Endogenous Production Networks and Learning-by-Networking

Article *in* SSRN Electronic Journal · January 2020

DOI: 10.2139/ssrn.3542371

1 author:

Melisa Bilgin
Università commerciale Luigi Bocconi

Endogenous Production Networks and Learning-by-Networking

Nuriye Melisa Bilgin*

December 20, 2020

Abstract: This paper investigates the underlying mechanism of shock propagation while building on firm-to-firm linkages. It also provides how firm-level input-output linkages across firms provide an amplification mechanism of shocks. After finding strong evidence that supports the asymmetry of the firm-level production networks, I build a model that lays a theoretical foundation between productivity and performance in production networks. Empirical evidence reveals the close relationship between the expansion of a firm's production network and its productivity. The productivity changes in each firm studied through the sophistication of a network while proposing a learning-by-networking hypothesis with other firms in their production network. .

Key Words: Aggregate fluctuations, Firms, Input-Output, Learning-by-Exporting, Networks, Shocks, Productivity, Production, Propagation

JEL codes: E23, E32, F14, L11.

*e-mail: nubilgin@ku.edu.tr . I thank my advisor, Kamil Yilmaz, for guidance. I also want to thank Gianmarco Ottaviano for the suggestions that improved the paper. For helpful discussions on an earlier draft, I thank Umut Akovali, Merve Baysoy, Hilde Bjornland, Cem Cakmakli, Jenny Chan, Cem Gorgun, Madina Karamysheva, Erol Taymaz, Atakan Yalcin, Sevcan Yesiltas and participants at the Econometric Society World Congress 2020, Econometric Society Winter School 2020, INFER 2020. I would also like to thank the Ministry of Industry and Technology of Turkey. I am grateful to GBS Team.

1 Introduction

Understanding the role of integrated supply-chains and their implications for the aggregate economy is fundamental for policymakers. Increasing integration of the production process within and across borders and how these structures act as shock propagation mechanisms is the focus of the debate. The existing literature on production networks and international trade studies focus on shock propagation through these linkages, but without further examining how the rearrangement of these networks provides a learning mechanism. This study proposes a first attempt to fill this gap.

Organization of firm production network and dynamic changes in its supplier and customer linkages may affect the industry further economy-wide outputs. Thus, shocks originating from the micro-level associations can turn into macroeconomic fluctuations. In such an environment, the main interest is to understand heterogeneity across the firm-level production networks. Studying the differential effects of these linkages can improve our knowledge about the nature of aggregate fluctuations and mechanisms that originated from the dynamic integration of supply-chains.

Endogenous network formation and the gains associated with the organization of the firm-to-firm linkages are the focus of this paper. This paper builds on Antras et al. (2017) to identify endogenous production networks across firms. Literature concentrates on how firms self-select into exporting and importing based on their productivities and country-specific variables. Yet, the literature lacks an explanation of how firms organize their production networks. In order to demonstrate dynamic changes in production networks, I present how the expansion of the supplier network decisions frames firms' cost function by introducing linkage formation costs. The model provides evidence of how firms are heterogeneous in their sourcing decisions and the gains associated with this formation. A major focus of the model is to investigate how heterogeneous firms shape their network based on their productivities by providing a basic solution for the firm maximization. Theoretical evidence illustrates that firms can expand their number and variety of their suppliers if they can afford the linkage formation costs. These costs endogenize the firm's production network. Hence, less productive firms are not able to form linkages that have higher costs.

In order to understand the potential mechanisms originate from the heterogeneity of firms in their production network position, it is crucial to evaluate the conditions in which the micro-level linkages act as conductors of shocks and how firms decode their networks. This paper starts by documenting the empirical sparsity of firm-to-firm linkages and how idiosyncratic shocks to major firms could diffuse through the economy in the presence of asymmetries. According to the standard diversification argument of Lucas (1977), as the number of firms goes to infinity, aggregate volatility becomes negligible at the rate of $1/\sqrt{N}$ due to the law of large numbers. However, this feature requires strong assumptions, and it is only valid if the tail parameter of the power-law distribution exceeds 2. In other words, the failure of the standard diversification argument leads to aggregate fluctuations in the economy if it is not well diversified[1][2]. It is necessary to note that investigation of this structure for firm-level linkages confirms that the Turkish production network is not well-diversified, and so a power-law distribution with fat-tails can capture linkages across firms. In that case, shocks are not absorbed by the network, and shocks hitting the critical firms may lead to aggregate fluctuations in Turkey's output.

After providing the facts about Turkish manufacturing firms and their production network, I develop a simple model of network expansion of firms while building on the Antras et al. (2017) and Eaton and Kortum (2002) to illustrate the importance of firm linkages and generate predictions on potential consequences related to supplier and customer transactions across firms. The model consists of two types of firms: Upstream and Downstream firms. Downstream firms can choose their suppliers for intermediate inputs from any if they can afford the linkage-specific fixed cost. After choosing its suppliers, firms encounter their marginal costs which are not constant as the standard trade models. Marginal costs are not constant as in the standard trade models, these costs are shaped according to the firm's supplier decisions as in Antras et al. (2017). There is a dispersion among the supplier-specific input productivities. As firms expand their network and increase the number of suppliers, firms' productivity is expected to increase. Overall, a firm's performance is shaped by its production network and its international trade engagement. The model provides evidence on how firms learn-by-networking according to their position in the supply chain, and it highlights the network effects if the production process is vertically or horizontally integrated. The first prediction of the model is that a firm's productivity directly depends on its supplier network. A second prediction is that if a firm chooses to export, it should perform better than the firms that operate only in the domestic market. The third prediction is that production network complexity increases with international trade.

In the empirical part, I test the model's predictions by relying on microdata that incorporates business-to-business transactions, imports, exports, and balance sheet information for Turkish manufacturing firms between 2006 and 2017 by focusing on

[1]As stated in Gabaix (2011), the diversification argument fails if the firm-size distribution exhibits fat-tails that specify the granularity of the economy. Also, Acemoglu et al. (2012) focuses on how idiosyncratic shocks to sectors lead to aggregate fluctuations in the case of a fat-tailed distribution of input-output linkages with specific tail parameters.

[2]The literature argues that most of those linkages are the underlying mechanism behind the shock transmission even at the sectoral level, such as Carvalho (2014), examination of U.S. Input-Output network exploits the lack of balance among suppliers by focusing on the out-degree distribution.

value-added and total factor productivities as a proxy for firm performance. The empirical analysis using cross-sectional firm-level data are in line with the model predictions: value-added of the firm depends on its domestic and international suppliers; productive firms are the ones who rely on imported intermediate inputs and export and network effects persist in direct and indirect linkages. Further, the decomposition of trade partners hints at the different premiums associated with various destinations. Overall, empirical evidence is consistent with theory, and it reveals the differential effects of production networks on shaping the firm performance.

In its most important contribution, this work provides evidence on how firms learn-by-networking by illustrating the endogenous changes in domestic and international supplier and customer networks with firm performance. As a firm's average productivity and its suppliers/purchasers increase, its productivity is likely to grow. The order of the productivity increase is expected to start with the suppliers. Then it is followed by the rise in the firm's productivity, and finally, by the purchasers' productivity. Also, this intuition is valid for the income level of the trade partner. First, the supply network increases, and after that, it is followed by an increase in firm productivity, which, in return, enhances the growth of the export network. Also, this paper demonstrates how exporting decisions increase a firm's productivity. This study examines the causality between productivity and exporting decisions by relying on Turkish manufacturing firms. Unlike previous work, this paper demonstrates that a firm must increase its production network's sophistication before beginning to export.

This study contributes to several different strands of the literature. The first is the literature that reviews the role of input-output linkages across sectors as a transmission mechanism [3] (Long and Plosser (1983); Horvath (1998), Horvath (2000); Shea (2002); Gabaix (2011); Acemoglu et al. (2012); Carvalho et al. (2016)). Although these papers focus on sectoral-level linkages, an emerging component of this strand declares that firm-level idiosyncratic shocks will diffuse into the economy (Di Giovanni et al. (2014); Carvalho and Voigtländer (2014); Barrot and Sauvagnat (2016); Mayer et al. (2016); Tintelnot et al. (2018) ; Di Giovanni et al. (2018); Boehm et al. (2019)). Following the evidence on propagation, the estimations in this paper rely on firm-level origins of aggregate fluctuations. Papers that assume exogenously-specified networks discuss how shocks propagate through these linkages. Yet, the assumption of supply-chains staying

[3] Similarly, this paper demonstrates how firms decide on their position in the production network according to their marginal costs. The focus also includes the direction of shocks. Shea (2002) states that technology and taste shocks have opposite effects. According to those estimations, technology shocks diffuse downstream, whereas taste shocks shift the upstream demand curves. Similarly, Acemoglu et al. (2016) exploit a pattern for the demand-side and supply-side transmission mechanism. Unlike the previous work, this paper provides evidence of the importance of firm competitiveness and productivity by relying on domestic and international firms' networks.

constant is not sensible. To overcome this problem, there is recently emerging literature that investigates the endogenous formation of production networks including Oberfield (2018), Acemoglu and Azar (2020) and Taschereau-Dumouchel (2020). Importantly, Oberfield (2018) demonstrates that individual choices shape the production networks of firms.

Another strand of the literature evaluates the impact of international trade on productivity. Here the focus of the study is the relationship between engagement in international trade and economic growth. [45] Literature proposes self-selection and learning-by-exporting to inspect the productivity gains associated with the exporting. The literature indicates that firms self-select into international markets since firms are heterogeneous based on their productivities. Introducing trade frictions, Melitz (2003) argues that only firms with higher productivity will export, a decision that attributes to the iceberg costs and the fixed costs incurred by exporting decisions. Another noteworthy point is the variation in the productivity level of the firm following the export decision. Interestingly, this paper's results support the literature that examines learning-by-exporting theories, including De Loecker (2007), who find a substantial increase in the productivity of the firms that start to export. This study adds this literature by exploiting the role of production networks in trade while proposing a learning-by-networking structure. The findings are in line with studies that demonstrate the link between exporting and total factor productivity. But, the estimations in these studies restrict their analysis to exporting decisions. I build on this literature by proposing that firms learn from their suppliers and customers.

The remainder of the paper is structured as follows. Section 2 presents the facts about the Turkish production network. Section 3 introduces the model and discusses the shock propagation mechanisms. A brief description of the dataset is provided in section 4. Section 5 provides a detailed discussion of the origins of the shocks through first and higher-order linkages. The decomposition of an international trade network and its implications are discussed in Section 7. Section 8 analyzes the drivers of the learning mechanism by focusing on the network structure of the firm. Section 9 concludes the paper.

[4] For instance, Bernard and Jensen (1999) analyzes the causal relationship between productivity and exporting. They argue that before shipping abroad, prospective exporters begin to show desirable performance characteristics. Examining Chilean plant-level data, Pavcnik (2002) finds significant evidence of an improvement in plant-level productivity following Chile's trade liberalization. Other studies identify the importance of firm-level networks on productivity, including Bernard et al. (2019).

[5] This paper is also closely related to the literature that investigates the global value-chains and their implications for economic development and social upgrading (see **?**, **?** and **?** and many more contributions to this literature as reviewed in **?**). However, rather than restricting only firms that trade intermediates, this paper aims to span all firms that participate in the production of both intermediates and final goods.

2 Facts about Turkish Production Network

This section presents the building blocks of this paper, including the general characteristics of Turkish manufacturing firms. I rely on the micro-foundations of network theory to reveal why firm-level shocks in the Turkish manufacturing industry can generate aggregate fluctuations. Then, I shift the focus to the sources of variation in firm-level productivity.

