Essays in International Economics and Industrial Organization

Inauguraldissertation zur Erlangung des akademischen Grades eines Doktors der Wirtschaftswissenschaften der Universität Mannheim

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Frühjahrs-/Sommersemester 2025

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Tag der Disputation: 28. Juli, 2025

Acknowledgements

While writing this dissertation, I have highly benefited from the comments and suggestions of my supervisors, Harald Fadinger and Nicolas Schutz. Their sharp points and support have helped me refine my arguments and conduct quality analyses of issues related to international trade. I have highly benefited from the expertise and excellent teaching by professors at the Univesity of Mannheim. The coursework has equipped me with relevant skills and knowledge to conduct a thorough analysis of economic problems and to contribute to economic science. My doctoral studies would have been much more difficult without the support, excellent organization, valuable advice, and diligent work of CDSE and GESS administration and the University of Mannheim Welcome Center. I am also grateful to my classmates for emotional support throughout the process of completing this dissertation and valuable suggestions on the content and arguments.

The first and the second chapter include results from my job market paper "Effects of Input Trade Liberalization with Strategic Sourcing". This paper would not be possible without the product-level dataset recording activities of Ukrainian food-processing firms. Professor Volodymyr Vakhitov has shared this dataset with me and provided instructions on its construction and cleaning routines. Apart from my supervisors, several members of the Department of Economics at the University of Mannheim have provided valuable suggestions and feedback on earlier versions of this paper including Antonio Ciccone, Andreas Gulyas, Matthias Meier, Volker Nocke, Krzysztof Pytka, Jan Schymik, Michelle Sovinsky. I also acknowledge valuable feedback from other participants of internal seminars at the University of Mannheim. I have highly benefited from discussions of this paper by Monika Mrázová, Ciarán Mac Domhnaill, and Ignasi Merediz Solà. I am also grateful to Pol Antràs, Paola Conconi, Alejandro Cuñat, Carsten Eckel, Hartmut Egger, Michael Irlacher, Udo Kreickemeier, Leonardo Navarro, Mathieu Parenti, Philip Ushchew, Gerald Willmann, Stephen Ross Yeaple, and other participants of the 16th FIW Research Conference "International Economics" (WU Vienna), 17th RGS Doctoral Conference (Universität Duisburg-Essen), the 25th Workshop "Internationale Wirtschaftsbeziehungen" (Universität Göttingen), 23rd RIEF Doctoral Meeting (PSL), 39th ENTER Jamboree (ULB), 7th Workshop on International Economic Networks (University of Vienna), 25th

European Trade Study Group Conference (Athens University of Economics and Business) for useful comments, questions, and feedback. I have also highly benefited from insightful comments and suggestions from Laura Alfaro, Johannes Boehm, Igal Hendel, Dávid Krisztián Nagy, and Jaume Ventura during their visits to the University of Mannheim. I am also grateful to Stuart Currie for valuable suggestions on the style and language use of the introduction. I gratefully acknowledge financial support from the German Research Foundation through CRC TR 224 for this project.

The third chapter is based on my joint paper with Mykola Ryzhenkov and Volodymyr Vakhitov "Financial Frictions, Markups, and Unilateral Trade Liberalization". Apart from my supervisors and co-authors, several members of the Department of Economics at the University of Mannheim have provided valuable suggestions and feedback on earlier versions of this paper, including Husnu Dalgic, Andreas Gulyas, Minki Kim, Moritz Kuhn, Krzysztof Pytka, and Jan Schymik. I also acknowledge valuable feedback from other participants of internal seminars at the University of Mannheim. Earlier versions of this paper were presented at the 1st JIE Summer School (University of Crete), Doctoral Workshop on Quantitative Dynamic Economics (University of Strasbourg), 6th FHM+ Development Economics Workshop(Frankfurt am Main), 16th FIW Research Conference "International Economics" (WU Vienna), the 25th Workshop "Internationale Wirtschaftsbeziehungen" (Universität Göttingen), First International Virtual Conference on Ukraine (Jönköping International Business School), 25th European Trade Study Group Conference (Athens University of Economics and Business), and the Bank of Estonia. We are thankful for the valuable comments and feedback we received from participants and organizers of these events, including Sebnem Kalemli-Ozcan, Samuel Ligonniere, Veronica Rappoport, Florian Unger and others. We are also thankful to Carlos Urrutia, Daniel Yi Xu, Ariell Reshef, Nicolas Coeurdacier, and Paola Conconi for insightful comments and suggestions on this paper during their visits to the University of Mannheim. I also acknowledge financial support through a bridging grant provided by Landesgraduiertenförderung. Mykola Ryzhenkov and I acknowledge financial support from the German Research Foundation (DFG) and from the state of Baden-Württemberg through bwHPC.

I also acknowledge the substantial contribution of continuous support and prayers of my family members during my doctoral studies. I am grateful to Volodymyr Vakhitov, Tom Coupe, and Tymofiy Mylovanov for writing recommendation letters that helped me enroll in the doctoral program at CDSE GESS University of Mannheim. I am also thankful to Kyiv School of Economics and Sumy State University professors for preparing me for academic career and helping me develop invaluable knowledge and skills.

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Preface

This dissertation sheds light on the effects of trade policy. Chapter 1 provides theoretical analysis of firm behavior in a model in which firms make geographical importing decisions under oligopolistic competition. In Chapter 2, I calibrate the model from Chapter 1 to the Ukrainian production dataset and use the calibrated model to evaluate the welfare effects of input trade liberalization that happened during the accession of Ukraine to the World Trade Organization (WTO) in 2008. In Chapter 3, I study the aggregate and distributional effects of unilateral trade liberalization for a small open economy in which firms face credit constraints and set variable markups.

Structural model of strategic sourcing: Theoretical analysis. In this chapter, I develop a structural model based on Antràs et al. (2017) in which firms under oligopolistic competition decide where to source intermediate inputs from. I assume that firms decide on their sourcing strategies before competing in quantities. In this model, if outputs are strategic substitutes, firms face incentives to manipulate the output decisions of competitors by importing intermediate inputs outside of the Home country. Nonetheless, the individual and welfare implications of sourcing decisions under oligopolistic competition do not strongly differ from those under monopolistic competition if outputs are strategic substitutes. I show that if outputs are strategic substitutes, more efficient firms receive a larger increase in variable profits from starting to source inputs from a new country. I also show that if outputs are strategic substitutes, parameter restrictions ensure that for two firms with identical fixed costs, the benevolent social planner would prefer a more efficient firm to start sourcing from a new country.

Effects of Input Trade Liberalization with Strategic Sourcing. In this chapter, I study effects of input trade liberalization under oligopolistic competition. I use a multi-country model accounting for endogenous sourcing decisions and strategic behavior of heterogeneous firms to quantify the welfare effects of the accession of Ukraine into the WTO in 2008 on Ukrainian food-processing sectors. I find that welfare improves slightly under oligopolistic competition, with consumers gaining and firms losing. Endogenous adjustment of sourcing strategies accounts for a quantitatively important fraction of welfare gains. Strategic sourcing and variability in markups both contribute to a smaller welfare improvement than under monopolistic competition.

Financial Frictions, Markups, and Unilateral Trade Liberalization. This chapter is based on my joint work with Mykola Ryzhenkov and Volodymyr Vakhitov. We study the response of a small open economy with credit constraints and variable markups to unilateral trade liberalization by a more developed trading partner. We use a dynamic heterogeneous agents model based on Kohn et al. (2020) to quantify the welfare and allocative efficiency effects of the unilateral increase in Ukraine's market access to the European Union in 2014. To obtain a better match with the data, we allow for variable markups in the domestic market, trade imbalances, and interest rate increasing with the level of foreign debt. We find that better market access improves welfare but lowers allocative efficiency, as productivity losses due to increased capital misallocation exceed productivity gains due to a reduction in markup dispersion. Variable markups exacerbate the increase in capital misallocation due to unilateral trade liberalization in the economy with credit constraints.

Chapter 1

Structural Model of Strategic Sourcing: Theoretical Properties[1]

[1] Some exercises in this chapter were conducted using product-level dataset for Ukrainian manufacturing firms from Ukrainian Food-Processing sectors. Access to this dataset and cleaning routines were provided by Professor Volodymyr Vakhitov.

1.1 Introduction

Today, it is a standard wisdom that removing barriers to input trade improves efficiency and welfare. As consumers pay lower prices for the same products and as firms pay smaller prices for intermediate inputs, the economy benefits. How sizable are the resulting welfare gains? Many papers have estimated large effects,[2] but few of them have considered the possibility that importing firms might have substantial market power. In that scenario, responses of markups to input tariff cuts might lead to a reduction in price declines, and therefore to smaller consumer benefits. Welfare can improve even less in the market with a small number of firms, because some firms might abstain from importing as a best response to more aggressive sourcing by competitors.

The international economics literature following Melitz (2003) typically conjectures that the economy is populated by heterogeneous firms of negligible size engaging in monopolistic competition and facing CES demand. Several studies, including Antràs et al. (2017), Bernard et al. (2022), Blaum et al. (2019), adopt this assumption when they model importing decisions of firms. Greater tractability comes at the cost of unrealistic predictions. Firstly, equilibrium markups are constant and identical across firms.[3] Secondly, under monopolistic competition firms do not strategically interact. It cannot happen that Chevrolet decides not to source semiconductors from Taiwan, because Ford commits to source components from the Czech Republic. Allowing for oligopolistic competition can help to explain both puzzles.

Within the extensive literature, Atkeson and Burstein (2008), Amiti et al. (2014), Hottman et al. (2016), Bernard et al. (2018), and Gaubert and Itskhoki (2021) argue that oligopolistic behavior is not just a theoretical possibility, but one that manifests itself in the data affecting micro- and macro-responses of economies to shocks. In Figure 1.1, using data for the Ukrainian food-processing sectors for 2007, I present the share of total domestic revenues of the top five largest firms in each sector. In about 75% of these sectors, the top five firms generate more than 50% of total revenues. In about 50% of these sectors, firms directly sourcing intermediate inputs from abroad account for more than 50% of total sectoral revenues. Given the relatively low numbers of firms in each sector as well as high levels of concentration, it is difficult to believe that firms perceive themselves and their competitors as negligibly small as under monopolistic competition. If, as in Antràs et al. (2017), foreign sourcing directly affects firms' marginal costs and is associated with fixed costs, it is natural to think that strategic incentives might influence firms' decisions on supplier geography. Firms might want to import not just to reduce their own total costs, but also to manipulate decisions of their competitors.

[2] including Halpern et al. (2015), Caliendo and Parro (2015), Antràs et al. (2017), Blaum et al. (2019)

[3] For this reason, these models fail to explain an incomplete pass-through of input tariff cuts to prices during the trade reform in India reported in De Loecker et al. (2016)

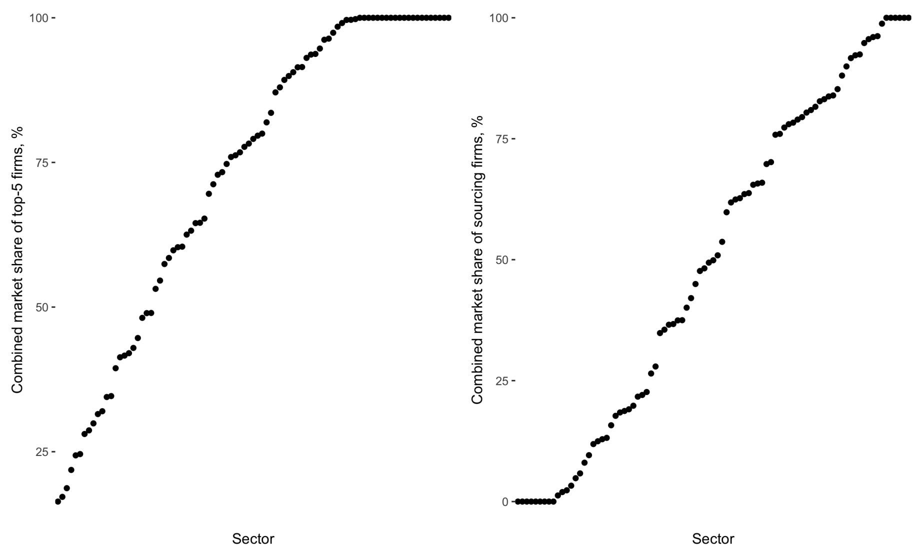


Figure 1.1: Combined Market Shares of Top Five Largest Firms and Firms Sourcing Intermediate Inputs from Abroad in Ukrainian Food-processing Sectors in 2007

Note: This figure plots the sectoral shares of domestic revenues generated by the top five largest firms (the left panel) and firms directly importing intermediate inputs from abroad (the right panel) in total revenues calculated for Ukrainian food-processing sectors in the year 2007. Sectors are presented in increasing order of the calculated shares.

I study the welfare effects of input trade liberalization under endogenous sourcing decisions, firm heterogeneity, and oligopolistic competition. I build on the multi-country sourcing model by Antràs et al. (2017), in which firms decide on the geography of their suppliers under monopolistic competition. Firms can improve efficiency when they expand the suppliers' geography, but the associated fixed costs might prevent such efficiency improvements. I modify model in Antràs et al. (2017) by allowing for oligopolistic competition in the final good sector. I further assume that firms engage in a two-stage game with complete information: they decide on the suppliers' geography simultaneously before deciding on quantities.

I show that when outputs are strategic substitutes in the second stage, oligopolistic competition brings about a more aggressive sourcing behavior compared to monopolistic competition. Firms are more aggressive, as they take into account that expanding the geography of their supplies improves their profits not just by reducing total costs but also by reducing the outputs of competitors in the quantity-setting stage. Despite the obvious differences in firms' sourcing incentives, the micro-predictions of the model are not dramatically different from the model under monopolistic competition. I show that provided outputs are strategic substitutes in the second stage, an identical expansion of suppliers' geography leads to a larger increase in variable profits for a more efficient firm compared to a less efficient one. I also show that provided outputs are strategic substitutes, for a broad range of parameter values, an identical expansion of suppliers' geography by a more efficient firm contributes more to consumer surplus and total variable profits. I also derive conditions under which starting to source from a new country increases labor demand across domestic suppliers and the profitability of sourcing inputs from more countries.

