $Exposure^{Suppliers,HighLiq}_{fsr,T-2}$ ($Exposure^{Buyers,HighLiq}_{fsr,T-2}$) denotes the weighted average of liquidity-unconstrained suppliers' (buyers') exposure (i.e. suppliers (buyers) with inventory to sales ratio above the industry median as of $T-2$) of firm f. $Exposure^{Suppliers,LowLiq}_{fsr,T-2}$ ($Exposure^{Buyers,LowLiq}_{fsr,T-2}$) denotes the weighted average of liquidity-constrained suppliers' (buyers') exposure (i.e. suppliers (buyers) with inventory to sales ratio below 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 industry-region level.