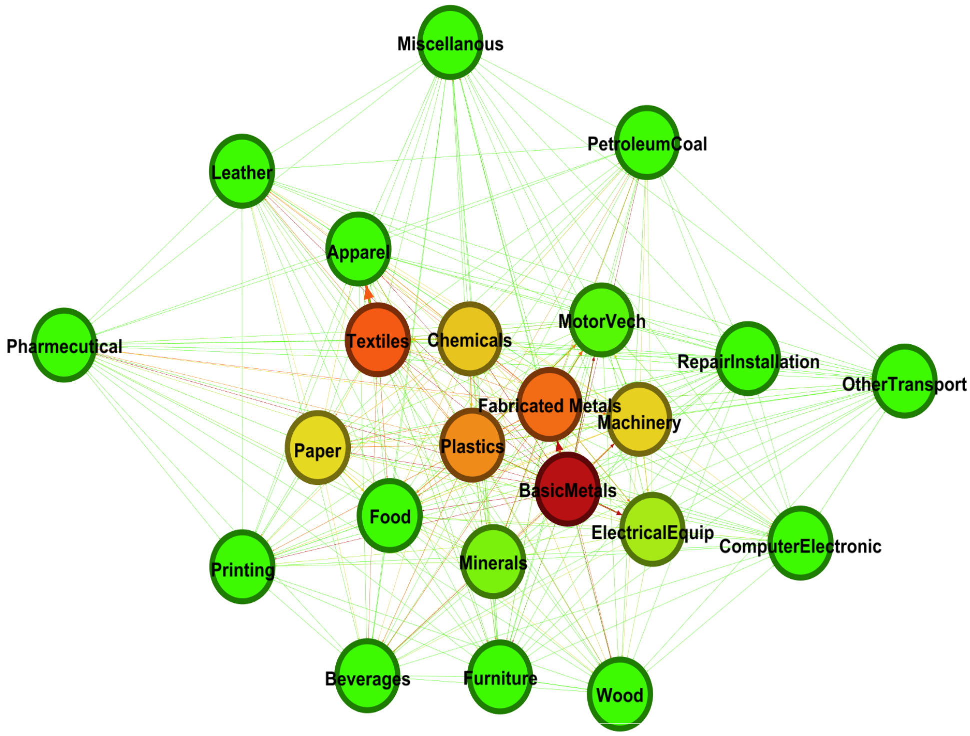


Figure 1: Domestic Production Network *Notes:*Turkish Manufacturing Industries aggregated according to 2-digit NACE Rev 2. Classification.

In the remainder of this paper, a network's adjacency matrix was established as the production linkages among manufacturing firms. Vertices represent the sales and purchases of intermediate goods and weighted with the value of the transaction. Correspondingly, each node represents a firm. Since the cost of transactions varies across firms, this paper employs a directed and weighted network structure among firms. The goal is to discover the variations among firms by focusing on firms' weighted degree distributions in the supply chain. Weighted in- and out-degree distributions capture the demand and supply sides of each firm's production process.

Fact 1. *The linkages among manufacturing sectors are heterogeneous for the Turkish production network.*

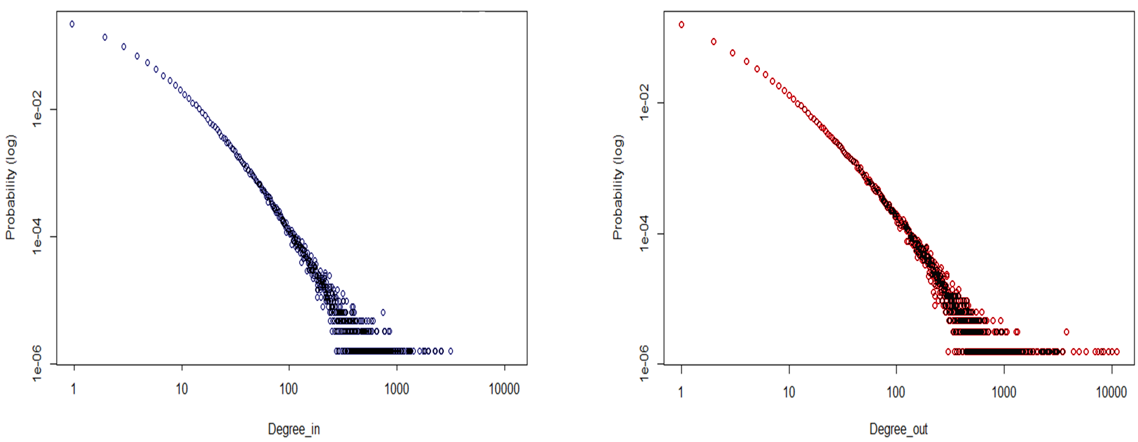
The network shown in Figure 1 is constructed from the input-output linkages among the manufacturing sectors. It illustrates the heterogeneity among production linkages at the sectoral level. It attributes to the sectoral level illustration of the weighted links that we observe at the firm-level. In the remainder of this paper, the calculations estimated for the production networks refer to the firm-level.

Location of the nodes determined with The Force Atlas 2 algorithm (see Jacomy et al. (2014)). Sectors with higher intermediate input transactions are closer to each other; others that engage in relatively less trade are pushed away from the center. Colors indicate the industry's importance as a supplier to other sectors; they turn from green to dark red depending on the sectoral out-degree. In this way, upstream sectors with higher weighted out-degrees tend to have red or dark red colors.

Several takeaways from the sectoral network analysis motivate this paper's interpretation of the micro-origins of aggregate fluctuations. Input-output linkages between sectors are highly heterogeneous. Also, we would expect supply shocks that hit upstream industries, which are located close to the center of the network, will transmit to other placed sectors in the periphery through the weighted edges. Furthermore, industries that positioned close to each other due to significant transactions in intermediate inputs. Even the aggregated sectoral level linkages demonstrate the sparsity of the network.

To evaluate the impact of asymmetries in firm performance, the rest of the paper investigates the firm-level production network and its corresponding weighted links among firms.

Fact 2. *Both weighted out- and weighted in-degree distributions reveal fat-tails at firm-level.*



(a) Weighted In-Degree

(b) Weighted Out-Degree

Figure 2: Firm-level Weighted Degree Distributions

Figure 2 presents the probability mass function of manufacturing firms' intermediate output supply as a weighted out-degree and intermediate input purchase as a weighted in-degree. The distributions of degrees shown in these figures are incredibly skewed, revealing the Turkish firm network's asymmetry. The firms located in the right tail of the degree distributions correspond to firms with a large number of links. Firms found in these fat tails indicate that those firms are the significant and superstar firms of the production network. More, if disruptions originate from those firms, their impact on the economy will not vanish in the long run.

Shocks to firms with high weighted in- or out-degrees may generate a domino effect through the production network. Based on these graphs, we can conclude that the Turkish manufacturing production network is highly asymmetric. Extreme asymmetries in the manufacturing industries are attributable to the firms' presence located on the right tail of the distribution. As suppliers or purchasers of intermediate inputs, they are "too connected to fail."

Lucas (1977)'s standard diversification argument states that idiosyncratic shocks die at the rate of $\sqrt{N}$, as N goes to infinity. Notably, this fact does not apply if the production linkages among firms follow fat-tailed distributions. Both Gabaix (2011) and Acemoglu et al. (2012) present results that shows the aggregate volatility of output decays slower with the rate of $\frac{1}{N^{1-1/\zeta}}$ with tail parameter ζ. If the tail parameter ζ lies between 1 and 2, then the decay process in volatility is much slower than the proposed rate of $\sqrt{N}$.

Surprisingly, the standard diversification argument does not apply to this supply-chain. Still, just looking at the graphs of in- and out-degrees distribution is not sufficient to conclude. We need to identify the distribution of the firm-level in- and out-degrees using standard tests. As Figures 2(b) and 2(a) suggest, it would be best to fit the power-law distribution (see equation (1)) to the data using the Hill-type MLE estimates of Clauset et al. (2009) with endogenous cutoffs.

Following in the footsteps of Gabaix (2011) and Acemoglu et al. (2012), we check the tail parameter ζ, which lies at the heart of the analysis corresponding to asymmetries among firms. For the values of ζ that are larger than 2, the first two moments are well defined, and the shocks wash out at a consistent rate with the standard diversification argument. For the tail parameters smaller than 1, none of the moments of the distributions are defined. If the tail parameter is equal to one, $\zeta = 1$, the Zipf's law applies, and the decay rate is proportional to $1/ln(N)$. Nevertheless, when $\zeta \in (1, 2]$, the variance becomes infinite, and standard diversification fails. Correspondingly, firm-level shocks diffuse through the aggregate economy.

$$p_k = ck^{-\zeta} \tag{1}$$

	ζ	xmin	logl	Kstat	Ksp	Obs.
Outdegree	1.51	0.00	229.24	0.04	0.98	5494103
Indegree	1.60	0.00	367.05	0.04	0.99	5494103

Table 1: Power Law Estimation Notes: For the goodness-of-fit test, the estimation relies on The Kolmogorov-Smirnoff (KS), the table of KS values, and test statistics Ksp evaluated for the power-law distribution.

Table 1 presents the tail parameters of the Turkish production network. From 2006 to 2017, it significantly fits the power-law distribution.[6]. Interestingly, the distribution of the firm-level in and out-degrees associated with power-law distribution. Thus, the network structure sustains its asymmetry with very similar tail parameters. The tail concentrated with more mass, and the economy is not diversified enough to average out the idiosyncratic shocks. This result motivates the fact that shocks propagate through firm-level input-output linkages.

Fact 3. *Average firm-level total factor productivity (TFP) in the Turkish manufacturing industry is subject to significant fluctuations over time.*

(a) Average TFP (b) Annual TFP growth

Figure 3: TFP of the Turkish Manufacturing Firms

Figure 3 presents the annual average and growth of the firm-level TFP of manufacturing firms over time. As expected, this time-varying measure decreases with the global financial crisis. For this reason, the estimations in this paper take into account these variations by using year fixed effects. For the calculation of the firm-level

[6]The values of Ksp smaller than 0.5 indicate that there is no evidence to support that distribution is not power-law.

production functions, I follow Levinsohn and Petrin (2003) and use intermediate inputs as a proxy to control the unobservables. To overcome the identification problem that originates with the usage of both labor and intermediate inputs, I undertake the correction suggested Ackerberg et al. (2006). In this paper's remainder, I use the productivity estimates obtained from estimations that have lagged inputs as instrumental variables. Once the production function is estimated, it is possible to get total factor productivity, which is the difference between the actual and the estimated log output. For the robustness, I also obtain the production function estimates using the alternative Olley-Pakes methodology. The correlation matrix in Appendix A shows that the TFP measures obtained using the Levinsohn-Petrin method with the Ackerberg correction highly correlated with those obtained by the alternative Olley-Pakes methodology.

Fact 4. *Across manufacturing sectors, there is substantial variation in the average TFP during the 2007-2016 period.*

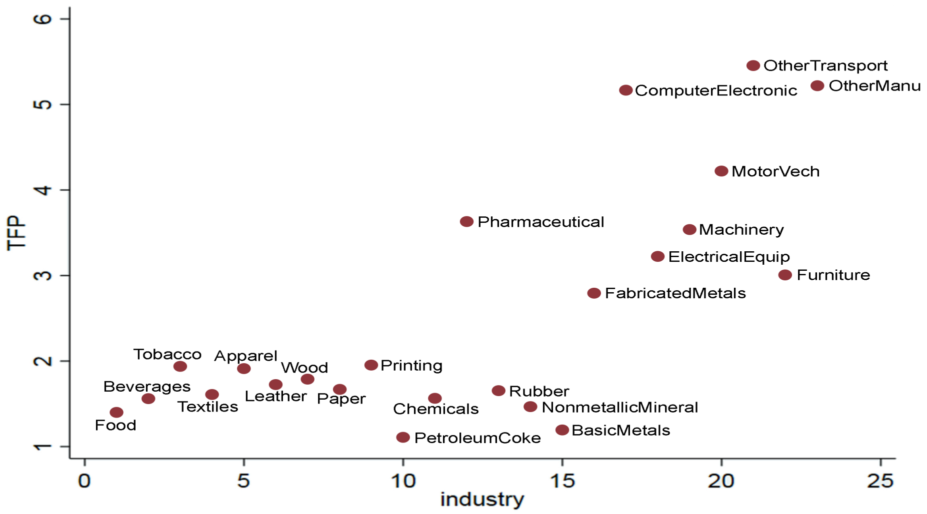


Figure 4: Average TFP across manufacturing sectors Turkey

Figure 4 presents how TFP varies among different manufacturing sectors classified according to the NACE Rev 2. The least productive sectors involve coke manufacturing and refined petroleum products with the production of primary metals. In contrast, productive manufacturing Turkish sectors dominated by other manufacturers, transport equipment manufacturing, computer, electronic, and optical product manufacturing.