Literature review: This study augments the literature analyzing endogenous sourcing decisions by global firms. Numerous studies, including Muûls and Pisu (2009), Antràs et al. (2017), Bernard et al. (2018), and Dhyne et al. (2020), show that only a small fraction of firms in the data directly source intermediate inputs from abroad. On the one hand, more productive firms self-select into importing, and on the other hand, importing improves firms' productivity[4] and provides access to the same inputs at lower prices.[5] Antràs et al. (2017), Bernard et al. (2018), and Carluccio et al. (2019) show that such cost reduction effects create interdependencies, when a firm decides on its optimal sourcing strategy in a multi-country model. In practice, such interdependencies make the sourcing problem of this firm difficult to solve.[6] My study of firms' decisions on optimal sourcing geography under oligopolistic competition shows that, despite even greater complexity due to strategic sourcing, such a multi-country sourcing model can still be efficiently solved. I apply tools from the literature on discrete strategic decisions of oligopolistic firms to arrive at the solution. I contribute to this literature by analyzing implications of strategic interactions on firms' global sourcing behavior.

This work also relates to the literature on strategic cost reduction decisions under oligopoly. Spencer and Brander (1983) show that in the game, in which firms make cost-reducing research and development (R&D) investments in the first stage and compete in quantities in the second stage, firms exert excessive cost-reducing effort. Authors propose R&D subsidies as means to improve welfare. Spence (1984) and D'Aspremont and Jacquemin (1988) show that this result is sensitive to the second stage mode of competition and to the absence of spillover effects. Farrell and Shapiro (1990) show that excessive investment incentives remain even in a model with firm heterogeneity. Leahy and Neary (1997) analyze the effects of R&D cooperation in a general model and show that strategic cost-reducing incentives can either be excessive or insufficient depending on the mode of the second stage competition and the strength of spillovers. López and Vives (2019) analyze how common ownership affects investment and output in a model with strategic cost-reducing investment with spillovers. The aforementioned theoretical literature abstracts from firms' decisions on whether or not to reduce marginal costs. Igami (2018)

[4] see Halpern et al. (2015), Bøler et al. (2015)

[5] see Amiti et al. (2014), Antràs et al. (2017), Bernard et al. (2018)

[6] Rapidly growing literature develops approaches to reduce time requirements for solving combinatorial discrete choice problems with interdependencies across choices but not across firms. See Jia (2008), Eckert and Arkolakis (2017), Alfaro-Urena et al. (2023), Castro-Vincenzi (2024), Oberfield et al. (2024), Kulesza (2024) for recent contributions

models discrete offshoring decisions of firms in the Hard Disk Drive (HDD) industry using a dynamic game with incomplete information. This work is closely related to mine. I assume, however, complete information and allow for richer firm heterogeneity and a greater number of sourcing locations. Making use of aggregative-games methods developed in Nocke and Schutz (2018a), Nocke and Schutz (2018b), and Breinlich et al. (2023), I undertake a comparison of welfare effects in models with oligopolistic and monopolistic competition.

1.2 Theoretical Model

1.2.1 Economic Environment

Demand: Consider a world with a fixed number of countries ordered by 1...L. I focus on a small open economy H. Consumers in H have quasi-linear preferences with respect to food and non-food items:

$$U = q_0 + E \int_{z\in Z} \alpha(z) log \left(\sum_{j\in J(z)} a_j^{\frac{1}{\sigma}} q_j^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} dz \tag{1.1}$$

Non-food items aggregate into a Hicksian composite commodity (or the outside good), while food items enter nested subutility, having a similar structure to Breinlich et al. (2023). The food subutility is upper-tier Cobb-Douglas and lower-tier constant elasticity of substitution (CES) (the total spending of consumers on food equals E). In the upper tier, this sub-utility combines the output aggregators of a continuum of food sectors, which I index by z.The expenditure share on goods from sector z is $\alpha(z)$. Each output aggregator combines the products of a fixed number of single-product firms from the set $J(z)$ with the means of CES output aggregator $Q(z) = \left(\sum_{j\in J(z)} a_j^{\frac{1}{\sigma}} q_j^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$. The elasticity of substitution $\sigma > 1$ is the same in all food sectors. I model q_j as the output of firm j and use a_j as a j-specific quality or consumer taste shifter or firm appeal as in Hottman et al. (2016). The higher the a_j, the higher the demand for the j's product, conditional on price. Food is neither exported nor imported (perhaps due to high transportation costs).

Utility maximization yields the following inverse demand function:

$$p_i = a_i^{\frac{1}{\sigma}} q_i^{-\frac{1}{\sigma}} Q(z)^{-\frac{\sigma-1}{\sigma}} \alpha(z) E \tag{1.2}$$

In this model, the demand the firm faces becomes less elastic, the lower the firm's price, and the greater the firm's appeal. Differences in demand elasticities occur because, unlike under monopolistic competition, an oligopolistic firm internalizes the effect of its own decision on the sectoral output aggregator. When a firm slightly increases its output, the aggregator increases in proportion to the firm's market share, $s_i \in (0,1)$. The market share of firm i has the following expression:

$$s_i = \frac{a_i^{\frac{1}{\sigma}} q_i^{\frac{\sigma-1}{\sigma}}}{\sum\limits_{j \in J(z)} a_j^{\frac{1}{\sigma}} q_j^{\frac{\sigma-1}{\sigma}}} \tag{1.3}$$

Trade in Inputs. I consider a set of assumptions very similar to the one in Antràs et al. (2017). The production function of firm i takes the CES form with elasticity of substitution ζ:

$$q_i = \varphi_i \left[\int_0^1 X_i(\nu)^{\frac{\zeta-1}{\zeta}} d\nu \right]^{\frac{\zeta}{\zeta-1}} \tag{1.4}$$

Each firm receives a unique random draw of productivity (φ_i) and uses a CES production function to transform a unit measure of intermediate firm-specific inputs ν into output q_i. Each location (including H) has an exogenously-given level of technology($\mathcal{T}_l$) and a perfectly competitive labor market, in which workers receive a competitive wage W_l. I normalize transportation costs within H to 1 and denote the shipping costs from location l to H as $\tau_{lH} > 1$. Although food producers cannot sell to other countries, they can still source inputs from intermediate input producers from other countries. The firm could find its specific inputs in any location sold by perfectly competitive firms, who use labor as the only factor of production. Production of ν for the firm i in l requires $b_{li}(\nu)$ units of labor. Unit labor requirements are random, drawn from the Frechet distribution with the shape parameter $\theta > 1$ and the scale parameter $\mathcal{T}_l > 0$. Below, I provide a cumulative distribution function (CDF) of $b_{il}(\nu)$:

$$P(b_{il}(\nu) \geq b) = e^{-\mathcal{T}_l b^{\theta}} \tag{1.5}$$

The lower the θ, the larger is the dispersion of unit labor requirements. Low enough θ might make location with outstanding technology and low labor costs still inefficient in producing some of the firm's specific inputs. Sourcing allows the firm to increase competition between suppliers of each input and, in this way, make prices paid for inputs weakly smaller. Exactly as in Antràs et al. (2017), I call the firm's set of sourcing locations an optimal sourcing strategy and denote it by $\mathcal{J}_i$. To reconcile the model with the data, I introduce fixed costs of foreign sourcing, which differ across all firms and locations. $f_{iH} = 0$ for all $i \in J(z), 0 < f_{il} < \infty$ for every location $l \neq H$, for every $i \in J(z)$.

Game set-up and timing: Firms engage in a two-stage game with complete information.

In the first stage, firms simultaneously decide on sourcing strategies $\mathcal{J}$; in the second stage, they compete in quantities, knowing the marginal costs and quality shifters of all firms in their sectors.

1.2.2 Subgame Perfect Nash Equilibrium

I solve the game backward, starting from the second stage.

Marginal costs: Consider firm i. In the second stage, all firms pre-commit to $\mathcal{J}_i$. As $f_{iH} = 0$, $H \in \mathcal{J}_i$. Finding the optimal location for each input, the firm can calculate the cost-minimizing level of marginal costs consistent with the $\mathcal{J}_i$ by integrating over the distribution of optimal input prices. The resulting expression for marginal costs is identical to the one in Antràs et al. (2017):[7]

$$MC_i = \frac{1}{\varphi_i}(\gamma\Theta(\mathcal{J}_i))^{-\frac{1}{\theta}} \tag{1.6}$$

The marginal cost function in (1.6) is a product of the inverse of productivity, a decreasing function of the gamma function of the parameters ($\gamma = \left[\Gamma\left(\frac{\theta+1-\zeta}{\theta}\right)\right]^{\frac{\theta}{1-\zeta}}$), and the optimal sourcing capability of the firm in the sense of Antràs et al. (2017). The sourcing capability represents an index summarizing all sourcing locations' technologies discounting them with transportation costs and location-specific factor prices):

$$\Theta(\mathcal{J}_i) = \sum_{l \in \mathcal{J}_i} \mathcal{T}_l (w_l \tau_{lH})^{-\theta} \tag{1.7}$$

In the second stage, differences in marginal costs between firms stem from heterogeneity in productivity and differences in optimal sourcing strategies. To simplify the structural analysis, I normalize $\mathcal{T}_H(w_H\tau_{HH})^{-\theta} = 1$. If a given firm only sources inputs from Home, its $\Theta(\mathcal{J}_i) = 1$, otherwise, $\Theta(\mathcal{J}_i) > 1$. A firm that sources inputs from more locations optimally pays weakly lower prices for all its inputs, and the resulting difference in marginal costs is proportional to the difference in sourcing capabilities.

Quantities: Given that for all firms in the sector, sourcing strategies are predetermined, the game of complete information allows all firms to observe each others' marginal costs and quality demand shifters. Following Breinlich et al. (2023), I aggregate this information for each firm using a unidimensional sufficient statistic, quality-adjusted productivity. I denote it by T_i and call it firm's type:

$$T_i = a_i^{\frac{1}{\sigma}} \left(\frac{\alpha E}{\varphi_i^{-1}(\gamma\Theta(\mathcal{J}_i))^{-\frac{1}{\theta}}} \frac{\sigma - 1}{\sigma} \right)^{\frac{\sigma-1}{\sigma}} \tag{1.8}$$

[7] as in Antràs et al. (2017), a well-defined intermediate input price index requires $\theta > \zeta - 1$

If I set $\Theta(\mathcal{J}_i) = 1$, I obtain $\hat{T}_i$, the so-called counterfactual autarky type. For a firm without access to foreign intermediate inputs, its type equals $\hat{T}_i$.

Next, I solve the quantity setting game, using the aggregative games approach. I aggregate information on the qualities and optimal outputs of firms, using the aggregator $\mathcal{H}^* = \sum_{j \in J} a_j^{\frac{1}{\sigma}} q_j^{*\frac{\sigma-1}{\sigma}}$. I define the second stage equilibrium market share as $\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right)$. This market share solves the equation coming from firm's first-order condition for profit maximization with respect to output, implicitly-defined by the market share fitting-in function:

$$1 - s_i^* = s_i^{*\frac{1}{\sigma-1}} \left(\frac{T_i}{\mathcal{H}^*}\right)^{\frac{\sigma}{1-\sigma}} \tag{1.9}$$

The unique second stage pure strategy Nash equilibrium consists of the vector of market shares, solving the system of equations (1.9) for all firms given the equilibrium $\mathcal{H}^*$.[8] Similarly to Nocke and Schutz (2018a), Breinlich et al. (2023), I can find this equilibrium by solving for $\mathcal{H}^*$, equating the sum of $\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right)$ to 1:

$$\sum_j \mathcal{S}\left(\frac{T_j}{\mathcal{H}^*}\right) = 1 \tag{1.10}$$

Using the equilibrium market shares, I can derive the price of the firm i as $p_i = \frac{1}{(1-s_i^*)\frac{\sigma-1}{\sigma}} MC_i$ and solve for q_i^*. The equilibrium Lerner index of the firm $\mu_i = \frac{p_i - MC_i}{p_i}$ increases in its market share, $\mu(s) = \frac{1}{\sigma} + \frac{\sigma-1}{\sigma}s$. I use $\mu(s)$ to calculate the second stage equilibrium profits as a function of the second stage equilibrium market share and total revenue in the sector: $\pi_{\mu s}(s^*, \alpha E) = \mu(s^*)s^*\alpha E$.

Modeling quantity competition with firms facing isoelastic demand poses some important challenges. Bulow et al. (1985) show that with isoelastic demand, outputs might fail to be strategic substitutes if the demand becomes so convex that the own marginal revenue becomes upward-sloping in outputs of competitors. In the next lemma, I show that outputs are strategic substitutes if the demand curves for all firms are sufficiently elastic. The lower bound on demand elasticity requires that firms' market shares do not exceed $\frac{1}{2}$.