Fact 5. *Importers and exporters differ in terms of firm characteristics.*

The literature argues that exporters and importers' characteristics differ in terms of firm characteristics from those operating only in the domestic market. Following Bernard and Jensen (1999) and De Loecker (2007), this part of the paper focuses on these differences to assesses the economic importance of international trade. To determine whether firm characteristics do vary across these groups, I run the following OLS regression:

$$y_{i,t,j} = \alpha + \beta\, trade_{i,t,j} + \eta\, l_{i,t,j} + \mu_t + \lambda_j + \epsilon_{i,t,j} \tag{2}$$

where $y_{i,t,k}$ is the characteristics of firm i at year t in industry k; $trade_{i,t,k}$ is the dummy that takes values 0 or 1, and it indicates whether the firm is only an exporter, only an importer or both importer and exporter; and $l_{i,t,k}$ is the log of the number of firm employees. The regressions controlled for different NACE Rev.2 sectors and years, sequentially.

Firm Characteristic	$\beta_{exporter}$	$\beta_{importer}$	β_{both}
Value-added per worker	0.09	0.09	0.10
Profit per worker	0.10	0.10	0.11
Productivity per worker	0.43	0.41	0.45
Average wage	0.09	0.11	0.16

Table 2: Firm characteristics and premiums of importing and exporting. Notes: All regressions include industry and time fixed effects. The physical units are deflated according to the 2-digit industry deflators.

A straightforward measure, β of the equation 2, estimates the differential between firms that directly import, export, or perform both provided in Table 2. This principal interest β indicates the firms' relative performance according to their engagement in international trade. In each case, groups that participate in global trade display superior performance. The firms, both export and import by themselves have the highest premia. According to Table 2, their value-added per worker is 10% more than firms that do not participate in international trade. Also, they are more profitable, and they tend to pay higher wages than other firms. But the main focus of this exercise is the productivity per worker. I also find that these firms are forty percent more productive than the firms that limit themselves to the domestic market. In the next section, I investigate these variations among the firms.

3 Model

This section provides how the productivity of firms linked to their production networks while presenting the endogenous formation of these linkages building on Antras et al. (2017). The economy consists of two sectors: Manufacturing and non-manufacturing as an outside sector. There are two types of firms in the manufacturing sector: Upstream and Downstream firms. Households supply labor inelastically and their preferences shaped according to the consumption of different goods with symmetric CES aggregator:

$$U_{mi} = (\int_{w \in \omega_i} q_i(w)^{\frac{(\sigma-1)}{\sigma}} dw)^{\frac{\sigma}{(\sigma-1)}} \tag{3}$$

where $\sigma > 1$ for elasticity of substitution and ω_i defines the available manufacturing goods for the final consumption. Followingly, preferences defined as

$$q_i(w) = E_i P_i^{\sigma-1} p_i(w)^{-\sigma} \tag{4}$$

where P_i is the standard ideal price index, p_i is the price of w and aggregate spending is E_i in industry i. Further, market demand of firm i has the following form

$$B_i = \frac{1}{\sigma}(\frac{\sigma}{\sigma-1})^{1-\sigma} E_i P_i^{\sigma-1} \tag{5}$$

The manufacturing sector consists of upstream and downstream firms. There N downstream firms and those firms require intermediate inputs from upstream firms to produce. Downstream firms are heterogeneous in terms of how they transform inputs to the output. Market structure is characterized by monopolistic competition with free entry.

The crucial part of this model is the linkage formation. The downstream firm's supplier and buyer linkages are not exogenous and firms have to pay fixed costs to form linkages with the other firms in the economy. This fixed cost is defined as linkage formation. Thus, these decisions endogenize the production network. Downstream firms follow the definition of Melitz (2003). In this setting, firms learn their core productivity φ after paying the fixed cost of linkage formation. Firms have to pay this linkage formation cost in terms of labor. In this way, core productivity is drawn from the distribution of $g_i(\varphi)$. Intermediate inputs bundle are imperfectly substitutable with each other and it contains a continuum of firm-specific inputs with the elasticity of substitution ρ.

Upstream firms consist of J firms which provide intermediate inputs to downstream firms and linkage formation is associated with finding a supplier. Upstream firms are classified by perfect competition. Hence, intermediate good producers sell their outputs at the marginal cost. The price of intermediate input for a firm i from an upstream firm j is :

$$p_i(j, \varphi; N_i(\varphi)) = min_{j \in N_i(\varphi)}[n_{ij} a_j(j, \varphi) X_{ij}] \tag{6}$$

where N_{ij} is the cost of networking with the intermediate good producer firm j, $Ni(\varphi)$ is the networking strategy of firm i and $a_j(j,\varphi)$ is the labor requirement to produce intermediate good for firm j. $N_i(\varphi)$ presents the set of suppliers for firm i with productivity φ. Also, this network $N_i(\varphi)$ is associated with fixed cost of networking f_{ij} of fixed cost to firm j. Then, the marginal cost encountered by firm i is:

$$c_i(\varphi) = \frac{1}{\varphi}(\int_0^j p_i(j,\varphi; N_i(\varphi))^{1-\sigma} dj)^{\frac{1}{(1-\sigma)}} \tag{7}$$

Replacing the prices with the marginal costs from sourcing j:

$$c_i(N_i(\varphi),\varphi) = \frac{1}{\varphi}(\int_0^j (N_{ij} a_j(j,\varphi) X_{ij})^{1-\sigma} dj)^{\frac{1}{(1-\sigma)}} \tag{8}$$

where X_{ij} is the amount of intermediate good transferred from firm j to firm i. Firms operate in this asymmetric market structure while upstream firms provide inputs and downstream firms combine goods firm-specific intermediate inputs for production. Building on Eaton and Kortum (2002) and Antras et al. (2017) intermediate input efficiencies are firm-specific with $a_j(j,\varphi)$ and upstream firms draw the value of input productivity $a_j(j,\varphi)$ from Fréchet distribution:

$$Pr(a_j(j,\varphi) \geq a) = e^{-T_j a^{\theta}} \tag{9}$$

where T_j is the technology of supplier firm j and the variance of shocks (productivity dispersion parameter) is θ. The values of θ represent how comparative advantage differs across upstream firms as in Eaton and Kortum (2002). Further, these draws are independent across firms and inputs.

3.1 Networking Capability

The crucial part of this model is the networking capability of firms. Firms decide first their networking strategy by choosing their suppliers. Then, downstream firms pay the fixed cost and choose the suppliers with the lowest cost and according to this decision marginal cost is known to the downstream firm. As a result, the probability of downstream firm i buying input from upstream firm j is

$$\alpha_{ij} = \frac{T_j(\frac{N_{ij}}{X_{ij}})^{-\theta}}{\Theta_i(\varphi)} \tag{10}$$

where N_{ij} is the cost of adding a new supplier or customer to its supply-chain which is defined as trade costs as in Eaton and Kortum (2002) and Antras et al. (2017) and T is the technology. The networking capability, Θ defined as the sum of all suppliers:

$$\Theta_i(\varphi) = \sum_{k \in N_i(\varepsilon)} T_k(\frac{N_{ik}}{X_{ik}})^{-\theta} \tag{11}$$

The networking capability increase with both technology T_k and the amount supplied as an intermediate good X_{ik} and it is negatively associated with the linkage fixed cost N_{ik} where k is a upstream firm.

After forming its supplier network, the marginal cost of a firm defined as [7]

$$c_i(\varphi) = \frac{1}{\varphi}(\gamma \Theta_i(\varphi) X_{ij})^{-1/\theta} \tag{12}$$

As firms expand their supplier network, its networking capability will increase further. But firms have to pay a fixed linkage formation cost to each additional supplier. As a result, a firm that can expand its network will increase its productivity. Replacing the networking capability provides the following profit function for a downstream firm

$$\Pi_i(\varphi, I_{i1}, .., I_{ij}) = \varphi^{\sigma-1}(\gamma \sum_{j=1}^{N} I_{ij} T_j (\frac{N_{ij}}{X_{ij}})^{-\theta})^{\frac{\sigma-1}{\theta}} B_i - w_i \sum I_{ij} f_{ij} \tag{13}$$

where I_{ij} is the indicator variables takes a value of one of the firm j is in the supplier network of firm i, and B_i is the residual demand. The profit function suggests that adding another supplier decreases the marginal cost of a firm. However, a sophisticated network as any additional linkage with any supplier is associated with the fixed cost.

The profit function is non-linear as shown in 13 is supermodular in networking capability Θ_i, intermediate inputs X_{ij} and core productivity φ. Thus, firms can have a higher cost advantage by increasing their upstream suppliers or its in-degree in the network literature terms. The profit maximization of firms also depend on the costs of linkage formation cost as N_{ij}.

3.2 Exporting Decision

This section presents how exporting decision impacts the learning mechanisms of the downstream firms. Similar to Melitz (2003) firms have to pay a fixed cost for exporting and this decision depends on the networking capability of the firm i. Following Eaton and Kortum (2002) exporting depends on the comparative advantage of the firm which is defined similarly as the networking capability:

$$\beta_{xi} = \frac{T_i(\tau_{xi} w_i)^{-\theta}}{\Theta_x(\varphi)} \tag{14}$$

[7] Derivation of the cost function follows Eaton and Kortum (2002) and Antras et al. (2017) on the derivation of aggregate price index. The assumption follows Antras et al. (2017) $\theta > \rho - 1$.

where τ_{xi} is the iceberg costs, w_i is the wage in country i and β_{xi} is the total of the networking capability of firm i defined as the terms of probability of finding a customer. Similar to the previous result, a firm's cost depends on its supplier productivities and form of its network by minimizing the cost function. Besides, firms can sell their output to foreign markets after paying the fixed costs. The export decision relies upon the fixed costs and the comparative advantage in terms of productivity. Thus, firm i has the following profit function when its export network determined endogenously:

$$\Pi_i(\varphi, I_{i1}, .., I_{ij}) = \varphi^{\sigma-1}(\gamma \sum_{j=1}^{N} I_{ij}T_j(\frac{N_{ij}}{X_{ij}})^{-\theta})^{\frac{\sigma-1}{\sigma}}(1+\sum_{x=1}^{N}\beta_{xi})^{(1+\sigma)}B_i - w_i \sum I_{ij}f_{ij} - w_i \sum X_{xi}f_{xi} \tag{15}$$

In general equilibrium, consumers spend a constant share in the manufacturing industry. Given the free entry condition for market demand, there exists a unique market demand in the industry equilibrium.

Proposition 1. For each I_{ij} and $X_{xi} \in (0, 1)$, both solution to firm's networking and exporting capability is non-decreasing in of φ. Reduction of linkage formation costs or fixed costs increases the networking capability of a firm by keeping the demand constant.

The proposition indicates how the expansion of the firm's suppliers and its decision to enter into foreign markets depends on productivity. Hence, productive firms can expand their supply-chain or they can select into foreign markets. The sophistication of the supply-chain transforms firms to become more productive by generating a cost advantage. According to this Proposition, it will be easier to extend the network for firms that encounter a decrease in linkage formation or fixed costs.

Proposition 2. An increase in the networking capability leads to expansion to foreign markets. Further, a decrease in the iceberg costs leads to development in both participation in export markets. More, it will improve the sourcing of a firm.

This proposition states how firms learn from their production networks and exporting. Increase in firm productivity results in export participation and the requirement of additional suppliers. In addition, variables that increase the networking capability $N_i(\varphi)$ as reduction of linkage formation costs with other firms or increase in the technology of the upstream firm will lead to an increase in X_{xi}. All in all, this mechanism presents learning-by-networking. In other words, productive firms become more productive with the expansion of both customer and supplier networks.

4 Data

The empirical part relies on the combination of several Turkish firm-level datasets between the years 2006 and 2017. This paper restricts its attention to manufacturing firms. To do so, four-digit NACE Rev. 2. sector codes used to identify these firms. Only firms classified as manufacturing industries, according to NACE Rev. 2. included in the dataset.

The production networks identified in this paper created according to the VAT statements of each firm. Firms have to report each transaction to the Ministry of Finance. The lower limit of these transactions is 5000 Turkish Liras, which is approximately 610 U.S. dollars. These reportings are the building blocks of the weighted production links among firms.

The customs declarations are the dataset that covers the different destinations of the firm's international partners for the firms that directly export or import. Customs report the name of the partner country with which the firm trades. Since estimations for each country would not be efficient, this study forms various groups with similar properties. The appendix provides the details of these groupings.

.

Year	Firms, #	Size	Direct Exporters	Direct Importers
2006	116,575	28.45	15.70	15.30
2007	127,629	28.32	15.52	15.01
2008	133,585	27.59	15.45	14.36
2009	135,768	25.37	15.39	13.29
2010	136,648	26.69	15.69	14.21
2011	140,800	27.88	15.66	14.72
2012	144,983	28.09	15.86	14.39
2013	154,076	27.88	16.19	14.11
2014	161,007	28.11	16.64	13.93
2015	169,049	28.21	16.20	13.63
2016	175,440	27.67	16.18	13.01
2017	182,560	27.49	14.42	11.69

Table 3: Descriptive Statistics *Notes:* Firms, # is the number of firms each year in the manufacturing industries. The average size is the mean of the number of registered employees. Direct importers or exporters shows the percentage of firms that export or import each year.

The balance sheets, income statements, and the number of registered employees of each firm included in the calculations to cover all characteristics. Proceeding parts focus on the estimates of value-added and total factor productivity to distinguish the variations across firms. The final data is an unbalanced panel covering twelve years, and Table 3 presents the descriptive statistics. Additionally, all of the firms' physical units in the corresponding period deflated according to the producer price indices for each two-digit industry—these PPI indices were collected from the Turkish Statistical Institute.

5 Shock Propagation

Due to variations in their capital, labor, sector, and intermediate input decisions, firms are heterogeneous in measured total factor productivity. But what shifts the productivity of manufacturing firms is a black box based on a Cobb-Douglas production function. This section evaluates the impact of firms' domestic and international input-output linkages on productivity by considering the firms' production networks' complete structure.

After classifying the production network by utilizing buyer-seller declarations, this section searches for empirical evidence to find the underlying shock propagation mechanism. Recall that the model section demonstrates the importance of the input-output linkages, and these predictions present the direction of shock propagation. To check for different shocks, I concentrate on diverse patterns of diffusion on firm-level linkages.

In this section, the impact of weighted and linked network edges on productivity evaluated while using the TFPs of each firm. Each dependent variable corresponds to the firm's input-output transactions of the previous period. These independent variables are the weights of the network edges that correspond to the volume of the transactions.

The following specification used to quantify these,

$$\begin{aligned} dlny_{i,t} = \beta_{Di}\, DomI_{t-1} + \beta_I\, ImpI_{t-1} + \beta_{Dq}\, DomQ_{t-1} + \beta_E\, ExpQ_{t-1} \\ + \zeta_s + \nu_l + \mu_t + \epsilon_i \end{aligned} \tag{16}$$

According to this designation, input supply $DomI_{t-1}$, refers to the firm's intermediate inputs from the domestic market, whereas imports are denoted as $ImpI_{t-1}$. Correspondingly, the output $DomQ_{t-1}$ is the supplied value to the domestic market. $ExpQ_{t-1}$ is the value that the firm directly exports to other markets. ζ_s is the 4-digit industry fixed effects, ν_l is the size fixed effect, and μ_t is the year fixed effect. The coefficients β_{Di}, β_{Ii}, β_{Dq} and β_{Eq} measure the significance for variable of interest as the productivity.

5.1 First-Order Propagation

Direct propagation refers to the first-order links among firms. This mechanism treats the production network as if it has only first-order linkages across firms. In this part, the main interest is to understand the distinction between the various links. Then in a discussion of indirect propagation, it examines second-order suppliers and customers in the production network.

Table 4 presents the estimates of production network effects on the productivity of each firm. In this light, Column 5 shows the relevance of the production linkages to the firm's TFP; furthermore, these coefficients align with the model's predictions.

	Total Factor Productivity				
β_{Di}	0.80				-2.64**
	(1.61)				(1.14)
β_I		3.97**			2.68**
		(1.04)			(0.98)
β_{Dq}			-3.31**		-0.91
			(1.70)		(1.48)
β_E				8.08**	5.18**
				(1.01)	(1.20)
R^2	0.00	0.58	0.01	0.68	0.72
# of Obs.			—— 1,066,818 ——		

Table 4: Domestic and International Production Networks and Firm-level Productivity
Notes: This table presents estimates of the firm-level productivity regressions on domestic and international input-output linkages. All regressions include fixed effects for size, 4-digit industry, and year. The robust standard errors are reported in parentheses. $**$, $*$, and + indicate the significance at the 1%, 5% and 10% levels, respectively.

According to Table 4, the export and import premia are always positive and significant, despite the sector and size fixed effects. Yet compared to firms that rely on foreign inputs, firms that use domestic inputs are less productive. That said, this paper is the first to establish the significance of international trade based on each firm's production network. Interestingly, the superior performance of Turkish manufacturing firms is due to their imports and exports. This explanation is compatible with the hypothesis espoused in the literature that the most productive firms engage in foreign trade.

These findings have critical policy-making implications. For Turkish manufacturing firms, international trade involvement is the only factor associated with higher productivity, as indicated in Table 4. Since productivity is a necessary component of growth, eliminating trade barriers, reducing the tariffs for imported intermediate inputs, and using subsidies to promote foreign sales could lead to more productive and competitive manufacturing firms.

5.2 Higher-Order Propagation

This section focuses on how firm-level shocks diffuse into the aggregate economy. Therefore, the estimations examine the relevance of second-order degrees for indirect propagation through network effects. In particular, the subscript 2 designates the indirect (second-order) supplier or customer of firms which are represented as $\beta_{Di,2}$, $\beta_{I,2}$, $\beta_{Dq,2}$ and $\beta_{E,2}$ in the regression. For instance, $\beta_{I,1}$ is the amount if and only if the firm itself imports, whereas $\beta_{I,2}$ corresponds to the second-order (indirect) importers. Stated differently, $\beta_{I,2}$ is the value purchased by the firm from another direct importer firm as the higher-order network linkage.

	Total Factor Productivity				
$\beta_{Di,1}$	-3.47**				-2.72**
	(1.48)				(1.12)
$\beta_{Di,2}$	0.13**				0.09**
	(0.05)				(0.03)
$\beta_{I,1}$		3.97**			2.69**
		(1.04)			(0.98)
$\beta_{I,2}$		0.01**			0.01**
		(0.00)			(0.00)
$\beta_{Dq,1}$			-3.31**		-0.85
			(1.69)		(1.36)
$\beta_{Dq,2}$			0.09		-0.01
			(0.07)		(0.02)
$\beta_{E,1}$				8.06**	5.14**
				(1.01)	(1.20)
$\beta_{E,2}$				0.16**	0.18**
				(0.05)	(0.04)
R^2	0.01	0.58	0.01	0.69	0.73
# of Obs.	—— 1,066,818 ——				

Table 5: Second-order Propagation and Firm-level Productivity *Notes:* This table presents estimates of the firm-level productivity regressions on the first and second-order input-output linkages. All regressions include fixed effects for size, 4-digit industry, and year. The robust standard errors are reported in parentheses. $**$, $*$, and $+$ indicate the significance at the 1%, 5% and 10% levels, respectively.

Table 5 reports the results for the indirect propagation. Interestingly, the second-order transmission is significant and also consistent with the baseline estimations. Even though the coefficients are smaller than those of the first-order linkages, the shocks persist even in second-order degrees. These results emphasize the propagation of shocks at the firm-level and provide evidence on the origins of aggregate fluctuations.

6 Productivity and Trade Partners

The impact of international trade on productivity is illustrated in the last part. Therefore, this section concentrates on the role of different trade partners on TFP. Literature finds that gains vary according to the various destinations of exports. De Loecker (2007) demonstrates that productivity gains in Slovenian firms are driven by the firms that export to North America, Western, and Southern Europe. Further, Crinò and Epifani (2012) argues that TFP is negatively associated with sales to low-income destinations for Italian firms. The natural question is whether there is a link between firm-level productivity and the trade partner's characteristics.

This is the first study investigating the productivity premia with different trade partners of Turkish firms to the best of my knowledge. Furthermore, the estimations presented in this section add to the literature by also taking import origins into account.

6.1 Export Destinations

The following part estimates the premium after the decomposition of the trade partners. Yet, not all of the destinations are significantly linked to productivity gains. The firms are more productive if they export to destinations, including North America, Western Europe, and Others, according to Table 6.

	Total Factor Productivity						
β_{NA}	0.16*						0.11*
	(0.07)						(0.05)
β_{EA}		0.14					-0.02
		(0.11)					(0.08)
β_{WE}			0.11**				0.09**
			(0.02)				(0.02)
β_{SEB}				0.12			0.05
				(0.09)			(0.07)
β_{MENA}					0.03+		0.02
					(0.02)		(0.02)
β_{Oth}						0.13*	0.11**
						(0.06)	(0.04)
R^2	0.06	0.01	0.21	0.04	0.02	0.21	0.31
Obs.	—— 1,066,818 ——						

Table 6: Exports Destinations and Productivity *Notes:* This table presents estimates of the firm-level productivity regressions on export partner dummies. All regressions include fixed effects for size, 4-digit industry and year. The robust standard errors are reported in parentheses. $**$, $*$, and $+$ indicate the significance at the 1%, 5% and 10% levels, respectively.

Following the empirical evidence, one can conclude that more productive firms export to higher-income countries, where demand for quality is higher. This section emphasizes a crucial inference: when a firm is not productive, it is not easy to sell or survive in competitive markets, such as Western Europe and North America. The MENA region deserves special attention. Although Table 6 shows it to be significant, that significance is lost when the regressions are estimated with the other destinations. This variation first arose when Turkish exporters switch their export markets following the European Union contraction after the global financial crisis. Keeping this in mind, the MENA region was the alternative destination for exporters during this turning point.

6.2 Import Origins

The previous results, in Section 5.1, assess the difference between imported and domestic inputs on the TFP. The following exercise examines whether the origin of the imported intermediates influences the total factor productivity.

	Total Factor Productivity						
β_{NA}	0.17*						0.06
	(0.05)						(0.05)
β_{EA}		0.16**					0.12**
		(0.04)					(0.02)
β_{WE}			0.09**				0.06*
			(0.03)				(0.03)
β_{SEB}				0.08**			0.08*
				(0.01)			(0.01)
β_{MENA}					0.02**		0.01+
					(0.00)		(0.01)
β_{Oth}						0.05	0.03
						(0.03)	(0.03)
R^2	0.05	0.02	0.05	0.20	0.04	0.10	0.34
Obs.	—— 1,066,818 ——						

Table 7: Import Origins and Productivity *Notes:* This table presents estimates of the firm-level productivity regressions on geographical import source country dummies. All regressions include fixed effects for size, 4-digit industry, and year. The robust standard errors are reported in parentheses. ∗∗, ∗, and + indicate the significance at the 1%, 5% and 10% levels, respectively.

Table 6 and 7 point to the pattern of productive Turkish manufacturers. For imports, most productive firms import from East Asia, including China. Further, the quantitative estimates of significant trade partners are dominated by low-income countries. Nevertheless, the pattern is almost the opposite of export destinations, and these estimates yield another puzzle: How do Turkish manufacturing firms that engage in the trade have productivity premia? This is almost certainly due to several advantages that Turkey enjoys being part of the Customs Union, its low labor costs, and its geographical location.

In summary, it is clear that the income level of trade matters for productivity premia. There is a variation across each import or export partner, depending on their income level. In contrast to the literature findings, I find that high-income trade partners correlated with higher TFP for only exports. The pattern is almost the opposite of imports.