Lemma 1. *Suppose, for any firm j in the sector, $s_j \leq \frac{1}{2}$. Then, outputs are strategic substitutes across all firms.*

Proof. See Appendix 1.4.2 □

First stage sourcing strategies: Now I proceed to the first stage of the game. Given that any change in the sourcing capability affects T_i through $\Theta(\mathcal{J}_i)$, in the first stage, the firm can calculate second-stage profits for every candidate sourcing strategy given every combination of

[8] Breinlich et al. (2023) provide proofs of existence and uniqueness of Nash equilibrium under a more general set of assumptions.

its competitors' strategies. Now, suppose that adding a sourcing location l changes the value of the output aggregator from $\mathcal{H}'^*$ to $\mathcal{H}''^*$. The firm i adds (removes) l (l') into (from) $\mathcal{J}_i$ as a best response to sourcing strategies of competitors as long as the resulting increase (decrease) in $\pi_{\mu s}(s^*, \alpha E)$ justifies (not) paying the associated fixed costs(f_{il}). Subgame perfect Nash equilibrium (SPNE) requires that for every firm i, for every $l \in \mathcal{J}_i$ and $l' \notin \mathcal{J}_i$, the following equations are satisfied:

$$\begin{aligned} &\pi_{\mu s}\left(\mathcal{S}\left(\frac{\hat{T}_i \Theta(\mathcal{J}_i)^{\frac{\sigma-1}{\sigma\theta}}}{\mathcal{H}''^*}\right), \alpha E\right) - \pi_{\mu s}\left(\mathcal{S}\left(\frac{\hat{T}_i \Theta(\mathcal{J}_i \setminus l)^{\frac{\sigma-1}{\sigma\theta}}}{\mathcal{H}'^*}\right), \alpha E\right) \geq f_{il} \\ &\pi_{\mu s}\left(\mathcal{S}\left(\frac{\hat{T}_i \Theta(\mathcal{J}_i \bigcup l')^{\frac{\sigma-1}{\sigma\theta}}}{\mathcal{H}''^*}\right), \alpha E\right) - \pi_{\mu s}\left(\mathcal{S}\left(\frac{\hat{T}_i \Theta(\mathcal{J}_i)^{\frac{\sigma-1}{\sigma\theta}}}{\mathcal{H}'^*}\right), \alpha E\right) < f_{il'} \end{aligned} \tag{1.11}$$

In a subgame perfect Nash equilibrium, no unilateral deviation to an alternative sourcing strategy is profitable for any firm. Adding any set of sourcing locations will not be justified given the sourcing strategies of competitors, taking into account the associated fixed costs. Removing any subset of firm's sourcing strategy will lead to insufficient fixed cost economies to justify the resulting reduction in firm's variable profits, given the sourcing strategies of competitors. The theoretically unattractive feature of this game is that there is no guarantee that the SPNE in this game is unique. Moreover, there are no guarantees that the SPNE in pure strategies exists. In this way, the game shares similarities with the entry and multiproduct games by Bresnahan and Reiss (1990), Ciliberto and Tamer (2009), Eizenberg (2014), Fan and Yang (2020), Fan and Yang (2022). However, at least one subgame perfect Nash equilibrium should exist.[9]

1.2.3 Understanding Firm's Sourcing Incentives

In the model with monopolistic competition, firms reduce marginal costs to increase their variable profits, which are directly proportional to their scale. In my model, the firm's scale is not the only determinant of the profitability of sourcing decisions. To better understand what drives firms to add sourcing locations, I calculate a local change in the variable profits of firm i from adding a sourcing location:[10]

$$d\pi_{\mu s}(s*, \alpha E) = -q_i^* \left[1 + \frac{\sigma s_i^*}{1 + \sigma s_i^* - 2 s_i^*}\right] \left[1 - \frac{\delta(s_i^*)}{\delta(s_i^*) + \beta_i^*}\right] \frac{\partial MC_i}{\partial \Theta(\mathcal{J}_i)} d\Theta(\mathcal{J}_i), \tag{1.12}$$

[9]A pure strategy Nash equilibrium in the second stage allows computing first-stage payoffs for any profile of sourcing strategies. If we consider the first stage of the game as a discrete game with a finite number of players and strategies, the existence directly follows from the Nash theorem.

[10]See Appendix 1.4.1 for the full derivation. I also show how to arrive at this expression using a more standard approach by Leahy and Neary (1997), explained in greater detail in Belleflamme and Peitz (2015), Ch. 18.3.

where

$$\delta(s_i^*) = \frac{s_i^*(1-s_i^*)}{1+(\sigma-2)s_i^*}$$
$$\beta_i^* = \sum_{j\in J, j\neq i} \delta(s_j^*) \tag{1.13}$$

Under monopolistic competition, $d\pi_{\mu s}(s*,\alpha E) = -q_i^* \frac{\partial MC_i}{\partial \Theta(\mathcal{J}_i)} d\Theta(\mathcal{J}_i)$. The firm's perceived profitability from adding a new sourcing location only reflects the resulting reduction in its total costs proportional to its optimal output. The observability of firms' sourcing strategies in the second stage affects the perceived profitability of reducing marginal costs in two ways under oligopolistic competition. The first multiplier in (1.12) is larger than 1, the firm's profits are quadratic in market shares and, therefore, grow faster with improvements in relative efficiency. The second multiplier is less than 1, and firms are more cautious in improving relative efficiency, anticipating the resulting upward push to the output aggregator. Re-expressing (1.12), I can decompose the local change in variable profits into the direct and strategic effects:

$$d\pi_{\mu s}(s*,\alpha E) = \left[\underbrace{-q_i^*}_{\text{Direct cost reduction effect}} \underbrace{+q_i^* \frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*} - q_i^* \frac{\sigma s_i^*}{1+(\sigma-2)s_i^*}\left[1-\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\right]}_{\text{Strategic effect}} \right] \frac{\partial MC_i}{\partial \Theta(\mathcal{J}_i)} d\Theta(\mathcal{J}_i) \tag{1.14}$$

The decomposition above is familiar from several papers, studying games with strategic investments (notable examples include Spencer and Brander (1983), D'Aspremont and Jacquemin (1988), Farrell and Shapiro (1990), Leahy and Neary (1997)). The left term inside the brackets implies that cost reduction allows the firm to directly reduce its total costs; by the envelope theorem, profits increase proportionally to the second-stage optimal output. Under monopolistic competition or when firms determine optimal sourcing strategies simultaneously with output, this term completely describes how much they expect to receive from a given change in their marginal costs. Under oligopolistic competition, the firm takes into account that lower marginal costs will reduce the second-stage outputs of competitors. Such considerations generate an additional source of variable profit improvement; the literature calls it a "strategic effect". In general, it is ambiguous whether the sign of the strategic effect is positive or negative. However, I show that, provided that outputs are strategic substitutes across all firms in the sector, the strategic effect and the direct cost reduction effect have the same sign. Therefore, if the outputs are strategic substitutes, firms more aggressively add sourcing locations compared to firms ignoring the strategic effect.

Proposition 1. *Suppose that for any firm j in the sector, $s_j^* \leq \frac{1}{2}$. Then, for all firms*

$$\textit{sign}\{\textit{Direct cost reduction effect}\} = \textit{sign}\{\textit{Strategic effect}\}$$

Proof. See Appendix 1.4.2 □

Intuitively, the direct cost reduction effect is larger in size for a more efficient firm with a larger market share. However, it is not obvious whether a more efficient firm receives more profits from the strategic effect. Although less efficient firms have smaller scale, they have "more to steal" and more elastic demand. Nevertheless, I show that when outputs are strategic substitutes, additional business stealing effects do not result in less efficient firms having a larger willingness to source from additional locations if fixed costs are identical. In the next proposition, I show that the second-stage variable profits of more efficient firms improve by more from an identical change in sourcing capability if outputs are strategic substitutes.

Proposition 2. *Consider firms i and j. Suppose that $\frac{1}{2} \geq s_i^* > s_j^*$. Then, an identical small proportional increase in sourcing capability leads to a larger increase in variable profits for the firm i.*

Proof. See Appendix 1.4.2 □

Under monopolistic competition, Antràs et al. (2017) show that if some conditions are met, sourcing locations become complements for firms, as increasing sourcing capability makes further increases in sourcing capability more attractive. The variable profit function of a monopolistically competitive firm becomes convex in sourcing capability if demand is sufficiently elastic and if intermediate input prices are sufficiently dispersed. In the model of Antràs et al. (2017), a sufficient condition is $\frac{\sigma-1}{\theta} \geq 1$. However, this condition is no longer sufficient in the model with oligopolistic competition and strategic sourcing. The curvature of variable profits with respect to sourcing capability depends on the sign of the expression below:

$$\begin{aligned}&\text{sign}\left\{\frac{\partial^2 \pi_{\mu s}\left(\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right), \alpha E\right)}{\partial \Theta_i^2}\right\} = \\ &\text{sign}\left\{\frac{\sigma-1}{\theta}\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*}\left[g(s_i^*) - \frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\frac{\partial\delta(s_i^*)}{\partial s_i^*} - \left[\frac{\delta(s_i^*)}{\beta_i^*}\right]^2\sum_{j\neq i}\frac{\delta(s_j^*)}{\delta(s_i^*)+\beta_i^*}\frac{\partial\delta(s_j^*)}{\partial s_j^*}\right] - 1\right\},\end{aligned} \tag{1.15}$$

where $g(s_i^*) = \frac{1-2s_i^*}{1+\sigma s_i^*-2s_i^*} + \frac{\sigma\delta(s_i^*)}{(1+\sigma s_i^*-2s_i^*)(1+2\sigma s_i^*-2s_i^*)}$. As $s_i^* \to 0$, the value of (1.15) converges to $\frac{\sigma-1}{\theta} - 1$. If $\frac{\sigma-1}{\theta} - 1 < 0$, locations cannot be complements under oligopolistic competition. If $\frac{\sigma-1}{\theta} - 1 \geq 0$, depending on the values of σ and θ, either the locations are not complements for any firm, or the locations are complements for a subset of firms in the sector.

1.2.4 Sourcing Decisions and Welfare

The assumption of quasi-linear preferences allows using the sum of changes in consumer surplus (dCS) and total profits as a change in welfare (dW). In the following, I use the sectoral measure of consumer surplus from Breinlich et al. (2023): $CS = \alpha E\left[\frac{\sigma}{\sigma-1}\log\mathcal{H}^* - 1\right]$. Holding total consumer expenditure fixed, the change in consumer surplus equals $\alpha E\frac{\sigma}{\sigma-1}d\log\mathcal{H}^* = \alpha E\frac{1}{\sigma-1}d\log\left[\sum_j a_j p_j^{*1-\sigma}\right]$. I decompose the change in consumer surplus from changes in the vector of sourcing capabilities into two components(I use lower-script a to denote variables after the change and the lower-script b to denote variables before the change):

$$dCS = \alpha E\frac{1}{\sigma-1}\left[\log\left[\sum_j a_j p_{ja}^{*1-\sigma}\right] - \log\left[\sum_j a_j p_{jb}^{*1-\sigma}\right]\right] =$$

$$= \alpha E\frac{1}{\sigma-1}\left[\underbrace{\log\left[\sum_j a_j MC_{ja}^{1-\sigma}(1-s_{jb}^*)^{\sigma-1}\right] - \log\left[\sum_j a_j MC_{jb}^{1-\sigma}(1-s_{jb}^*)^{\sigma-1}\right]}_{\text{Change in marginal costs}} + \right. \tag{1.16}$$

$$\left. + \underbrace{\log\left[\sum_j a_j MC_{ja}^{1-\sigma}(1-s_{ja}^*)^{\sigma-1}\right] - \log\left[\sum_j a_j MC_{ja}^{1-\sigma}(1-s_{jb}^*)^{\sigma-1}\right]}_{\text{Markup adjustment}}\right]$$

The first component in (1.16) captures the direct effect of cost changes on the welfare of consumers, holding markups fixed (in the following, I denote it as dCS_CR); the second component captures the changes in consumer surplus from changes in markups (in the following, I denote it as dCS_MA) if I fix marginal costs at the post-liberalization level. In essence, the first component captures the change in consumer welfare from changes in marginal costs had the pass-through been complete (as market shares and markups remain at the level before the cost changes). The second component captures the net change in consumer surplus from the readjustment of firms' market shares and markups to the second-stage Nash equilibrium, given the updated marginal costs. Suppose that firm i starts sourcing from location l. The second effect captures an increase in the markup of i and declines in the markups of the other firms, leading to rather ambiguous effects on consumer surplus (note that in this case dCS_CR is weakly positive if no firm drops any location). dCS_MA contributes positively to consumer surplus if $\sum_j MC_{ja}^{1-\sigma}((1-s_{ja}^*)^{\sigma-1} - (1-s_{jb}^*)^{\sigma-1}) \geq 0$. $(1-s)^{\sigma-1}$ declines in s and is convex if $\sigma \geq 2$. At the same time, $MC^{1-\sigma}$ declines in MC. Therefore, an increase in market share by a more efficient firm and the resulting declines in market shares by less efficient firms often lead to a decline in dCS_MA. Reallocation of market shares towards more efficient firms strengthens output distortions, as consumers spend more on products with greater markups. At the same time, reallocation of market shares towards less efficient firms reduces markups of more efficient firms and benefits consumers spending more on the products of the latter. Nonetheless, when some firms in the sector reduce their marginal costs while others do not, the total effect on the welfare of consumers is necessarily positive.

Total profits, taking into account fixed costs of sourcing, are equal to the term below:

$$\left[\sum_j \mu(s_j^*)s_j^*\right]\alpha E - \sum_{j\in J}\sum_{l\in \mathcal{J}_j} f_{jl} = \left[\frac{1}{\sigma} + \frac{\sigma-1}{\sigma}HHI^*\right]\alpha E - \sum_{j\in J}\sum_{l\in \mathcal{J}_j} f_{jl}, \tag{1.17}$$

where HHI^* is the equilibrium Herfindahl–Hirschman market concentration index. Keeping consumer expenditure on sectoral goods (αE) fixed, total profits change with changes in total second-stage variable profits (dVP) and changes in fixed costs paid (dFC). Equation (1.17) shows that variable profits comove with HHI^*; any change increasing concentration increases total variable profits as well. To examine, when changes in marginal costs increase or decrease HHI^*, I calculate a local change in HHI^*, resulting from a small increase in sourcing capability by firm i:

$$dHHI^* = 2\frac{\sigma-1}{\theta}\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\left(\sum_{j\in\mathcal{J},j\neq i}\delta(s_j^*)(s_i^*-s_j^*)\right)\frac{d\Theta_i(\mathcal{J}_i)}{\Theta_i(\mathcal{J}_i)} \tag{1.18}$$

(1.18) shows that a change in $\Theta_i(\mathcal{J}_i)$ can either increase or reduce market concentration. If firm i is the most efficient, all components in $\sum_{j\in\mathcal{J},j\neq i}\delta(s_j^*)(s_i^*-s_j^*)$ are positive, the total variable profits increase due to the reallocation of market shares towards the most efficient firm. If firm i is not the most efficient, some components in the sum become negative and the level of concentration and total variable profits might fall as a result.