7 Learning-by-Networking

In this section, I exhibit that firms are more productive if they are part of a sophisticated production network. In other words, this part reveals that firms learn-by-networking. Previous literature restricts its attention to the exporting decision and the gains afterward. However, attributing productivity gains to only exporting is not convincing enough to assess growth.

There is a long-running debate in the literature on the direction of causality for the premia of exporting. Previous sections demonstrate that exporter firms are more productive than other firms, providing theoretical and empirical evidence. Nevertheless, the underlying direction between efficiency and exporting is the heart of this literature.

First-strand of the literature "self-selection", including Melitz (2003) and Yeaple (2005), argue that only firms that are more productive than others can export. On the contrary, another part of the literature defends the learning thesis after entering export markets. Bernard et al. (1995) and Alvarez and Lopez (2005) provide significant evidence on the premia following the entry. Yet, these studies restrict their attention only to exporting. Going one step further, I investigate the firms' network structure. However, understanding the pattern of these gains are substantial. In a critical insight, this section focuses on the recoding in the firms' networks. In contrast to previous studies, I argue that the mechanism that produces learning is networking across supply-chain. For this reason, I focus on the reason behind the efficiency associated with exporter firms. Interestingly, firms learn both by networking and exporting.

Another perspective is the causality running from productivity to self-selection of firms into international markets as an endogeneous decision of the firm. In this case, firms do not learn by interacting with other firms in their production networks or their competitors in the international markets. This hypothesis argues that these firms meant to be more productive due to their ability to cover fixed labor costs and iceberg costs to export their output. Thus, self-selection argues that there is not a significant relationship between exporting or networking on productivity. In this section, both of the two phenomena are observed in the Turkish manufacturing industry. But the weight of the self-selection is almost negligible when compared to learning-by-networking effects. After all, the network sophistication of the firms mainly drives the premium.

Even though there is significant evidence in the literature supporting that firms increase their productivity after deciding to export, the underlying mechanism is neglected. Here I argue that the origin of this significant change can be traced through the evolution of the firm's customer and supplier network. As firms become more productive, it is quite possible as they expand their local supplier and customer networks before their productivity moves above the threshold that bars it from exporting. First, they develop their role in the domestic supply-chain, which increases their role as both customers. Second, their supply increases. Hence, increasing out-degree and in-degree of a firm in domestic and international production networks enhances its competitiveness in the global markets. Third, because of their changing role in the production network, firms learn-by-networking.

Figure 5 portrays the productivity trajectories of two groups over time. The first group, shown with the red line, represents the firms that start exporting during the sample period. The second group (blue line) comprises firms that have never exported. Here, firms that are already exporters at the beginning of the sample are dropped to exploit productivity gains when firms successfully gain international market access. Time $t = 0$ denotes the period when a firm starts to export, which previously selling its output only in the domestic market.

The mean productivity of the firms that are never export presented in the blue line. In contrast, the color is different for the new exporters, as indicated in red — the reference year zero when firms decide to enter the international markets. After taking the reference year, other years were distributed accordingly. This graph includes the firm's productivity four years before exporting and four years after the entry. The first observation regarding the self-selection hypothesis is the difference before time zero. Even before exporting, including the previous four years, exporters tend to have higher productivity levels. Also though this difference is small, about eight percent, there is a clear distinction between the two groups.

Further, on each time interval, firms that started or about to start have significantly higher TFPs than other firms. This considerable difference points out that the two groups display different characteristics. In other words, firms that were operating efficiently than others even before the time $t = 0$. Hence, I can argue that firms can self select themselves due to their differences. However, it is an early conclusion without considering the reaction of firms after they start exporting. Additionally, the two groups obey the parallel trend assumption with the changing slope at time $t = -2$.

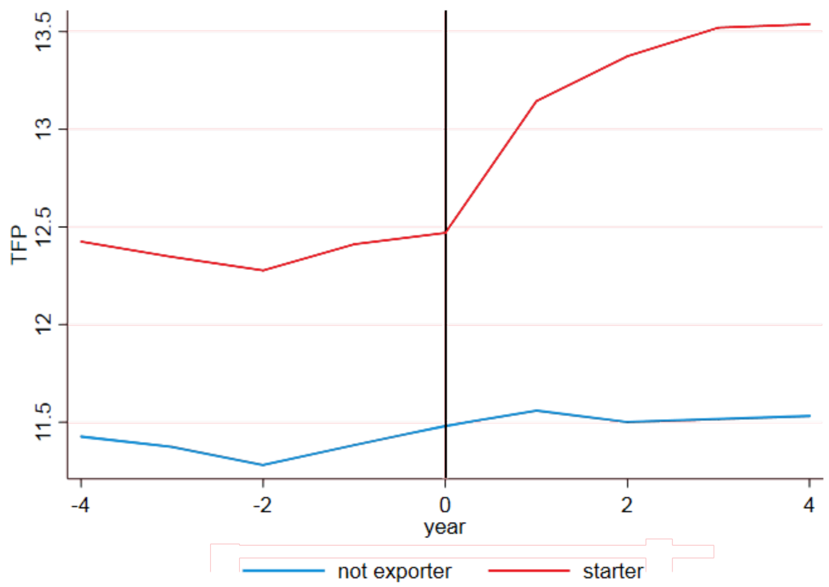


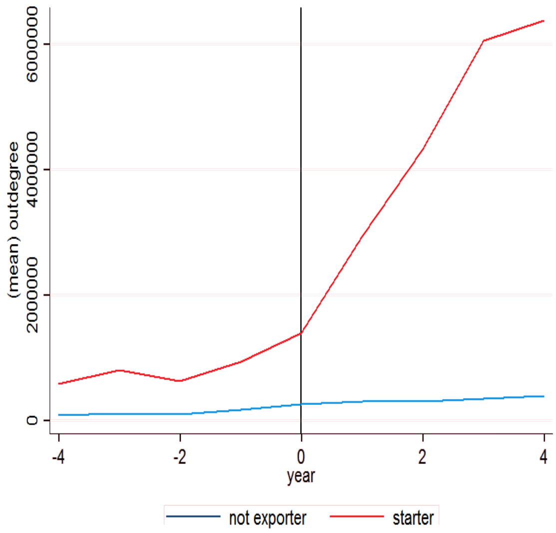
Figure 5: Productivity and Exporting

Notes: The blue line indicates the firms that never export, whereas the red line shows the firms' average productivity level that start exporting at time 0. The y-axis corresponds to firms' productivity level that never exports directly or starts to export for the first time.

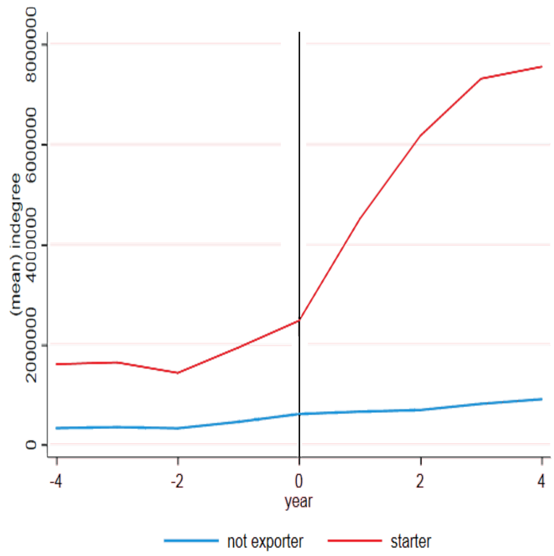
For testing the learning-by-hypothesis, the crucial part relies upon the changes observed after time $t = 0$. Interestingly, the most valuable observation of the analysis in Figure 5 is the expansion of the firms' TFP levels that start to export between time $t = -4$ to $t = 4$. After time zero, parallel trends disappear. The red line follows a definite upward trend after period 0, indicating support for the learning-by-exporting hypothesis. In contrast, firms that had never exported experiences no increase in productivity. Visual inspection of Figure 5 suggests that there is diversity across firms that begin to export, but does empirical evidence support this conclusion? The following part investigates the significance of TFP differences by relying on a differences-in-differences estimation.

7.1 Network Characteristics and Exporting

This section reviews the learning-by-networking, where TFP grows with the expansion of firm networks. Thus, I center on the time-varying upstream and downstream linkages according to their distributions in the network. To incorporate network sophistication, I rely on network literature where the firm's inputs and outputs are assigned as distributions by depending on the firms' weighted ties. Building on the firms' trade volumes, four distribution measures are set to a firm: out-degree, in-degree,



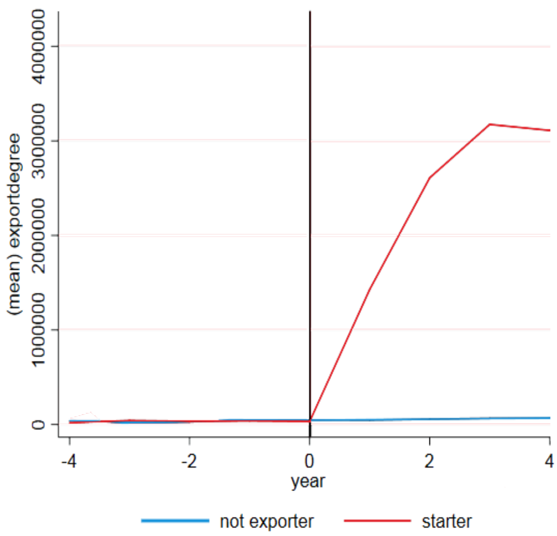
(a) Out-degree



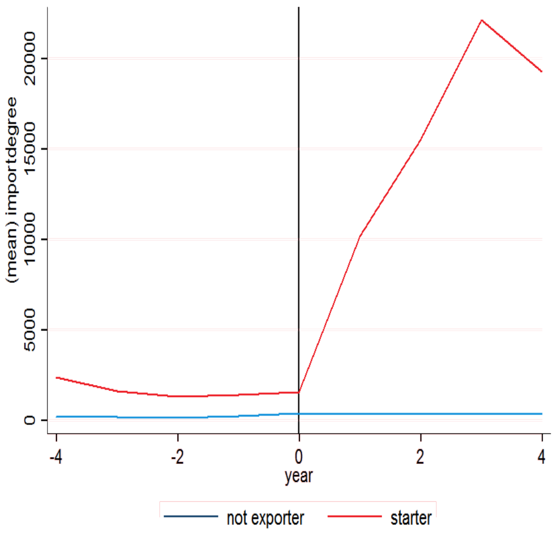
(b) In-degree

Figure 6: Domestic Network Characteristics

Notes: The figure on the right presents the time-varying out-degree distribution of the firms, whereas the graph on the left shows the in-degree distribution. The blue line indicates the firms that never export, whereas the red line shows the average degrees of the firms that start exporting at time 0.



(a) Export degree



(b) Import degree

Figure 7: International Network Characteristics

Notes: The figure on the right presents the time-varying export degree distribution of the firms, whereas the graph on the left shows the import degree distribution. The blue line indicates the firms that never export, whereas the red line shows the average degrees of the firms that start exporting at time 0.

import, and export degree. Out- and in-degree distributions based on the domestic production network. Out-degree relates to the firm's output, which is used as an intermediate input of another manufacturing firm. In contrast, the in-degree assigned as a proxy for the firms' purchases from other firms. As the import and export data available for trading partners, the weights are transferred to different countries cumulatively.

Figure 6 presents the weighted out- and in-degrees of the firms that start to export. This figure illustrates the firm's network position shifts in the domestic network. Before time zero, the rank of firms as suppliers or customers is different. The inputs and outputs of those firms are already more diversified than the other group. But after time zero, the performance of the two groups changes clearly. After time zero, suppliers become more complex, according to Figure 6. These firms depend on more specialized inputs, also out-degree confirms the learning-by-networking. Rather than being a firm with a smaller group of customers or suppliers, firms' production process becomes more complicated. The intuition is clear: before exporting, firms prepare themselves by increasing their network complexity as either customers or suppliers, as shown in Figure 6 after they start exporting, their specialization in the supply-chain increases substantially.