Above I show that under oligopolistic competition, input trade liberalization leads to nontrivial aggregate surplus effects, which depend on the size of the firm changing marginal costs. When fixed costs are different, if a more efficient firm reduces its marginal costs, welfare will not necessarily improve by more. However, I show that a similar proportional change in sourcing capability by a more efficient firm leads to a larger increase in consumer surplus and total second-stage variable profits, provided that outputs are strategic substitutes and products are not very close substitutes within sectors. Fixed cost subsidies targeting more efficient firms or uniform increases in fixed costs might increase societal gains from input trade liberalization by preventing less efficient firms from using foreign inputs if this discourages sourcing by more efficient firms.

Proposition 3. *Consider two firms i and j. Suppose that $\frac{1}{2} \geq s_i^* > s_j^*$ and $\sigma \in (1, 9.689)$. Then,* *an identical costless small proportional increase in sourcing capability by firm i leads to a larger increase in aggregate surplus.*

Proof. See Appendix 1.4.2 □

Even if input trade liberalization improves welfare, policymakers might refuse to cut input tariffs if such a policy results in net job destruction. Autor et al. (2013) show that the accession of China into the WTO resulted in job losses and reduced labor force participation in the US commuting zones, which were more exposed to import competition from China. Antràs et al. (2017) show that the China shock resulted in the net job destruction, since the increase in employment due to a higher wage bill by the US suppliers of importing firms and larger fixed costs paid did not offset layoffs by suppliers of exiting and not importing firms. Antràs et al. (2017) show that under monopolistic competition, when $\frac{\sigma-1}{\theta} \geq 1$, keeping the price index fixed, when a firm adds a sourcing location to its sourcing strategy, its expenditures on domestic intermediate inputs increase, increasing the wage bill and labor demand among its domestic suppliers. Under oligopolistic competition, even if the values of parameters satisfy $\frac{\sigma-1}{\theta} \geq 1$, unless the firm is very inefficient, expanding its sourcing geography might lead to job destruction among the firm's domestic suppliers. Such job destruction does not occur if the rise in $\Theta(\mathcal{J}_i)$ increases TC_{ih}, where by TC_{ih} I denote the total expenditures on domestic material inputs by firm i. Differentiating TC_{ih} with respect to $\Theta(\mathcal{J}_i)$, I find that

$$\text{sign}\left\{\frac{\partial TC_{ih}}{\partial\Theta(\mathcal{J}_i)}\right\} = \text{sign}\left\{\frac{\sigma-1}{\theta}\frac{1-2s_i^*}{1+(\sigma-2)s_i^*}\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*} - 1\right\} \tag{1.19}$$

Notice that, as in (1.15), the value of the expression in (1.19) converges to $\frac{\sigma-1}{\theta} - 1$ for a firm with a market share approaching 0. Therefore, if $\frac{\sigma-1}{\theta} \geq 1$, a small increase in the sourcing capability of a very inefficient firm might create new domestic jobs upstream. However, if the firm has a large enough market share, this firm replaces domestic inputs it used before with foreign intermediate inputs, depressing the wage bill for domestic upstream firms. Therefore, under oligopolistic competition, policymakers should also consider potential job destruction by domestic suppliers of firms, who source inputs from new locations in response to input tariff cuts.

1.3 Conclusions

In this work, I modify the model in Antràs et al. (2017) by introducing oligopolistic competition in product markets and strategic sourcing. In this model, if outputs are strategic substitutes, the firms have incentives to manipulate output decisions of competitors through sourcing inputs from other countries. Despite additional strategic incentives, firms' behavior is not too different from the one we observe under monopolistic competition. A more efficient firm still benefits more from a costless opportunity to start sourcing inputs from a new location compared to a less efficient firm. Under some parametric restrictions, welfare improves by more if a more efficient firm enjoys such an opportunity. Oligopolistic competition and strategic sourcing introduce several additional margins into the analysis of the welfare effects of input trade liberalization. In Chapter 2, we explore these margins with application to the analysis of the effects of the accession of Ukraine into the WTO on consumers and producers in the Ukrainian food-processing sectors.

1.4 Appendix

1.4.1 Derivation of Marginal Variable Profits from Sourcing

In this section, I use approach of Nocke and Schutz (2018a) to derive (1.12). I start by applying the chain rule:

$$d\pi_{\mu s}\left(\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right),\alpha E\right)=\frac{\partial \pi_{\mu s}\left(\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right),\alpha E\right)}{\partial \mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right)}\frac{\partial \mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right)}{\partial \frac{T_i}{\mathcal{H}^*}}\frac{\partial \frac{T_i}{\mathcal{H}^*}}{\partial T_i}\frac{\partial T_i}{\partial MC_i}\frac{\partial MC_i}{\partial \Theta(\mathcal{J}_i)}d\Theta(\mathcal{J}_i) \tag{1.20}$$

I compute the terms in (1.20) using an implicit differentiation from Nocke and Schutz (2018a):

$$\begin{aligned}
\frac{\partial \mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right)}{\partial \frac{T_i}{\mathcal{H}^*}} &= \sigma\delta(s_i^*)\frac{\mathcal{H}^*}{T_i}\\
\frac{d\mathcal{H}^*}{dT_i} = \frac{\frac{\partial \mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right)}{\partial \frac{T_i}{\mathcal{H}^*}}}{\sum_{j\in J}\frac{\partial \mathcal{S}\left(\frac{T_j}{\mathcal{H}^*}\right)}{\partial \frac{T_j}{\mathcal{H}^*}}\frac{T_j}{\mathcal{H}^*}} &= \frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\frac{\mathcal{H}^*}{T_i}\\
\frac{\partial \frac{T_i}{\mathcal{H}^*}}{\partial T_i}\mathcal{H}^* &= \frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*}
\end{aligned} \tag{1.21}$$

Plugging these terms into expression and simplifying, I obtain:[11]

$$\begin{aligned}
d\pi_{\mu s}(s*,\alpha E) &= (1+2(\sigma-1)s_i^*)\delta(s_i^*)\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*}\frac{\sigma-1}{\sigma\theta}\frac{\alpha E}{\Theta(\mathcal{J}_i)}d\Theta(\mathcal{J}_i)=\\
&= -q_i^*\left[1+\frac{\sigma s_i^*}{1+\sigma s_i^*-2s_i^*}\right]\left[1-\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\right]\frac{\partial MC_i}{\partial \Theta(\mathcal{J}_i)}d\Theta(\mathcal{J}_i)
\end{aligned} \tag{1.22}$$

It might be helpful to decompose expression in (1.22) into direct and strategic effect, as in Leahy and Neary (1997). To do that, I define $\pi_i = q_i(p_i - MC_i)$,[12] $q\left(\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right),\alpha E, MC_i\right) = \frac{\sigma-1}{\sigma}\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right)\left(1-\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right)\right)\frac{\alpha E}{MC_i}$. Below I decompose the change in π_i from a small change in MC_i

[11] Here I use $s_i^*(1-s_i^*) = s_i^{*\frac{\sigma}{\sigma-1}}\mathcal{H}^{*\frac{\sigma}{\sigma-1}}T_i^{\frac{\sigma}{1-\sigma}} = \frac{\sigma}{\sigma-1}\frac{q_i^* MC_i}{\alpha E}$ as well as $\frac{\partial MC_i}{\partial\Theta(\mathcal{J}_i)} = -\frac{1}{\theta}\frac{MC_i}{\Theta(\mathcal{J}_i)}$

[12] Observe that neither q_i nor p_i are required to be consistent with the second stage Nash equilibrium

into direct effect, own output effect, and strategic effect:

$$\begin{aligned}
\frac{\partial \pi_i^*}{\partial MC_i} &= -q_i^* + \frac{\partial \pi_i}{\partial q_i}\frac{\partial q\left(\mathcal{S}\left(\frac{T_i}{\mathcal{H}^*}\right), \alpha E, MC_i\right)}{\partial MC_i} + \sum_{j\in J, j\neq i}\frac{\partial \pi_i}{\partial q_j}\frac{\partial q\left(\mathcal{S}\left(\frac{T_j}{\mathcal{H}^*}\right), \alpha E, MC_j\right)}{\partial MC_i} \\
\frac{\partial \pi_i}{\partial q_j} &= -\frac{\sigma-1}{\sigma}\frac{s_j p_i q_i}{q_j} \\
\frac{\partial q\left(\mathcal{S}\left(\frac{T_j}{\mathcal{H}^*}\right), \alpha E, MC_j\right)}{\partial MC_i} &= \frac{\partial q\left(\mathcal{S}\left(\frac{T_j}{\mathcal{H}^*}\right), \alpha E, MC_j\right)}{\partial \mathcal{S}\left(\frac{T_j}{\mathcal{H}^*}\right)}\frac{\partial \mathcal{S}\left(\frac{T_j}{\mathcal{H}^*}\right)}{\partial \frac{T_i}{\mathcal{H}^*}}\frac{\partial \frac{T_j}{\mathcal{H}^*}}{\partial \mathcal{H}^*}\frac{\partial \mathcal{H}^*}{\partial T_i}\frac{\partial T_i}{\partial MC_i} = \\
&= \frac{(1-2s_j^*)}{MC_j}(\sigma-1)\frac{\sigma-1}{\sigma}\frac{\alpha E}{MC_i}\frac{\delta(s_i^*)\delta(s_j^*)}{\delta(s_i^*)+\beta_i^*}
\end{aligned} \tag{1.23}$$

Now I evaluate $\frac{\partial \pi_i}{\partial MC_i}$ around the second stage Nash equilibrium before changes in marginal costs. Clearly, $\frac{\partial \pi_i}{\partial q_i} = 0$. When I plug-in the terms derived above and regroup, I obtain the expression below:

$$\begin{aligned}
\frac{\partial \pi_i^*}{\partial MC_i} &= -q_i^* + \sum_{j\in J, j\neq i}\left[-\frac{\sigma-1}{\sigma}\right]\frac{s_j^* p_i^* q_i^*}{q_j^*}\frac{(1-2s_j^*)}{MC_j}(\sigma-1)\frac{\sigma-1}{\sigma}\frac{\alpha E}{MC_i}\frac{\delta(s_i^*)\delta(s_j^*)}{\delta(s_i^*)+\beta_i^*} = \\
&= -q_i^* + \sum_{j\in J, j\neq i}\left[-\frac{\sigma-1}{\sigma}(\sigma-1)\right]\frac{\delta(s_i^*)p_i^*}{MC_i}\frac{s_j^*\frac{\sigma-1}{\sigma}\alpha E}{q_j^* MC_j}q_i^*(1-2s_j^*)\frac{\delta(s_j^*)}{\delta(s_i^*)+\beta_i^*} = \\
&= -q_i^* + \sum_{j\in J, j\neq i}[1-\sigma]\frac{s_i^*}{1+(\sigma-2)s_i^*}\frac{1}{1-s_j^*}q_i^*(1-2s_j^*)\frac{\delta(s_j^*)}{\delta(s_i^*)+\beta_i^*} = \\
&= -q_i^* + [1-\sigma]\,q_i^*\frac{s_i^*}{1+(\sigma-2)s_i^*}\sum_{j\in J, j\neq i}\left[\frac{1+(\sigma-2)s_j^*}{1-s_j^*}\frac{\delta(s_j^*)}{\delta(s_i^*)+\beta_i^*} - \frac{\sigma s_j^*}{1-s_j^*}\frac{\delta(s_j^*)}{\delta(s_i^*)+\beta_i^*}\right] = \\
&= -q_i^* + [1-\sigma]\,q_i^*\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*} - [1-\sigma]\,q_i^*\frac{s_i^*}{1+(\sigma-2)s_i^*}\sum_{j\in J, j\neq i}\frac{\sigma s_j^*}{1-s_j^*}\frac{\delta(s_j^*)}{\delta(s_i^*)+\beta_i^*} = \\
&= -q_i^* + q_i^*\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*} + q_i^*\frac{\sigma s_i^*}{1+(\sigma-2)s_i^*}\sum_{j\in J, j\neq i}\frac{-s_j^* + [\sigma-1]\frac{s_j^{*2}}{1+(\sigma-2)s_j^*}}{\delta(s_i^*)+\beta_i^*} = \\
&= \underbrace{-q_i^*}_{\text{Direct effect}} \underbrace{+\,q_i^*\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*} - q_i^*\frac{\sigma s_i^*}{1+(\sigma-2)s_i^*}\left[1-\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\right]}_{\text{Strategic effect}}
\end{aligned} \tag{1.24}$$

1.4.2 Technical Proofs

Lemma 1. *Suppose, for any firm j in the sector, $s_j \leq \frac{1}{2}$. Then, outputs are strategic substitutes across all firms.*