The firm's international network characteristics are linked to trade partners that the firm exports or imports. Import-degree marks a critical mechanism; the firms that would start to involve in international trade have higher import-degree than the firms that never export during the estimation interval. Another point to notice is that export-degree have a positive trend after the entry. All in all, these network characteristics are always ignored in the literature. But the figures 6 and 7 exploit the underlying mechanism of productivity gains. As the manufacturing firms become more diversified in their supply-chains, they become more productive and specialized.

7.2 Difference-in-Differences Estimations

Eyeballing analysis of Figure 5 illustrates the diversity of the firms after time zero. In this section, the empirical specification aims to estimate the causal effects of exporting. Thus, the following part relies on the differences-in-differences between the two groups. The treatment is opening the firm networks to international trade for the first time. The calculation period covers the years between 2006 and 2016. The treatment group consists of firms that do not export at the beginning of the period and chooses to export later. Contrarily, the control group incorporates the firms that only supply to the domestic market. The aim is to distinguish the impact of treatment by analyzing the shifts in the firm's TFPs, out-degrees, and in-degrees. Yet, judgment based on only this criteria is critical. To match the firms with similar properties, firms matched according to their propensity scores before the estimation. Thus, I use the nearest neighbor matching. This exercise's primary purpose is to design a control group whose size is similar to the treatment group. In this way, the algorithm tracks non-exporting firms and export entrants that have comparable properties.

An attractive feature of this matching is selecting the control and treated firms with the closest propensity scores. As noted above, this exercise is crucially important because these marginal gains in productivity may differ across different sizes. Thus, the comparison became the productivity differences between control and treated firms that depend on a similar labor amount.

		TFP	**Outdegree**	**Indegree**
β_{Exp}		0.19^{**}	0.11^{**}	0.14^{**}
	s.e.	(0.02)	(0.02)	(0.02)
	R^2	0.07	0.03	0.04
β_{Imp}		0.06^{**}	0.04^{**}	0.00^{**}
	s.e.	(0.01)	(0.02)	(0.00)
	R^2	0.03	0.02	0.02

Table 8: Productivity and Network Gains from Importing and Exporting

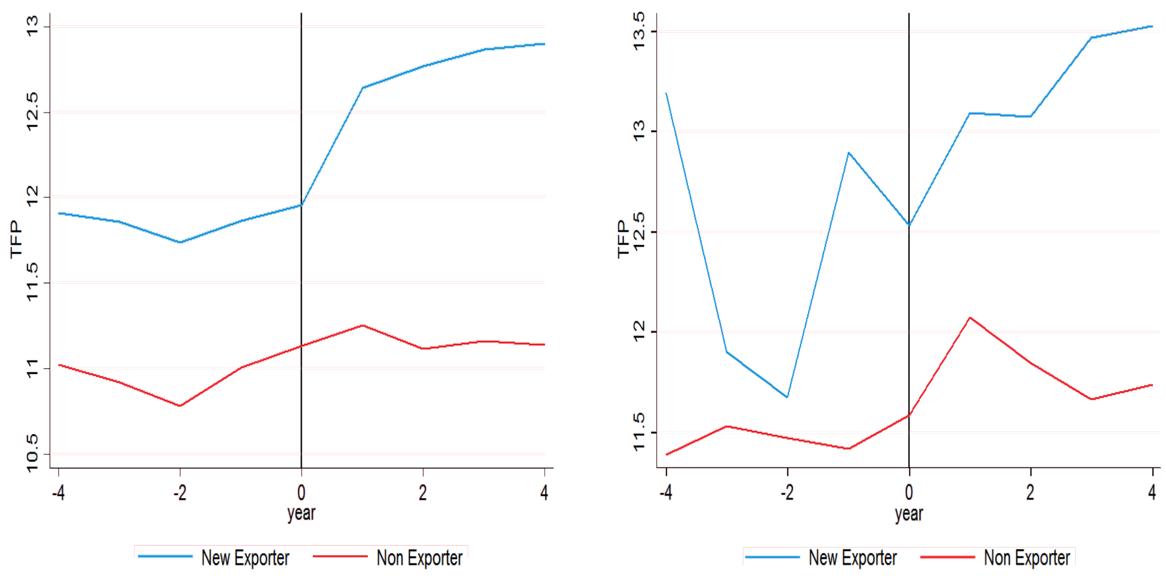
Notes: This table presents the difference-in-difference estimates of TFP, out-degree, and in-degree distribution. Treatment is starting to importing or exporting. Standard errors clustered at the firm-level in each regression, $+$, $**$, and $*$ indicate the significance at the 1%, 5%, and 10% levels, respectively.

Table 8 evaluates productivity, out-degree, and in-degree premia by linking the new exporters and importers. The number of controls determines the firms that never import or export, with the comparable size for the treatments. This exercise is suitable for two reasons. First, the results point to the productivity changes associated with learning-by-networking with the exporting or importing decision. As noted in Table 8, firms learn as they enter international markets. However, gains from exporting are significantly higher than those for importing. In other words, exporting firms become %19 productive after time$=0$. The premia also are significant for new importers, although the increase is only %6. These estimates are consistent with the model suggestions made in Section 3. Thus, the empirical evidence indicates that firms that export enjoy higher productivity than firms that only restrict their sales to the domestic market.

Firms expand their networks as they start to engage in international trade. Different than the literature, these estimations point to how value-chains evolve as the firms enhance their competitiveness. The specialization of their role as supplier/customer increases significantly for the firms in the treatment group. Further, firms with higher degrees generate higher TFPs. These results confirm a link between productivity and the sophistication of all manufacturing firms' networks, but it does not distinguish between sectors. In the next section, I investigate variation in the two-digit manufacturing industries to control for these characteristics.

7.3 Productivity and Network Gains at Industry Level

According to the previous section, all Turkish manufacturing firms that start to export for the first time experience a significant and substantial increase in their productivity. Yet, this variation originates from the firms' position in the supply chain. Though limiting these results without considering the industry characteristics could be misleading, the matching process controls similar sizes for the firms, but sectoral aspects may encounter the consequences.



(a) Fabricated Metals, 25 (b) Other Manufacturing, 32

Figure 8: Learning-by-Networking at Industry Level

Notes: The figure on the right shows the firms classified as Fabricated Metals according to the NACE 2-digit classification with 25. In contrast, the left graph presents the firms that belong to the Other Manufacturing classification with the code of 32. The blue line indicates the firms that never export, whereas the red line shows the firms' average degrees that start shipping at time 0.

To investigate the learning-by-networking hypothesis among various manufacturing industries, I run a similar regression for each industry type within NACE 2-digit classified sectors. The matching process detects the firm's nearest neighbor with the closest propensity score in the same industry to see the causal impact of shipping internationally.

Figure 8 represents the differences between the two industries: Fabricated Metals and Other Manufacturing, which covers the manufacturing of sports goods, toys, and medical instruments. For Fabricated Metals, treatment and control groups exhibit diverse behavior following the treatment, which is beginning to export in this case. This graph designates a critical difference. Though the firms classified as Other Manufacturing industries, the treatment's effect is doubtful since both groups improve their productivity. Besides, these two groups behave very differently before time zero, breaking down the parallel trend assumption.

Industry	**TFP**	**Outdegree**	**Indegree**
Food	1.70**	1.94**	2.05**
	(0.49)	(0.51)	(0.55)
Textiles	1.11**	1.19**	1.23**
	(0.34)	(0.40)	(0.30)
Apparel	0.86**	0.65*	1.05**
	(0.32)	(0.33)	(0.39)
Wood	0.98*	1.24*	0.78**
	(0.42)	(0.51)	(0.26)
Printing	0.45**	0.24	0.37+
	(0.20)	(0.16)	(0.19)
Pharmaceuticals	0.49	0.50**	0.52**
	(1.94)	(0.17)	(0.16)
Plastics	0.59**	0.50**	0.52**
	(0.20)	(0.17)	(0.16)
Fabricated	0.66**	0.84**	0.32**
Metals	(0.19)	(0.23)	(0.11)
Furniture	0.07+	0.09*	0.11
	(0.04)	(0.06)	(0.07)

Table 9: Productivity and Network Gains at Industry Level

Notes: This table presents the difference-in-difference estimates of TFP, out-degree, and in-degree distribution at the industry-level. Treatment is entry to exporting—standard errors clustered at the firm-level in each regression. Standard errors are presented in parentheses. $+$, $*$, and $**$ denote the significance of the coefficients at %10, %5 and %1, respectively.

Table 9 presents the difference-in-differences coefficients for each manufacturing industry after controlling for industry class differences. Surprisingly, not all manufacturing industries learn-by-doing. Only nine sectors experience more sophisticated networks and productivity gains among all 22-manufacturing industry NACE Rev.2. Classes. Further, the evidence is well-matched with Figure 8. Fabricated

Metals, for instance, significantly benefit from learning from networking.

Nevertheless, there is not any substantial evidence on Other Manufacturing industries, as expected. Also, the Appendix provides estimates for other sectors that do not experience notable improvements. This exercise's remarkable feature is how productivity and is an essential part of the supply chain are related. Although not all the two-digit manufacturing sectors display the same premiums, the empirical evidence verifies that the two concepts are accompanying.

Interestingly, not all manufacturing expands their value-chains or increase their productivity following the exporting decision. This variation might be due to government policies that target different sectors. In 2006, The Turkish authorities launched a comprehensive export strategy and action plan named "TURQUALITY" to promote sustainable export growth in several industries. This program aims to support branding in international markets and encourage their exports. These industries include Food, Textile, Apparel, Machinery, Chemicals, Plastics, Furniture, and Motor Vehicles. Remarkably, most of the targeted industries in this program experience more sophisticated production networks and increased their productivity.

7.4 Income Level of the Destination

The last part illustrates the network and productivity gains from exporting to any international market. In this part, I examine the destination characteristics by decomposing their income level. Literature, including De Loecker (2007), argues that firms that only export to high-income destinations learn more from exporting. In this part, I split the export destinations into three categories: lower-middle-income, upper-middle-income, and high-income following the recent World Bank's country classifications for 2019-2020. The firms that mostly target the low-income countries dropped from the sample due to their small observations.

To match a firm's destination with the income level, the firms' export destinations broken into World Bank classifications for each reported transaction. Next, the firm's destination category is ranked by its highest export volumes for each year. Figure 9 illustrates the TFPs of these groups. Unlike the previous findings in the literature, the firms that export to high-income countries for the first time already have higher productivity before zero. Further, this distinction persists until the fourth period. But for the upper-middle and lower-income, the behavior and the trends are roughly identical. Then, by relying on Figure 9, self-selection exists. Unlike the previous findings, there is no learning mechanism associated with income-level since the gap between these groups is essentially the same for each estimation period. Hence, the firms that target high-income destinations do not necessarily improve their productivities with exporting. At last, these firms already self-select themselves into higher-income countries even before entering international markets.

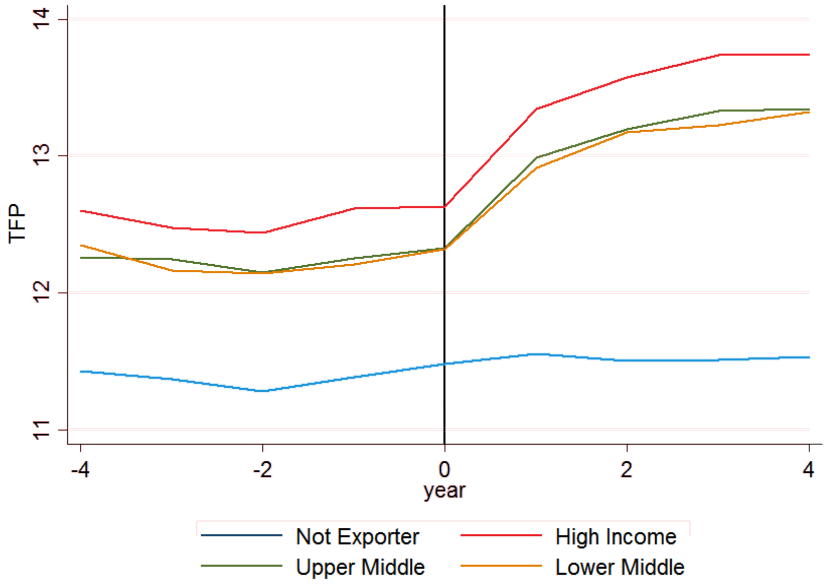


Figure 9: Income Level of the Destination

Notes: The lines indicate the groupings according to the firm's income-level of destination for the exports. The red line presents the firms that export most of their output to high-income, the green line shows the upper middle income, and the yellow line indicates the firms that majorly sell to lower-middle-income countries. Also, the blue line shows the firms that never export. The y-axis corresponds to the productivity level of the different groups.