Proof. First of all, I derive the marginal revenue of the firm:

$$MR_i = p_i + \frac{\partial p_i}{\partial q_i} q_i \tag{1.25}$$

Next, I implicitly differentiate firm's first order condition for profit maximization to compute change in q_i resulting from a small change in q_j for some $j \neq i$. Given the assumption of constant marginal costs, $dq_i = -\frac{\frac{\partial MR_i}{\partial q_j}}{\frac{\partial MR_i}{\partial q_i}} dq_j$. Since MR_i declines in q_i, in order for outputs to be strategic substitutes, I require $\frac{\partial MR_i}{\partial q_j} \leq 0$ for all $j \neq i$. Below I show that this condition requires $s_i \leq \frac{1}{2}$:

$$\begin{aligned}
\frac{\partial MR_i}{\partial q_j} &= \frac{\partial p_i}{\partial q_j} + \frac{\partial^2 p_i}{\partial q_i \partial q_j} q_i + \frac{\partial p_i}{\partial q_i} \underbrace{\frac{\partial q_i}{\partial q_j}}_{=0} = \\
&= -\frac{\sigma - 1}{\sigma} \frac{p_i s_j}{q_j} + p_i \left[\frac{\sigma - 1}{\sigma} \frac{1}{\sigma} \frac{s_j}{q_j} + 2 \left[\frac{\sigma - 1}{\sigma} \right]^2 \frac{s_i s_j}{q_j} \right] = \\
&= \frac{\sigma - 1}{\sigma} \frac{p_i s_j}{q_j} (2 s_i - 1)
\end{aligned} \tag{1.26}$$

Clearly, $\frac{\partial MR_i}{\partial q_j} \leq 0$ if $s_i \leq \frac{1}{2}$. This completes the proof. □

Proposition 1. *Suppose that for any firm j in the sector, $s_j^* \leq \frac{1}{2}$. Then, for all firms*

$$sign\{\text{Direct cost reduction effect}\} = sign\{\text{Strategic effect}\}$$

Proof. To prove the claim, it suffices to show that

$$\frac{\delta(s_i^*)}{\delta(s_i^*) + \beta_i^*} - \frac{\sigma s_i^*}{1 + \sigma s_i^* - 2 s_i^*} + \frac{\delta(s_i^*)}{\delta(s_i^*) + \beta_i^*} \frac{\sigma s_i^*}{1 + \sigma s_i^* - 2 s_i^*} \leq 0 \tag{1.27}$$

Observe that

$$\begin{aligned}
\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*} - \frac{\sigma s_i^*}{1+\sigma s_i^* - 2s_i^*} + \frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\frac{\sigma s_i^*}{1+\sigma s_i^* - 2s_i^*} = \\
= \frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*} - \frac{\beta_i}{\delta(s_i^*)+\beta_i^*}\frac{\sigma s_i^*}{1+\sigma s_i^* - 2s_i^*} = \\
= \frac{1}{\delta(s_i^*)+\beta_i^*}\frac{s_i^*}{1+\sigma s_i^* - 2s_i^*}(1-s_i^*-\sigma\beta_i^*) = \\
= \frac{1}{\delta(s_i^*)+\beta_i^*}\frac{s_i^*}{1+\sigma s_i^* - 2s_i^*}\sum_{j\neq i}\left(s_j^* - \frac{\sigma s_j^*(1-s_j^*)}{1+\sigma s_j^* - 2s_j^*}\right) = \\
= \frac{1}{\delta(s_i^*)+\beta_i^*}\frac{s_i^*}{1+\sigma s_i^* - 2s_i^*}\sum_{j\neq i} s_j^*\frac{1-\sigma+2s_j^*(\sigma-1)}{1+\sigma s_j^* - 2s_j^*} = \\
= \frac{1}{\delta(s_i^*)+\beta_i^*}\frac{(\sigma-1)s_i^*}{1+\sigma s_i^* - 2s_i^*}\sum_{j\neq i} s_j^*\frac{2s_j^*-1}{1+\sigma s_j^* - 2s_j^*}
\end{aligned} \tag{1.28}$$

Clearly, if for every $j \neq i, s_j^* \leq \frac{1}{2}$, the sign of (1.27) is negative. This completes the proof. □

Lemma 2. *Consider the function*

$$\delta(s) = \frac{s(1-s)}{1+(\sigma-2)s}$$

This function is concave on $s \in (0,1)$ and attains a global maximum at $s_m = \frac{1}{1+\sqrt{\sigma-1}}$. $\delta(s_m) = \frac{1}{(1+\sqrt{\sigma-1})^2}$

Proof. First of all, observe that

$$\frac{\partial\delta(s)}{\partial s} = \frac{1-2s-(\sigma-2)\delta(s)}{1+(\sigma-2)s} \tag{1.29}$$

The second derivative is equal to

$$\frac{\partial^2\delta(s)}{\partial s^2} = -\frac{2(\sigma-1)}{(1+(\sigma-2)s)^3} \tag{1.30}$$

Note that $\frac{\partial^2\delta(s)}{\partial s^2} < 0$ at $s \in (0,1)$, thus, the $\delta(s)$ is concave and attains a global maximum on this interval. Denoting the maximizer of $\delta(s)$ as s_m, I can find it by solving $\frac{\partial\delta(s)}{\partial s} = 0$ or $1-2s_m = (\sigma-2)\delta(s_m)$. Multiplying both sides by $1+(\sigma-2)s_m$ and simplifying, I find that the equation's root satisfies:

$$1-2s_m = (\sigma-2)s_m^2 \tag{1.31}$$

By adding s_m^2 to both sides of the equation, I obtain the expression below:

$$(1-s_m)^2 = (\sigma-1)s_m^2 \tag{1.32}$$

The positive root of this equation is $s_m = \frac{1}{1+\sqrt{\sigma-1}}$. Since $1-2s_m = (\sigma-2)\delta(s_m) = (\sigma-2)s_m^2$, $\delta(s_m) = s_m^2 = \frac{1}{(1+\sqrt{\sigma-1})^2}$. This completes the proof. □

Proposition 2. *Consider firms i and j. Suppose that $\frac{1}{2} \geq s_i^* > s_j^*$. Then, an identical small proportional increase in sourcing capability leads to a larger increase in variable profits for the firm i.*

Proof. First of all, I rewrite the term from (1.12) for firm i in the following way:

$$d\pi_{\mu s}(s*, \alpha E) \approx (1+2(\sigma-1)s_i^*)\delta(s_i^*)\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*}\frac{\sigma-1}{\sigma\theta}\frac{d\Theta(\mathcal{J}_i)}{\Theta(\mathcal{J}_i)} \tag{1.33}$$

Showing that $(1+2(\sigma-1)s_i^*)\delta(s_i^*)\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*} - (1+2(\sigma-1)s_j^*)\delta(s_j^*)\frac{\beta_j^*}{\delta(s_j^*)+\beta_j^*} > 0$ suffices to prove the claim. Observe that

$$\begin{aligned}
&(1+2(\sigma-1)s_i^*)\delta(s_i^*)\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*} - (1+2(\sigma-1)s_j^*)\delta(s_j^*)\frac{\beta_j^*}{\delta(s_j^*)+\beta_j^*} = \\
&= (1+2(\sigma-1)s_i^*)\delta(s_i^*)\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*} - (1+2(\sigma-1)s_j^*)\delta(s_i^*)\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*} + \\
&+ (1+2(\sigma-1)s_j^*)\delta(s_i^*)\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*} - (1+2(\sigma-1)s_j^*)\delta(s_j^*)\frac{\beta_j^*}{\delta(s_j^*)+\beta_j^*} = \\
&= \frac{1}{\delta(s_i^*)+\beta_i^*}\Big(2(\sigma-1)\delta(s_i^*)\beta_i^*(s_i^*-s_j^*) + (1+2(\sigma-1)s_j^*)(\delta(s_i^*)\beta_i^* - \delta(s_j^*)\beta_j^*)\Big) = \\
&= \frac{1}{\delta(s_i^*)+\beta_i^*}\left(2(\sigma-1)\delta(s_i^*)\beta_i^*(s_i^*-s_j^*) + (1+2(\sigma-1)s_j^*)(\delta(s_i^*)-\delta(s_j^*))\sum_{l\neq i,j}\delta(s_l^*)\right)
\end{aligned} \tag{1.34}$$

According to Lemma 2, depending on the value of σ, I might have 3 cases. If $\sigma \in (1;2)$, $\delta(s)$ increases in s for $s \leq \frac{1}{2}$, in this case, it is clear that the claim is satisfied, as $\delta(s_i^*) - \delta(s_j^*) > 0$ if $s_i^* > s_j^*$. If $\sigma > 2$, then I might either have $\delta(s_i^*) - \delta(s_j^*) > 0$ or $\delta(s_i^*) - \delta(s_j^*) \leq 0$. The claim is satisfied in the former case; to complete the proof, it suffices to show that in the latter case, I still have $(1+2(\sigma-1)s_i^*)\delta(s_i^*)\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*} - (1+2(\sigma-1)s_j^*)\delta(s_j^*)\frac{\beta_j^*}{\delta(s_j^*)+\beta_j^*} > 0$.

Suppose that $\delta(s_i^*) - \delta(s_j^*) \le 0$. Then, as $\beta_i^* = \sum_{l \ne i,j} \delta(s_l^*) + \delta(s_j^*)$

$$\begin{aligned}
2(\sigma-1)\delta(s_i^*)\beta_i^*(s_i^* - s_j^*) + (1+2(\sigma-1)s_j^*)(\delta(s_i^*) - \delta(s_j^*)) \sum_{l \ne i,j} \delta(s_l^*) \ge \\
\ge 2(\sigma-1)\delta(s_i^*)\beta_i^*(s_i^* - s_j^*) + (1+2(\sigma-1)s_j^*)(\delta(s_i^*) - \delta(s_j^*))\beta_i^* = \\
= \beta_i^*(2(\sigma-1)\delta(s_i^*)(s_i^* - s_j^*) + (1+2(\sigma-1)s_j^*)(\delta(s_i^*) - \delta(s_j^*))) = \\
= \beta_i^*(\delta(s_i^*) - \delta(s_j^*) + 2(\sigma-1)\delta(s_i^*)s_i^* - 2(\sigma-1)\delta(s_j^*)s_j^*) = \\
= \beta_i^*(\delta(s_i^*)(1+2(\sigma-1)s_i^*) - \delta(s_j^*)(1+2(\sigma-1)s_j^*)) = \\
= \beta_i^*(s_i^*(1-s_i^*) - s_j^*(1-s_j^*) + \sigma s_i^* \delta(s_i^*) - \sigma s_j^* \delta(s_j^*)) > 0
\end{aligned} \tag{1.35}$$

The last step follows from the fact that $s_i^*(1-s_i^*) > s_j^*(1-s_j^*)$ as long as $\frac{1}{2} \ge s_i^* > s_j^*$, $\sigma s_i^* \delta(s_i^*) - \sigma s_j^* \delta(s_j^*) > 0$, as $\sigma s \delta(s) = s(1-s)\frac{\sigma s}{1-2s+\sigma s}$ is a product of two positive and increasing functions of s as long as $\frac{1}{2} \ge s_i^* > s_j^*$. This completes the proof. □

Lemma 3. *If* $\sigma \in (1, 9.689)$, $\frac{\sigma}{\sigma-1} - 2(\sigma-1)\sum_{l \in J} \delta(s_l^*) s_l^* \ge 0$

Proof. Notice that, by lemma 1, $\forall l \in J$, $\delta(s_l^*) \le \delta(s_m) = \frac{1}{(1+\sqrt{\sigma-1})^2}$. Therefore,

$$\begin{aligned}
\frac{\sigma}{\sigma-1} - 2(\sigma-1)\sum_{l \in J}\delta(s_l^*)s_l^* \ge \frac{\sigma}{\sigma-1} - 2(\sigma-1)\sum_{l \in J}\frac{s_l^*}{(1+\sqrt{\sigma-1})^2} = \\
= \frac{\sigma}{\sigma-1} - \frac{2(\sigma-1)}{(1+\sqrt{\sigma-1})^2}\sum_{l \in J} s_l^* = \\
= \frac{\sigma}{\sigma-1} - \frac{2(\sigma-1)}{(1+\sqrt{\sigma-1})^2} = \\
= \frac{2\sigma\sqrt{\sigma-1} - \sigma^2 + 4\sigma - 2}{(\sigma-1)(1+\sqrt{\sigma-1})^2}
\end{aligned} \tag{1.36}$$

Expression in (1.36) is positive if $2\sigma\sqrt{\sigma-1} - \sigma^2 + 4\sigma - 2 \ge 0$. Define $b(\sigma) = 2\sigma\sqrt{\sigma-1} - \sigma^2 + 4\sigma - 2 = 2\sigma\sqrt{\sigma-1} - (\sigma-2)^2 + 2$. If $\sigma \in (1,2]$, $(\sigma-2)^2 \in [0,1)$, therefore, $b(\sigma) > 0$. If $\sigma > 2$, observe that

$$\begin{aligned}
\frac{\partial b(\sigma)}{\partial \sigma} &= -2\sigma + 2\sqrt{\sigma-1} + \frac{\sigma}{\sqrt{\sigma-1}} + 4 \\
\frac{\partial^2 b(\sigma)}{\partial \sigma^2} &= -2 + \frac{2}{\sqrt{\sigma-1}} - \frac{\sigma}{2\sqrt{\sigma-1}(\sigma-1)}
\end{aligned} \tag{1.37}$$

Clearly, $\frac{\partial^2 b(\sigma)}{\partial \sigma^2} < 0$ if $\sigma > 2$. $b(\sigma)$ is concave for $\sigma > 2$. Observe that $\lim \frac{\partial b(\sigma)}{\partial \sigma}_{\sigma \to 2} = 4$, $\left.\frac{\partial b(\sigma)}{\partial \sigma}\right|_{\sigma=20} \approx -22.69388744$. By the concavity of $b(\sigma)$ and continuity of $\frac{\partial b(\sigma)}{\partial \sigma}$, the intermediate value theorem shows that $\frac{\partial b(\sigma)}{\partial\sigma}$ crosses 0 at a single point between $\sigma \in [2,20]$.[13] Applying bisection root-finding method, I find that this happens at $\sigma \approx 5.377273$. If $\sigma \in (2, 5.377273]$, $b(\sigma)$ increases in σ, it attains the lowest value at $\sigma \to 2$, $\lim_{\sigma\to 2} b(\sigma) = 6 > 0$. Therefore, $b(\sigma) > 0$ if $\sigma \in (2, 5.377276]$. If $\sigma \in (5.377276, 20]$, $b(\sigma)$ declines in σ and attains the lowest value at $\sigma = 20$, $b(\sigma)|_{\sigma=20} \approx -147.644$.[14] Since $\max b(\sigma) > 0$, continuity of $b(\sigma)$ and $\frac{\partial b(\sigma)}{\partial\sigma} < 0$ for $\sigma > 5.377276$ imply that, by the intermediate value theorem, $b(\sigma)$ should cross 0 at a unique point for $\sigma \in [5.377276, 20]$. Using the bisection root-finding method, I find that this happens at $\sigma \approx 9.689$. Therefore, $b(\sigma) > 0$ if $\sigma \in (5.377276, 9.689)$. To sum up, expression in (1.36) is positive if $\sigma \in (1; 9.689)$ by positivity of $b(\sigma)$, which completes the proof. □

Proposition 3. *Consider two firms i and j. Suppose that $\frac{1}{2} \geq s_i^* > s_j^*$ and $\sigma \in (1, 9.689)$. Then, an identical costless small proportional increase in sourcing capability by firm i leads to a larger increase in aggregate surplus.*

Proof. I begin by writing aggregate surplus as the sum of consumer surplus and total profits:

$$AS = \alpha E\left[\frac{\sigma}{\sigma-1} log\mathcal{H}^* + \frac{\sigma-1}{\sigma}\sum_{j\in J} s_j^{*2} - \frac{\sigma-1}{\sigma}\right] - \sum_{j\in J}\sum_{l\in\mathcal{J}_j} f_{jl} \tag{1.38}$$

Now, suppose I allow both firms to costlessly change their sourcing capability by a small $\frac{d\Theta(\mathcal{J}_i)}{\Theta(\mathcal{J}_i)}$. Change by firm i results in the following change in AS:

$$\begin{aligned}
dAS &= \alpha E\left[\frac{\sigma}{\sigma-1}\frac{1}{\mathcal{H}^*}\frac{\partial\mathcal{H}^*}{\partial T_i} + 2\frac{\sigma-1}{\sigma}\left(s_i^*\frac{\partial S\left(\frac{T_i}{\mathcal{H}^*}\right)}{\partial\frac{T_i}{\mathcal{H}^*}}\frac{\partial\frac{T_i}{\mathcal{H}^*}}{\partial T_i} + \sum_{j\in J, j\neq i} s_j^*\frac{\partial S\left(\frac{T_j}{\mathcal{H}^*}\right)}{\partial\frac{T_j}{\mathcal{H}^*}}\frac{\partial\frac{T_j}{\mathcal{H}^*}}{\partial\mathcal{H}^*}\frac{\partial\mathcal{H}^*}{\partial T_i}\right)\right]\frac{\partial T_i}{\partial\Theta(\mathcal{J}_i)}d\Theta(\mathcal{J}_i) = \\
&= \alpha E\left[\frac{\sigma}{\sigma-1}\frac{1}{\mathcal{H}^*}\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\frac{\mathcal{H}^*}{T_i} + 2\frac{\sigma-1}{\sigma}\left(s_i^*\sigma\delta(s_i^*)\frac{\mathcal{H}^*}{T_i}\frac{\beta_i^*}{\delta(s_i^*)+\beta_i^*}\frac{1}{\mathcal{H}^*} + \right.\right. \\
&\quad \left.\left. + \sum_{j\in J, j\neq i} s_j^*\sigma\delta(s_j^*)\frac{\mathcal{H}^*}{T_j}\left[-\frac{T_j}{\mathcal{H}^{*2}}\right]\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\frac{\mathcal{H}^*}{T_i}\right)\right]\frac{(\sigma-1)}{\sigma\theta}\frac{T_i}{\Theta(\mathcal{J}_i)}d\Theta(\mathcal{J}_i) = \\
&= \alpha E\frac{d\Theta(\mathcal{J}_i)}{\Theta(\mathcal{J}_i)}\frac{(\sigma-1)}{\sigma\theta}\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\left[\frac{\sigma}{\sigma-1} + 2(\sigma-1)s_i^*\beta_i^* - 2(\sigma-1)\sum_{j\in J, j\neq i} s_j^*\delta(s_j^*)\right] = \\
&= \alpha E\frac{d\Theta(\mathcal{J}_i)}{\Theta(\mathcal{J}_i)}\frac{(\sigma-1)}{\sigma\theta}\frac{\delta(s_i^*)}{\delta(s_i^*)+\beta_i^*}\left[\frac{\sigma}{\sigma-1} + 2(\sigma-1)\sum_{j\in J, j\neq i}(s_i^* - s_j^*)\delta(s_j^*)\right]
\end{aligned} \tag{1.39}$$

[13]Note that concavity of $b(\sigma)$ for $\sigma > 2$ implies $\frac{\partial b(\sigma)}{\partial\sigma} < 0$ for $\sigma > 20$

[14]Note that since $b(\sigma)$ is concave in σ if $\sigma > 2$ and $\frac{\partial b(\sigma)}{\partial\sigma} < 0$ for $\sigma > 5.377276$, $b(\sigma) < 0$ for $\sigma > 20$

To complete the proof, it suffices to show that

$$\delta(s_i^*)\left[\frac{\sigma}{\sigma-1}+2(\sigma-1)\sum_{j\in J,j\neq i}(s_i^*-s_j^*)\delta(s_j^*)\right]-\delta(s_j^*)\left[\frac{\sigma}{\sigma-1}+2(\sigma-1)\sum_{l\in J,l\neq j}(s_j^*-s_l^*)\delta(s_l^*)\right]>0 \tag{1.40}$$

Now consider 2 cases:

- **Case 1**: $\delta(s_i^*)\geq\delta(s_j^*)$

I can decompose the term in (1.40) in the following way:

$$\begin{aligned}
&\frac{\sigma}{\sigma-1}(\delta(s_i^*)-\delta(s_j^*))+2(\sigma-1)\delta(s_i^*)\left[\sum_{j\in J,j\neq i}(s_i^*-s_j^*)\delta(s_j^*)\right]-2(\sigma-1)\delta(s_j^*)\left[\sum_{l\in J,l\neq j}(s_j^*-s_l^*)\delta(s_l^*)\right]=\\
&=\frac{\sigma}{\sigma-1}(\delta(s_i^*)-\delta(s_j^*))+2(\sigma-1)\left[\delta(s_i^*)s_i^*\beta_i^*-\delta(s_j^*)s_j^*\beta_j^*-\delta(s_i^*)\sum_{j\in J,j\neq i}\delta(s_j^*)s_j^*+\delta(s_j^*)\sum_{l\in J,l\neq j}\delta(s_l^*)s_l^*\right]=\\
&=\frac{\sigma}{\sigma-1}(\delta(s_i^*)-\delta(s_j^*))+2(\sigma-1)\left[(\delta(s_i^*)+\beta_i^*)(\delta(s_i^*)s_i^*-\delta(s_j^*)s_j^*)-(\delta(s_i^*)-\delta(s_j^*))\sum_{l\in J}\delta(s_l^*)s_l^*\right]=\\
&=(\delta(s_i^*)-\delta(s_j^*))\left[\frac{\sigma}{\sigma-1}-2(\sigma-1)\sum_{l\in J}\delta(s_l^*)s_l^*\right]+2(\sigma-1)(\delta(s_i^*)+\beta_i^*)(\delta(s_i^*)s_i^*-\delta(s_j^*)s_j^*)
\end{aligned} \tag{1.41}$$

From Proposition 2, I know that $\delta(s_i^*)s_i^*-\delta(s_j^*)s_j^*\geq 0$ if $\frac{1}{2}\geq s_i^*>s_j^*$. Lemma 3 shows that if $\sigma\in(1,9.689)$, $\left[\frac{\sigma}{\sigma-1}-2(\sigma-1)\sum_{l\in J}\delta(s_l^*)s_l^*\right]\geq 0$. Given $\delta(s_i^*)\geq\delta(s_j^*)$, the term in (1.40) is positive, which completes the proof.

- **Case 2**: $\delta(s_i^*)<\delta(s_j^*)$

As in the proof to 2, I use the fact that $s_i^*\delta(s_i^*)-s_j^*\delta(s_j^*)>0$ as long as $\frac{1}{2}\geq s_i^*>s_j^*$. Next I show that if $\delta(s_j^*)-\delta(s_i^*)>0$, (1.40) is larger than a strictly positive term:

$$\begin{aligned}
&\delta(s_i^*)\left[\frac{\sigma}{\sigma-1}+2(\sigma-1)\sum_{j\in J,j\neq i}(s_i^*-s_j^*)\delta(s_j^*)\right]-\delta(s_j^*)\left[\frac{\sigma}{\sigma-1}+2(\sigma-1)\sum_{l\in J,l\neq j}(s_j^*-s_l^*)\delta(s_l^*)\right]=\\
&=\frac{\sigma}{\sigma-1}(\delta(s_i^*)-\delta(s_j^*))+2(\sigma-1)\delta(s_i^*)\delta(s_j^*)(2s_i^*-2s_j^*)+\\
&+2(\sigma-1)(\delta(s_i^*)s_i^*-\delta(s_j^*)s_j^*)\sum_{l\in J,l\neq i,j}\delta(s_l^*)+2(\sigma-1)(\delta(s_j^*)-\delta(s_i^*))\sum_{l\in J,l\neq i,j}\delta(s_l^*)s_l^*>\\
&>\frac{\sigma}{\sigma-1}(\delta(s_i^*)-\delta(s_j^*))+2(\sigma-1)\delta(s_i^*)\delta(s_j^*)(2s_i^*-2s_j^*)=\\
&=\delta(s_i^*)\delta(s_j^*)\left[\frac{\sigma}{\sigma-1}\frac{1}{\delta(s_j^*)}-4(\sigma-1)s_j^*-\frac{\sigma}{\sigma-1}\frac{1}{\delta(s_i^*)}+4(\sigma-1)s_i^*\right]
\end{aligned} \tag{1.42}$$

Now I define function $a(s) = \frac{\sigma}{\sigma-1}\frac{1}{\delta(s)} - 4(\sigma-1)s$. First of all, notice that if $s \le \frac{1}{2}$,

$$\begin{aligned}\frac{\sigma}{\sigma-1}\frac{1}{\delta(s)} - 4(\sigma-1)s &= \frac{\sigma(1+(\sigma-2)s) - 4(\sigma-1)^2 s^2(1-s)}{(\sigma-1)s(1-s)} = \\ &= \frac{\sigma(1-2s) + s(\sigma^2 - 4(\sigma-1)^2 s(1-s))}{(\sigma-1)s(1-s)} \ge \\ &\ge \frac{\sigma(1-2s) + s(\sigma^2 - 4\frac{(\sigma-1)^2}{4})}{(\sigma-1)s(1-s)} = \frac{\sigma(1-2s)+s(2\sigma-1)}{(\sigma-1)s(1-s)} \ge 0\end{aligned} \tag{1.43}$$

The last step follows from the fact that $0 < s(1-s) \le \frac{1}{4}$ if $0 < s \le \frac{1}{2}$. This way I establish that $a(s) \ge 0$ if $s \le \frac{1}{2}$. Consequently, the last expression in brackets in (1.42) is positive if $a(s_j^*) > a(s_i^*)$. Next I write $\frac{\partial a(s)}{\partial s}$ in the following way:

$$\begin{aligned}\frac{\partial a(s)}{\partial s} &= \frac{\sigma}{\sigma-1}\frac{(\sigma-2)s(1-s) - (1+(\sigma-2)s)(1-2s)}{s^2(1-s)^2} - 4(\sigma-1) = \\ &= \frac{\sigma}{\sigma-1}\frac{(\sigma-1)s^2 - (1-s)^2}{s^2(1-s)^2} - 4(\sigma-1) = \\ &= \frac{\sigma s^2 - 4(\sigma-1)s^2(1-s)^2 - \frac{\sigma}{\sigma-1}(1-s)^2}{s^2(1-s)^2} = \\ &= \frac{(\sigma-1)s^2 + s^2 - 4(\sigma-1)s^2 - 4(\sigma-1)s^4 + 8(\sigma-1)s^3 - \frac{\sigma}{\sigma-1}(1-2s) - \frac{\sigma}{\sigma-1}s^2}{s^2(1-s)^2} = \\ &= \frac{(1-2s)\left((\sigma-1)s^2(1+2s) - 4(\sigma-1)s^2 - \frac{\sigma}{\sigma-1}\right) + s^2 - \frac{\sigma}{\sigma-1}s^2}{s^2(1-s)^2} = \\ &= \frac{(1-2s)\left((\sigma-1)s^2(2s-3) - \frac{\sigma}{\sigma-1}\right) - \frac{1}{\sigma-1}s^2}{s^2(1-s)^2} < 0\end{aligned} \tag{1.44}$$

Intuitively, $\frac{\partial a(s)}{\partial s} < 0$, as $-3 < (2s-3) < -1$ if $s \in (0,1)$. Consequently, $a(s_j^*) > a(s_i^*)$ if $s_j^* < s_i^* \le \frac{1}{2}$. Therefore, the term in (1.40) is larger than a strictly positive term if $\delta(s_i^*) < \delta(s_j^*)$. This completes the proof. □

Chapter 2

Effects of Input Trade Liberalization with Strategic Sourcing[1]

[1]Exercises in this chapter were conducted using product-level dataset for Ukrainian manufacturing firms from Ukrainian Food-Processing sectors. Access to this dataset and cleaning routines were provided by Professor Volodymyr Vakhitov.