7.5 Diversification of Exports to Sophistication of Networks

The firms which decide to develop their networks to international markets may choose where and how many markets to export. The diversification of the firm shifting from a single destination target to multiple countries can reach many customers. The most traditional diversification case is a common strategy to encourage positive growth by decreasing the risk. For that reason, the outcomes of creating a more complicated supply network may deviate from targeting only one market. This section covers the gains from the expansion of the export-degree in networks.

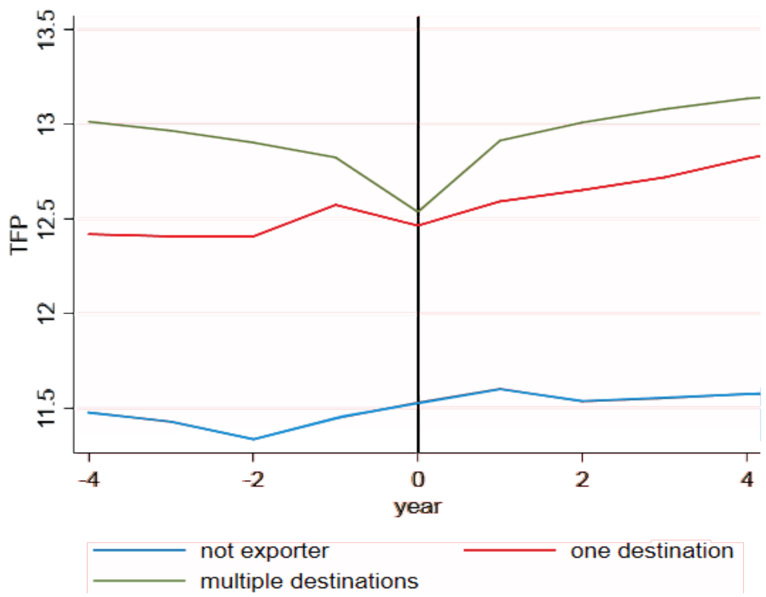


Figure 10: Diversification of Exports

Notes: The blue line exhibits the firms that never export; the red line shows the firms' average productivity that only export to one country, and the green line displays the TFP of the firms that ship their output to more than one destination.

Figure 10 distinguishes the two cases: TFP differentiation after starting to export to single or multiple destinations. Firms ship to various destinations become more competitive, according to Figure 10. Intuitively, learning-by-networking produces notable gains following time zero, whereas firms only restrict themselves to only one destination increase their productivity less than others. The main takeaway is that benefits increase by expanding their network role in the domestic supply-chain and their role in the international input-output network.

8 Conclusion

This paper shows the importance of a firm's production network sophistication for firm productivity while focusing on the micro-level evidence on shock propagation. Using the information distilled from a sizeable Turkish manufacturing firm database, I track the underlying factors correlated with firm's performance and growth.

Investigation of the production network structure mirrors several aspects of the aggregate economy. According to the firm-level transactions, distributions of both out- and in- degrees are incredibly skewed, exposing the production network's asymmetry. Hence, firms located in those tails are the origins of superstar effects through the supply chain. Further, this asymmetric formation yields a non-diversified economy. In this case, even the micro shocks hitting the tails may lead to aggregate fluctuations. Therefore, the input-output linkages that construct the production network can operate as a shock transmission mechanism.

After presenting the facts, this study demonstrates the theoretical foundations of production networks. The firm's suppliers play a crucial role in production and productivity for the manufacturing firms. Further, engaging in international trade recodes the complexity of the firm's production network. Therefore, this production network model serves as a foundation for the empirical results in this paper as a propagation mechanism of shocks.

With the results indicated by the model, this study concentrates on the nature of the shocks. These shocks transmit through the supplier and customer connections by first and higher-order connections. Network effects persist even in indirect linkages. For each link formed, imported inputs and exported output escalate the firm's total factor productivity. Interestingly, domestic input-output linkages are not significant in explaining the changes in productivity.

In particular, this paper proposes an alternative hypothesis for productivity premia as : "learning-by-networking". The critical insight is the change in the sophistication of the firms' networks before and after exporting. Unlike the previous literature, this paper documents that the underlying mechanism of learning requires a new arrangement of production networks with changing in- and out-degree distributions. The main takeaway of the paper is manufacturing firms learn-by-networking with other firms while expanding their value-chain.

Finally, gains from trade, reexamined by taking the network structures into account. Productivity gains correlated with the firm's network position in the supply chain, industry class, and the diversity of its export destinations. Yet, the income-level of the export partner is not related to any learning mechanism. All in all, critical evaluation of the alterations in productivity indicates that firms gain from networking.

References

Acemoglu, Daron, Ufuk Akcigit, and William Kerr (2016), "Networks and the macroeconomy: An empirical exploration," *NBER Macroeconomics Annual*, 30, 273–335.

Acemoglu, Daron and Pablo D Azar (2020), "Endogenous production networks," *Econometrica*, 88, 33–82.

Acemoglu, Daron, Vasco M Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi (2012), "The network origins of aggregate fluctuations," *Econometrica*, 80, 1977–2016.

Ackerberg, Daniel, Kevin Caves, and Garth Frazer (2006), "Structural identification of production functions," .

Alvarez, Roberto and Ricardo A Lopez (2005), "Exporting and performance: evidence from Chilean plants," *Canadian Journal of Economics/Revue canadienne d'économique*, 38, 1384–1400.

Antras, Pol, Teresa C Fort, and Felix Tintelnot (2017), "The margins of global sourcing: Theory and evidence from us firms," *American Economic Review*, 107, 2514–64.

Barrot, Jean-Noël and Julien Sauvagnat (2016), "Input specificity and the propagation of idiosyncratic shocks in production networks," *The Quarterly Journal of Economics*, 131, 1543–1592.

Bernard, Andrew B, Emmanuel Dhyne, Glenn Magerman, Kalina Manova, and Andreas Moxnes (2019), "The origins of firm heterogeneity: A production network approach," Tech. rep., National Bureau of Economic Research.

Bernard, Andrew B and J Bradford Jensen (1999), "Exceptional exporter performance: cause, effect, or both?" *Journal of international economics*, 47, 1–25.

Bernard, Andrew B, J Bradford Jensen, and Robert Z Lawrence (1995), "Exporters, jobs, and wages in US manufacturing: 1976-1987," *Brookings papers on economic activity. Microeconomics*, 1995, 67–119.

Boehm, Christoph E, Aaron Flaaen, and Nitya Pandalai-Nayar (2019), "Input linkages and the transmission of shocks: Firm-level evidence from the 2011 Tōhoku earthquake," *Review of Economics and Statistics*, 101, 60–75.

Carvalho, Vasco M (2014), "From micro to macro via production networks," *Journal of Economic Perspectives*, 28, 23–48.

Carvalho, Vasco M, Makoto Nirei, Yukiko Saito, and Alireza Tahbaz-Salehi (2016), "Supply chain disruptions: Evidence from the great east Japan earthquake," *Columbia Business School Research Paper*.

Carvalho, Vasco M and Nico Voigtländer (2014), "Input diffusion and the evolution of production networks," Tech. rep., National Bureau of Economic Research.

Clauset, Aaron, Cosma Rohilla Shalizi, and Mark EJ Newman (2009), "Power-law distributions in empirical data," *SIAM review*, 51, 661–703.

Crinò, Rosario and Paolo Epifani (2012), "Productivity, quality and export behaviour," *The Economic Journal*, 122, 1206–1243.

De Loecker, Jan (2007), "Do exports generate higher productivity? Evidence from Slovenia," *Journal of international economics*, 73, 69–98.

Di Giovanni, Julian, Andrei A Levchenko, and Isabelle Mejean (2014), "Firms, destinations, and aggregate fluctuations," *Econometrica*, 82, 1303–1340.

Di Giovanni, Julian, Andrei A Levchenko, and Isabelle Mejean (2018), "The micro origins of international business-cycle comovement," *American Economic Review*, 108, 82–108.

Eaton, Jonathan and Samuel Kortum (2002), "Technology, geography, and trade," *Econometrica*, 70, 1741–1779.

Gabaix, Xavier (2011), "The granular origins of aggregate fluctuations," *Econometrica*, 79, 733–772.

Horvath, Michael (1998), "Cyclicality and sectoral linkages: Aggregate fluctuations from independent sectoral shocks," *Review of Economic Dynamics*, 1, 781–808.

Horvath, Michael (2000), "Sectoral shocks and aggregate fluctuations," *Journal of Monetary Economics*, 45, 69–106.

Jacomy, Mathieu, Tommaso Venturini, Sebastien Heymann, and Mathieu Bastian (2014), "ForceAtlas2, a continuous graph layout algorithm for handy network visualization designed for the Gephi software," *PloS one*, 9, e98679.

Levinsohn, James and Amil Petrin (2003), "Estimating production functions using inputs to control for unobservables," *The review of economic studies*, 70, 317–341.

Long, John B and Charles I Plosser (1983), "Real business cycles," *Journal of political Economy*, 91, 39–69.

Lucas, Robert E (1977), "Understanding business cycles," in "Carnegie-Rochester conference series on public policy," 5, 7–29, North-Holland.

Mayer, Thierry, Marc J Melitz, and Gianmarco IP Ottaviano (2016), "Product mix and firm productivity responses to trade competition," Tech. rep., National Bureau of Economic Research.

Melitz, Marc J (2003), "The impact of trade on intra-industry reallocations and aggregate industry productivity," *econometrica*, 71, 1695–1725.

Oberfield, Ezra (2018), "A theory of input–output architecture," *Econometrica*, 86, 559–589.

Olley, S and A Pakes (1996), "The dynamics of productivity in the Telecommunications Equipment Industry, in "Econometrica", vol. 64," .

Pavcnik, Nina (2002), "Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants," *The Review of Economic Studies*, 69, 245–276.

Shea, John (2002), "Complementarities and comovements," *Journal of Money, Credit, and Banking*, 34, 412–433.

Taschereau-Dumouchel, Mathieu (2020), "Cascades and fluctuations in an economy with an endogenous production network," *Available at SSRN 3115854*.

Tintelnot, Felix, Ayumu Ken Kikkawa, Magne Mogstad, and Emmanuel Dhyne (2018), "Trade and domestic production networks," Tech. rep., National Bureau of Economic Research.

Yeaple, Stephen Ross (2005), "A simple model of firm heterogeneity, international trade, and wages," *Journal of international Economics*, 65, 1–20.

Appendix A. Productivity Calculations

This part implements the robustness of total factor productivity calculations with the different methodologies. TFP_op corresponds to the TFP calculations according to the Olley and Pakes (1996) whereas TFP_levpet is the TFP estimated without ACF Ackerberg et al. (2006) correction. The correlation matrix below shows that the TFP methodology employed in this paper, $TFP\_levpetACF$, is robust to various methodologies.