2.1 Introduction

In Chapter 1, I present a structural model in which firms make geographical sourcing decisions under oligopolistic competition. I proceed further by structurally estimating this model. The procedure is very challenging to implement due to the complexity of the firm's combinatorial discrete choice problem. Antràs et al. (2017) point out that under monopolistic competition, the firm's problem of finding optimal sourcing geography can quickly become computationally unfeasible, as returns from sourcing from a new location depend on other locations, from which firms source inputs. Under oligopoly, the returns from sourcing from a new location additionally depend on where competitors source inputs from. I adopt methods from strategic multiproduct games by Fan and Yang (2020) and Eizenberg (2014), who model product introduction decisions by multiproduct firms in the electronics industries. I follow these authors by assuming the strategic timing of decisions on firms' sourcing geographies and that observed sourcing geographies constitute SPNE in pure strategies. I use necessary conditions for its existence to estimate upper and lower bounds for firm-location-specific fixed costs. I solve the high-dimensional problem by adopting a best response iteration algorithm similar to Fan and Yang (2020). Applying these methods, I undertake several counterfactual experiments using the rich firm-level dataset containing information on product-level outputs, revenues, and suppliers' geography of Ukrainian food-processing firms.

In the first counterfactual experiment, I evaluate the gains from input trade. I estimate the aggregate surplus gains from moving from the SPNE, in which firms have no access to foreign intermediate inputs, to the one I observe in the data. Access to foreign intermediate inputs improves consumer surplus and reduces firms' profits with overall positive effects on welfare. Next, I evaluate the welfare effects of Ukraine's accession to the WTO in 2008 on consumers and firms in the Ukrainian food-processing industry. My results suggest that the more efficient firms were more active in sourcing from the WTO members before the accession. However, the WTO accession led to the addition of sourcing locations by less efficient firms, resulting in substantial consumer gains and losses in total profits. Consumer gains resulted not just from reductions in input prices, but also from the reallocation of market shares to firms with smaller markups. Total profits decrease due to the resulting reduction in market concentration and the additional fixed costs paid. Overall, I observe positive aggregate surplus effects with sizeable welfare improvement coming from firms readjusting their sourcing geography.

To quantify the size of welfare effects relative to those under monopolistic competition, I repeat the exercise with two adjustments. First, I simulate firms' decisions while restricting markups to be constant and identical across firms. In the second exercise, I simulate the decisions of firms under monopolistic competition. This exercise also implies that sourcing decisions are not made strategically. Across the three simulated models, welfare improvement is the smallest under oligopolistic competition with variable markups and the largest under monopolistic competition. Firms are less active in starting to source from the WTO countries under oligopolistic competition despite their incentives to manipulate outputs of competitors.

Literature review: This study contributes to an important stream of literature analyzing welfare effects from input trade liberalization. Caliendo and Parro (2015) and Balistreri et al. (2011) are among the first to explicitly account for sectoral linkages in evaluating welfare effects from trade liberalization. Caliendo and Parro (2015) use the perfectly-competitive multi-sectoral Ricardian model and show that considering trade in intermediate inputs is important in quantifying welfare gains from trade. Antràs et al. (2017) study the welfare effects of China's accession to the WTO using a multi-country model with monopolistic competition and firm heterogeneity; they show that welfare improvements result not just from cost reductions by importing firms, but also from readjustment of firms' sourcing strategies and by selecting out of less productive firms. Blaum et al. (2018) evaluate gains from input trade in a model with monopolistic competition, firm heterogeneity, and input-output linkages. To the best of my knowledge, no previous work has looked into the welfare effects of input trade liberalization under oligopolistic competition downstream. My study seeks to fill this gap. Changes in consumer surplus and total profits in the model with a fixed number of firms come from a direct reduction in marginal costs, adjustment of firms' sourcing strategies, and changes in the total fixed costs paid.

This study also relates to the literature on the estimation of discrete games. Bresnahan and Reiss (1990) point to substantial difficulties related to studying discrete decisions by firms facing oligopolistic competition in the presence of fixed costs. Under these assumptions, fixed costs can only be set-identified in the absence of an explicit equilibrium selection rule.[2] Several follow-up papers, including Ciliberto and Tamer (2009), Eizenberg (2014), Coşar et al. (2015), Fan and Yang (2020), Ciliberto and Jäkel (2021), and Fan and Yang (2022), model firms' product positioning and entry decisions under oligopolistic competition. They undertake counterfactual exercises under oligopolistic competition, making use of set-identified fixed costs. I contribute to this literature by adopting its methods to study the multi-country strategic sourcing problem of firms under oligopolistic competition.

[2]Number of papers including Jia (2008), Atkeson and Burstein (2008), Edmond et al. (2015), Breinlich et al. (2023) resort to equilibrium selection rules to conduct parametric estimation of fixed costs

2.2 Structural Implementation

2.2.1 Background Information and Counterfactual Design

The Ukraine's accession to the WTO happened in May 2008 after more than ten years of negotiations between Ukraine and the WTO member countries. The accession has allowed Ukrainian firms to sell goods to the WTO member countries, paying Most Favored Nation (MFN) tariffs. In exchange, Ukraine granted all members of the WTO MFN status and better access to its domestic market. To become eligible, Ukraine had to conform to rules of the WTO, in particular, to remove import quotas and non-tariff measures. According to Movchan et al. (2019), the accession was granted conditional on Ukraine removing the remaining phytosanitary, epidemiological checks, and other non-tariff barriers during the subsequent years.

It is challenging to evaluate the effects of the Ukraine's accession to the WTO. First of all, it happened the same year as the Global Financial Crisis hit Ukraine. Secondly, other trade events happened during the next five years, including the establishment of the Commonwealth of Independent States Free Trade Agreement in September 2012. Therefore, to isolate estimates of sourcing potentials from the general equilibrium effects of the Global Financial Crisis, I have to wait a sufficient number of years. However, if the number of years is too large, the effects of other trade events might contaminate my estimates. Consequently, I calibrate the model to the data for 2007 and simulate the effects of changing sourcing potentials estimated for 2007 to the ones I estimate for 2011.

I concentrate on the Ukrainian food-processing industry for a number of reasons. First, due to abundant cheap resources at home and significant non-tariff barriers still in place before the accession, the share of imported processed food products was relatively small in 2007. Given such import barriers, I treat the initial market shares of importers as negligibly small. Second, Ukrainian food-processing firms were not very active in selling their products abroad (the ratio of total exporting revenues to total revenues in my sample is less than 6%).[3] Third, food-processing sectors are highly downstream; processed food products are more likely to serve for consumption than as production inputs.

2.2.2 Data

To perform the counterfactual exercise, I use three data sources. I obtain firm-level information on values and quantities of all products Ukrainian food-processing firms exported and imported from the official customs database of exporting and importing transactions from 2007 to

[3]Therefore, I can abstract from complementarity between exporting and importing decisions, which would severely complicate my analysis.

2011. I obtain material input expenditures and total revenue net of tax from the official financial statements of Ukrainian firms between 2007 and 2011. I also obtain detailed information on the total revenues and total output for every product sold by Ukrainian food-processing firms (The North American Industry Classification System 15) from a unique dataset also used in Movchan et al. (2019). The dataset records revenue and output information for every product produced and sold by Ukrainian food-processing firms, using the 6-digit Ukrainian product classification which I can roughly map to the 4-digit harmonized system (HS4) good classification in the customs dataset. I clean these datasets using the procedure outlined in Appendix 2.5.1. I use the resulting dataset to calculate product-level domestic revenue and output by subtracting export revenues and output from total revenues and output for every product; I then use domestic revenue shares and unit values to recover structural variables.

A significant challenge I face when working with product-level revenue data is that the same firms can produce goods in multiple sectors. For example, the same firm can sell goods classified as "Jam" and "Bakery". If I define the market as the set of producers and consumers of goods within a given 6-digit production sector, such firm will not be a multi-product firm but will rather sell products on two markets. I assume that within the same firm products from different sectors are produced by separate and independent divisions of the same firm. I also assume that each division pays fixed costs of sourcing and forms sourcing strategies independently from other divisions. I model each division as a single-product firm. Because of data limitations, I overlook the possibility that the firm producing a 6-digit good might produce a group of different varieties of the same 6-digit product (in this way, technically becoming a multi-product firm).

2.2.3 Location Clustering and Estimation of Sourcing Potentials

I calibrate the model to the data for 2007 when food-processing firms were not very active in sourcing intermediate inputs from abroad. For this reason, I can count only a few locations for which I can obtain consistent estimates of sourcing potentials. To overcome this limitation, I redefine the sourcing location as a set of sourcing countries. For a baseline procedure, I partition the set of sourcing locations in the data into five composite locations: "countries outside the WTO" (non-WTO), "the WTO members who are not members of the EU"(WTO non-EU), "Members of the EU and the WTO who are Ukrainian neighbors"(WTO EU 1), "Members of the WTO from the eastern EU and the Scandinavian EU members"(WTO EU 2), "Members of the WTO from the western EU"(WTO EU 3). I find it important to consider the EU members and countries outside the EU separately due to the uniform trade policy among the members of the EU. On the other hand, before Ukraine entered the WTO, Ukraine had MFN agreements with some members of the EU; for this reason, I still observe substantial heterogeneity in response across the EU clusters.

For each group of countries above, I estimate the sourcing potentials using the methodology by Antràs et al. (2017). I recover the mean sourcing potential for each location using the model-consistent relationship between the expenditure shares on material inputs $l \neq H$ relative to the expenditure share on domestic material inputs. The share of material inputs from H equals $\chi_{iH} = \frac{1}{\Theta_i(\mathcal{J}_i)}$, while the share of material inputs from any other location l equals $\chi_{il} = \frac{\mathcal{T}_l(w_l \tau_{lH})^{-\theta}}{\Theta_i(\mathcal{J}_i)}$. Dividing the latter by the former, taking natural logarithms, and adding mean-zero measurement error term ξ_{il}, I obtain the empirical specification below:

$$log\left(\frac{\chi_{il}}{\chi_{iH}}\right) = log(\mathcal{T}_l(w_l \tau_{lH})^{-\theta}) + log(\xi_{il}) \tag{2.1}$$

Using the empirical specification in (2.1), for each composite location, I can identify $log(\mathcal{T}_l(w_l \tau_{lH})^{-\theta})$ by regressing the share of material inputs from location l divided by a share of domestic inputs on the countries' fixed effects as in Antràs et al. (2017).

Figure 2.1 depicts estimates of sourcing potentials for 2007 and 2011. The sourcing potential of "non-WTO" has changed between these years. Assuming that the WTO accession did not affect W_H,[4] this change signals that the sourcing potential of locations outside the WTO might change for reasons having nothing to do with the accession of Ukraine to the WTO. Consequently, I normalize sourcing potentials, leaving the relative share of inputs from locations outside the WTO unchanged. Except for "the WTO members from the Western EU", sourcing potentials of all locations containing the WTO members have increased. However, sourcing potential of the location "the WTO members from the Western EU" increased by less than sourcing potential of the location containing countries outside the WTO. This observation is not surprising, as even before the accession to the WTO, the government of Ukraine had MFN agreements with members of almost all members of the former composite location. It is reasonable to expect that import tariffs for countries with existing MFN agreements should not change.

[4]One of the ways to rationalize this assumption would be to assume that the outside non-tradable sector absorbs the resulting wage effects

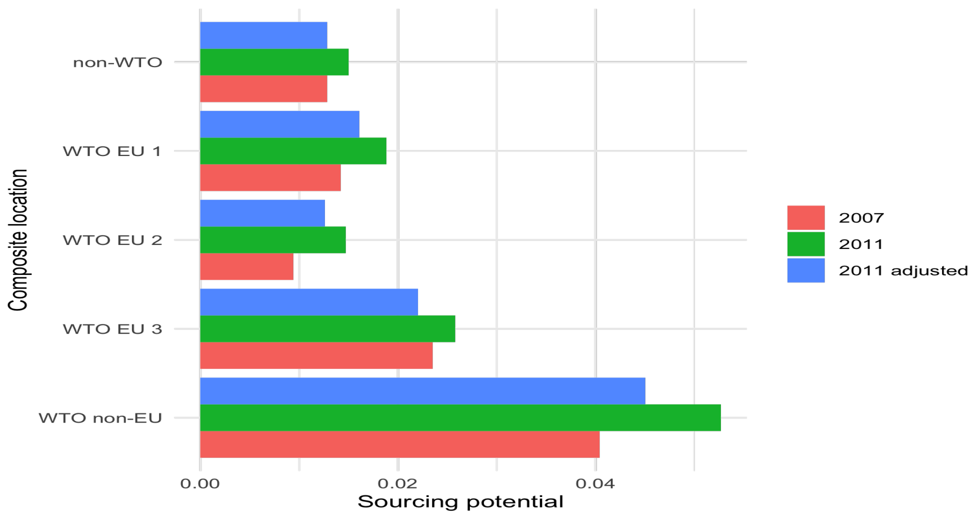


Figure 2.1: The WTO Accession and Sourcing Potentials of 5 Composite Locations

Note: This figure presents the estimates of sourcing potentials used in the structural estimation routine. I put the name of a composite location from Subsection 2.2.3 on the y-axis and the estimated values of sourcing potentials on the x-axis. I plot sourcing potentials for 2007 in red, those for 2011 in green, and the normalized sourcing potentials for 2011 (2011 adjusted) in blue.

2.2.4 Parametrization

For structural exercises, I require two key parameters, the elasticity of substitution (σ) and the input trade elasticity (θ). Similarly to Breinlich et al. (2023), I perform the baseline counterfactual exercises using $\sigma = 5$. I perform sensitivity checks, replacing σ with a greater or smaller value of the parameter in Subsection 2.3.3. For the baseline exercise I use the parameter estimate from Antràs et al. (2017), $\theta = 1.789$.[5]

2.2.5 Estimation of Fixed Cost Bounds

A small number of locations prevents estimating firm-specific fixed costs as in Eizenberg (2014), the multiplicity of equilibria prevents the use of methods matching theoretical and empirical moments as in Eaton et al. (2011), Antràs et al. (2017), and Breinlich et al. (2023). The strategy I adopt is close to Fan and Yang (2020). To estimate bounds on firm-location-specific fixed costs, I make several assumptions.