	$TFP\_levpetACF$	TFP_levpet	TFP_op
$TFP\_levpetACF$	1.00		
TFP_levpet	0.84	1.00	
TFP_op	0.79	0.96	1.00

Appendix B. Proofs of Propositions

Uniqueness of B_i

The networking of the problem of a firm relies on B_i and exogenous parameters. For this reason, the uniqueness of the market demand among all pairs of different pairs of downstream and upstream firms can be identified with the wages. Since there is a free entry condition, it can be described as f_e

$$w_i f_e = B_i \int_{\varphi_{im(i)}}^{\infty} (\gamma \Theta_i(\varphi) X_{ij})^{\frac{(\sigma-1)}{\theta}} \varphi^{\sigma-1} dG_i(\varphi) - w_i \int_{\varphi_{im(i)}}^{\infty} \sum_{j \in N_i(\varphi)} f_{ij} dG_i(\varphi) \tag{17}$$

where $m(i)$ is the intermediate input supplier of the least productive firm.

$$(\varphi_{im(i)})^{\sigma-1} B_i (\gamma T_{m(i)} (\frac{N_{i(m)}}{X_{ij}})^{-\theta})^{\frac{(\sigma-1)}{\theta}} = w_i f_{im(i)} \tag{18}$$

Taking the derivative of 17 with respect to B_i and replacing by 18 using leads to

$$\int_{\varphi_{im(i)}}^{\infty} \frac{d(\varphi^{\sigma-1}(\gamma \Theta_i(\varphi))^{\frac{(\sigma-1)}{\theta}} B_i - w_i \sum_{j \in N_i(\varphi) f_{ij}}}{dB_i} dG_{i(\varphi)} > 0 \tag{19}$$

As the firm's networking strategy remains constant an increase in market demand will increase the firm i's profits. In this way, right side of the 17 is monotonically increasing in B_i. Further as B $\rightarrow \infty$ all firms can source from each upstream firm:

$$B_i(\gamma T_{m(i)}(\frac{N_{i(m)}}{X_{ij}})^{-\theta})^{\frac{(\sigma-1)}{\theta}} - w_i f_{ij} \tag{20}$$

which goes to infinity.

Proof of Proposition 1 Assume there are two firms with productivities φ_1 and φ_2 where $\varphi_1 > v\varphi_2$. Let the networking strategy of the firms defines as $N_1(\varphi_1)$ and $N_2(\varphi_2)$. For firms that have higher productivity φ_1 to select $N_1(\varphi_1)$ over $N_2(\varphi_2)$ requires profits obtained among these two conditions to be

$$\varphi_1^{\sigma-1}(\gamma\Theta_i N_i(\varphi_1)X_{ij})^{\frac{\sigma-1}{\theta}}B_i - w_i \sum_{j\in N_i(\varphi_1)} I_{ij}f_{ij} > \varphi_2^{\sigma-1}(\gamma\Theta_i N_i(\varphi_2)X_{ij})^{\frac{\sigma-1}{\theta}}B_i - w_i \sum_{j\in N_i(\varphi_2)} I_{ij}f_{ij} \tag{21}$$

Further, firms with lower productivity arrange their networking strategy based on the condition

$$\varphi_2^{\sigma-1}(\gamma\Theta_i N_i(\varphi_2)X_{ij})^{\frac{\sigma-1}{\theta}}B_i - w_i \sum_{j\in N_i(\varphi_2)} I_{ij}f_{ij} > \varphi_1^{\sigma-1}(\gamma\Theta_i N_i(\varphi_1)X_{ij})^{\frac{\sigma-1}{\theta}}B_i - w_i \sum_{j\in N_i(\varphi_1)} I_{ij}f_{ij} \tag{22}$$

with these two profit functions,

$$[\varphi_1^{\sigma-1} - \varphi_2^{\sigma-1}][(\Theta_i N_i(\varphi_1))^{\frac{\sigma-1}{\theta}} - \Theta_i N_i(\varphi_2))^{\frac{\sigma-1}{\theta}}]\gamma^{\frac{\sigma-1}{\theta}}B_i > 0 \tag{23}$$

Since the productivity of the first firm is larger than the second firm it will imply that networking strategy of the more productive one should be larger than the other.

Proof of Proposition 2 The indicator functions of supplier I_{ij} and foreign customer X_{xi} takes values of 0 or 1. The profit function presented as

$$\Pi_i(\varphi, I_{i1}, .., I_{ij}) = \varphi^{\sigma-1}(\gamma\sum_{j=1}^{N} I_{ij}T_j(\frac{N_{ij}}{X_{ij}})^{-\theta})^{\frac{\sigma-1}{\sigma}}(1+\sum_{x=1}^{N}\beta_{xi})^{(1+\sigma)}B_i - w_i\sum I_{ij}f_{ij} - w_i\sum X_{xi}f_{xi} \tag{24}$$

this equation has increasing differences in both I_{ij} and X_{xi}. Further, it also presents increasing differences in X_{xi} and φ. Thus, variables that increase the networking capability $N_i(\varphi)$ such as reduction of linkage formation costs with other firms or increase in the technology of the upstream firm will lead to an increase in X_{xi}. For this reason, firms that increase their supplier network tend to select themselves into foreign markets.

In addition, for the case of complements $(\sigma-1)/\theta > 1$, if market demand is a constant reduction in iceberg costs results in an increase in exports as the standard trade model suggests. But depending on this profit function, it will also increase the suppliers of a firm. As a result, sourcing will increase following the reduction in iceberg costs of trade due to the fact that I_{ij} is non-increasing in iceberg costs. Hence, the firms which start to export would increase their production networks. The mechanism behind the exporting and sourcing decisions are following more productive firms participate in foreign markets and sophisticate their production network to decrease their marginal costs. All in all, productive firms become even more productive by expanding their network.

Appendix C. Countries

MENA	**Western Europe**	**Southern Europe**	**East Asia**	**North America**
	WE	**SEB**	**EA**	**NA**
Algeria	Austria	Albania	China	Canada
Bahrain	Belgium	Belarus	Hong Kong	U.S.
Djibouti	Denmark	Bosnia	Japan	Mexico
Egypt	Finland	Bulgaria	Philippines	Costa Rica
Ethiopia	France	Croatia	Singapore	Cuba
Iran	Germany	Czech Republic	South Korea	
Iraq	Iceland	Estonia	Taiwan	
Israil	Ireland	Greece	Vietnam	
Jordan	Italy	Hungary		
Kuwait	Luxembourg	Latvia		
Lebanon	Monaco	Lithuania		
Libya	Netherlands	Moldavia		
Morocco	Norway	Montenegro		
Oman	Portugal	Poland		
Qatar	Spain	Romania		
Saudi Arabia	Sweden	Russia		
Syria	Switzerland	Serbia		
Tunisia	U.K.	Slovakia		
Yemen		Ukraine		
		Yugoslavia		

Appendix D. Industry Classification

NACE Rev 2.	Industry
10	Manufacture of food products
11	Manufacture of beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of pharmaceutical products
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture
32	Other manufacturing

Appendix E. Other Manufacturing Industries

Industry	**TFP**	**Outdegree**	**Indegree**
Beverages	1.29	1.01	1.05
	(1.79)	(0.53)	(0.50)
Tobacco	17.41	47.18	9.51
	(98.52)	(223.36)	(49.53)
Leather	0.18	0.11	0.19
	(0.17)	(0.09)	(0.13)
Paper	0.80	0.77	0.51
	(0.90)	(0.56)	(0.39)
PetroCoke	1.24	1.13	0.42
	(2.44)	(2.06)	(2.37)
Chemicals	0.12	2.87	3.49
	(0.85)	(5.43)	(4.05)
Mineral	0.40	0.60	0.31
	(0.49)	(0.52)	(0.42)
BasicMetals	-0.90	0.61	0.85
	(1.09)	(1.02)	(0.77)
ComputerElectronic	-0.24	0.97	0.19
	(0.84)	(1.45)	(0.82)
ElectricalEquip	0.70	0.79	0.70*
	(0.77)	(0.71)	(0.35)
Machinery	-0.12	0.19	0.14
	(0.19)	(0.18)	(0.12)
MotorVech	0.16	0.31	0.71
	(0.19)	(0.49)	(0.61)
OtherTrans	4.33	0.45	1.05
	(6.74)	(0.84)	(3.34)
OtherManu	0.86	0.09	0.34
	(1.51)	(0.24)	(0.41)
RepairInstall	0.74	0.12	0.19
	(0.45)	(0.16)	(0.16)

Table F.1: Productivity and Network Gains at Industry Level

Notes: TThis table presents the difference-in-difference estimates of TFP,out-degree, and in-degree distribution at the industry-level. Treatment is entry to exporting. Standard errors are clustered in firm-level in each regression +, ∗ and ∗∗ denote the significance of the coefficients at %10, %5 and %1. Standard errors are presented in parentheses, and the third row provides the R^2 of each estimation.

Appendix F. Production Network at 4-digit Level

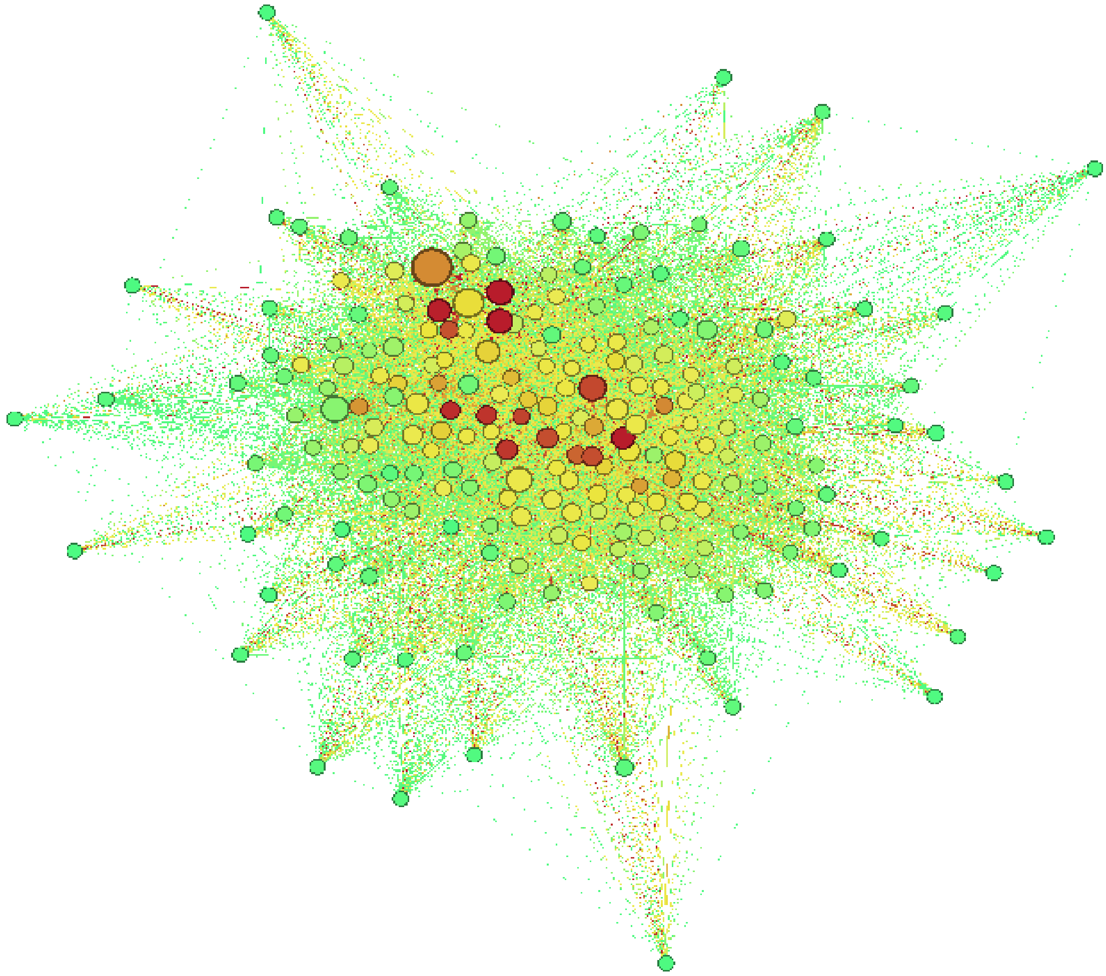


Figure G.1: Domestic Production Network *Notes:* Turkish Manufacturing Industries aggregated according to 4-digit NACE Rev 2. Classification, colors turn from green to dark red depending on the out-degrees of industries. Nodes locations estimated with the ForceAtlas2 algorithm Jacomy et al. (2014). Nodes highly trade with each other located together, and nodes are located in the periphery if the trade among others is relatively weak.