Assumption 1: Fixed costs f_{il} are firm-location specific, with support being a compact interval;

[5] Small number of observations for many locations does not allow me to obtain an estimate of θ in the same way as Antràs et al. (2017). In Appendix 2.5.4, I use firm-level data to estimate $\theta = 1.84$. However, I use the estimate of Antràs et al. (2017), since the authors' strategy allows one to disentangle measurement error in estimating sourcing potentials from the unobserved technology factors.

Assumption 2: Sourcing strategies in the data constitute a subgame perfect Nash equilibrium in pure strategies;

Assumption 3: Define $\bar{F}_{il}$ and $\underline{F}_{il}$ as, respectively, the upper and lower bound for f_{il}. For locations which are in $\mathcal{J}_i$, $\underline{F}_{il} = 0.5\bar{F}_{il}$, for locations not in $\mathcal{J}_i$, $\bar{F}_{il} = 5\underline{F}_{il}$;

Assumption 4: $\underline{F}_{il} > 0$.

Under assumptions 1-4, I can identify support bounds of firm-location-specific fixed costs. For location l, from which firm i sources inputs, I can identify $\bar{F}_{il}$ as the absolute value of loss in variable profits i receives when it removes l from its optimal sourcing strategy. Similarly, for location l', from which firm i does not source inputs, I can identify $\underline{F}_{il'}$ as the value of the additional variable profits i receives when it removes l' from its sourcing strategy. Using assumption 3, I can construct bounds that I cannot identify from the identified bounds.

Assumptions 1-4 are quite restrictive. For instance, assumption 2 requires that the observed outcome constitutes a pure strategy subgame perfect Nash equilibrium, the existence of which is not guaranteed. Assumption 3 implies that unidentified bounds are a fixed proportion of the identified bounds.[6] Assumption 1 is not too restrictive and follows Eizenberg (2014). To estimate fixed cost bounds, I first recover autarky types for each firm (I describe the procedure in Appendix 2.5.2). Then I perturb the observed sourcing strategy by either adding or removing a particular location and compute the resulting change in firm's profits, holding sourcing strategies and autarky types of all other firms fixed. In this way, I identify either $\underline{F}_{il}$ or $\bar{F}_{il}$ for each $i-l$ firm-location pair, then I use Assumption 3 to construct the remaining fixed cost bounds. Figure 2.2 depicts the distribution of upper and lower bounds, while Table 2.1 provides descriptive statistics of the upper and lower bounds that I am able to identify. The average identified upper bound is much larger than the average identified lower bound for any location that I consider.

[6] In Subsection 2.3.3, I check the robustness of my results to an alternative assumption that the length of the support of fixed costs is the same across all firms and equals the difference between the average upper and lower bounds across the bounds I am able to identify.

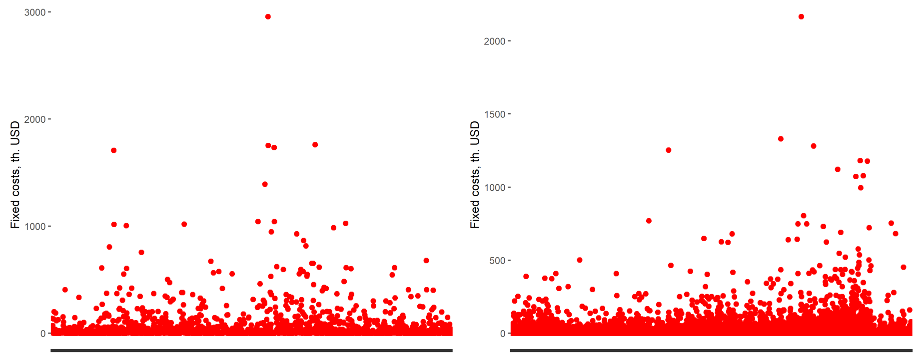


Figure 2.2: Identified Upper and Lower Bounds of Fixed Costs, th. USD

Note: This figure plots the dispersion of upper and lower bounds of fixed costs identified using the approach in Subsection 2.2.5. The left panel plots identified upper bounds, and the right panel plots identified lower bounds. Each point on the x-axes represents a firm-location pair for which bounds can be identified. I plot the size of the fixed cost bounds on the y-axis.

Table 2.1: Descriptive Statistics of Identified Fixed Costs, th. USD

Location	**Min**	**5th quantile**	**Mean**	**Median**	**95th quantile**	**Max**
Upper Bounds						
non-WTO	0.02	0.10	38.0	6.50	173	928
WTO EU 1	0.01	0.09	50.2	10	241	1026
WTO EU 2	0.01	0.06	34.2	10.4	146	681
WTO EU 3	0.02	0.15	79.6	19.5	363	1708
WTO non-EU	0.04	0.23	142	38.4	609	2956
Lower Bounds						
non-WTO	0.01	0.03	9.04	1.26	40.2	683
WTO EU 1	0.01	0.04	9.12	1.39	41.5	755
WTO EU 2	0.01	0.02	6.12	0.92	27.4	501
WTO EU 3	0.02	0.06	13.2	2.22	59.5	1254
WTO non-EU	0.04	0.10	27	4.07	122	2166

Note: This table contains descriptive statistics of the identified upper and lower bounds of fixed costs for each composite location with the composition described in Subsection 2.2.3. The upper panel provides the set of statistics for the identified upper bounds, while the lower panel provides the set of statistics for the identified lower bounds.

2.3 Counterfactual Exercises

Theoretical studies show that business stealing effects might motivate firms to exert too much cost-reducing effort. An interesting question is whether the fixed costs paid are so large that they absorb all the gains in variable profits and consumer surplus from input trade liberalization. In this section, I present two counterfactual experiments. In one of them, I move the economy from the state of complete autarky with firms not sourcing from any location to the outcome I observe in the data. In another counterfactual experiment, I use data from 2007 and replace sourcing potentials estimated before the accession of Ukraine to the WTO with sourcing potentials of the same locations estimated after the accession.

2.3.1 Gains from Input Trade

In this counterfactual experiment, I present bounds for the welfare effects of moving from input autarky to the observed outcome in the data for the 2007. Since I can only set-identify fixed costs, I present bounds for the effects on total profits, total fixed cost paid, and the total welfare effects (while the estimates of sourcing potentials allow calculating exact changes in variable profits and consumer surplus).[7] Table 2.2 summarizes the results.[8] I aggregate the results by summing the changes in welfare across 46 food-processing sectors.

I find that opening to foreign input markets substantially improves consumer welfare, with the resulting change in consumer surplus close to \$126 mn.[9] Holding markups fixed, consumer surplus increases by \$139.3 mn, readjustment of markups to the post-liberalization Nash equilibrium reduces consumer benefits by about 10.5%. 32 out of 46 sectors become more concentrated and total variable profits increase after the input trade liberalization. Subsection 1.2.4 suggests that such improvements are likely to occur if relatively more efficient firms are more active in global sourcing. I calculate the total fixed cost paid, using two assumptions on their support. Estimates of $\underline{F}_{il,1}$ use assumption 3 in Subsection 2.2.5. Estimates of $\underline{F}_{il,1}$ assume that the length of support is identical across all firm-location pairs. Overall, fixed costs paid by firms are large. Independently of the assumption on the support of fixed costs, total fixed costs paid absorb the entire gains in variable profits. Therefore, substantial improvements in consumer surplus come at the expense of significant losses in total profits. Although fixed costs are large, they are still insufficient to absorb gains in consumer surplus and variable profits. Even if I set fixed costs equal to the identified upper bound of fixed cost intervals, the total welfare improvement from input trade liberalization is still positive. The total wage bill by domestic suppliers reduces by \$178.9 mn and is not offset by increases in fixed costs. Ignoring general equilibrium effects, open input markets lead to a net destruction of between 9.5 and 41.2 th. manufacturing jobs.[10]

[7] For this exercise, I only consider sourcing locations already in sourcing strategies of some firms in 2007. For such firm-location pairs, the upper bounds identified using both assumptions are exactly the same.

[8] I choose the unit of account of 1 th. USD

[9] roughly, \$2.7 per Ukrainian resident or 1.6% of total consumer expenditures on products of Ukrainian food-processing firms in 2007.

[10] In calculations, I use the average monthly wage in Ukrainian food-processing sector in 2007 reported by Ukrainian Statistics Office as \$242.2, the average manufacturing monthly wage was around \$307.7 in 2007.

Table 2.2: Effects of Opening up to Input Trade, th. USD

Fixed cost bounds	dCS	dCS-MC	dCS-MA	dVP	dFC	dW
$f_{il} = \bar{F}_{il}$	125994.2	139280.3	-13286.1	14091	113301.3	26784.3
$f_{il} = \underline{F}_{il,1}$	125994.2	139280.3	-13286.1	14091	56650.6	83434.9
$f_{il} = \underline{F}_{il,2}$	125994.2	139280.3	-13286.1	14091	20978.5	119107.1

Note: This table provides the estimates of the gains from input trade using the data and the estimates of fixed costs. The upper row $\bar{F}_{il}$ sets fixed costs equal to the identified upper bounds for locations in sourcing strategies of firms. The middle and the lower rows set the total fixed costs paid equal to the lower bounds constructed using the two different assumptions on the support of fixed costs. dCS represents the total change in consumer surplus, which I further break down into the change from the reduction in marginal costs ($dCS-MC$) and the change due to markup adjustment ($dCS-MA$). dVP represents the total change in the second stage variable profits, dFC represents the total change in fixed costs paid, dW evaluates the net change in welfare.

2.3.2 The Accession to the WTO: Baseline

To evaluate the effects of the accession of Ukraine to the WTO on firms and consumers in Ukrainian food-processing sectors, I use the data for 2007 and then replace the sourcing potentials with the normalized sourcing potentials estimated for 2011. The counterfactual experiment is much more challenging to implement than the one in Subsection 2.3.1, as this experiment requires simulating new SPNE for every sector, given the updated values of sourcing potentials. I proceed in a similar way to Fan and Yang (2020):

1. For each firm-location pair, I make five uniform draws of fixed costs from the intervals between the bounds estimated in Subsection 2.2.5;

2. For each matrix of fixed cost draws, I simulate the set of new SPNE consistent with the new sourcing potentials and different matrices of fixed costs. I use a best-response iteration algorithm in the spirit of Fan and Yang (2020) to arrive at the strategy profile such that no firm has unilateral incentives to deviate from it after the change in sourcing potentials. I provide more details on the algorithm I use in Appendix 2.5.3;

3. For each strategy profile I obtain in step 2, I calculate changes in all the welfare components from moving from the strategy profile I observe in the data for the year 2007 to the one I simulate with the new sourcing potentials. Having the set of SPNE strategy profiles for each matrix of fixed cost draws, I construct welfare effects at the sectoral level, then I aggregate the results across sets of simulated SPNE.

I decompose the total welfare effects into intensive and extensive margin contributions. The intensive margin contribution evaluates the effects of input trade liberalization when the sourcing potentials of locations change, but the sourcing strategies remain as in 2007. This component measures welfare changes in the world, in which firms' sourcing strategies are exogenous and do not react to changes in transportation costs. The extensive margin contribution evaluates the change in welfare from the readjustment of sourcing strategies, holding sourcing potentials fixed to the 2011 level.

Table 2.3: Effects of the WTO Accession, th. USD

Margin Contribution	**dCS**	**dCS-MC**	**dCS-MA**	**dVP**	**dFC**	**dW**
Intensive margin	8729.9	9618.2	-888.3	987.9	0	9717.9
Extensive margin	4868.5	3887	981.5	-1161.8	2537.2	1169.3
Total	13598.4	13505.2	93.2	-173.9	2537.2	10887.2

Note: This table provides the estimates of the effects of the Ukraine's accession to the WTO, averaged over sets of simulated SPNE for 46 Ukrainian food-processing sectors for each matrix of fixed costs. The upper row summarizes the effects, holding firms' sourcing strategies fixed at the ones observed in 2007. The central row summarizes the net effect of the adjustment of sourcing strategies, following the changes in sourcing potentials. The lower row sums both welfare changes. dCS *represents the total change in consumer surplus, which I further break down into the change from the reduction in marginal costs (*$dCS - MC$*) and the change due to markup adjustments (*$dCS - MA$*).* dVP *represents the total change in the second stage variable profits,* dFC *represents the total change in fixed costs paid,* dW *evaluates the net change in welfare.*

The results summarized in Table 2.3 reflect the sizable effects of the Ukraine's accession to the WTO on consumers and firms in the food-processing sectors; the average welfare improvement across the simulated sets of SPNE is close to $10.9mn.[11] Consumer surplus mostly increases at the intensive margin. Smaller effects at the extensive margin happen, as some firms drop locations that are no longer profitable, and, partly, as less efficient firms actively steal business from more efficient competitors in response to better sourcing opportunities. To see why the second effect is important, observe that the markup adjustment component of consumer surplus contributes positively at the extensive margin. Moreover, the change in variable profits at the extensive margin is negative. Market concentration declines, as market shares reallocate towards less efficient firms reducing total variable profits. Active adding of sourcing locations by less efficient firms could explain both changes.

Now, assume that firms cannot adjust their sourcing strategies in response to changes. The growing sourcing potentials of the WTO member locations reduce marginal costs (Effect 1), resulting in larger markups for firms sourcing from the WTO members before the change (Effect 2) and lower markups for other firms (Effect 3). Effect 2 reduces the welfare of consumers, while Effect 3 increases it. When I allow firms to readjust their sourcing strategies, aggressive adding of

[11] roughly, 0.13% of total consumer expenditures on products of Ukrainian food-processing firms.

sourcing locations by less efficient firms slows down the increase in markups by firms, sourcing from the WTO members before, and in this way reduces Effect 2. Although adding new sourcing locations by less efficient firms increases their markups, consumer losses from the latter do not outweigh consumer benefits from the reduction in Effect 2. In the end, consumers pay smaller prices for the same goods not just due to reductions in marginal costs but also due to declines in markups for products they spend relatively more on. The sum of new fixed costs paid is not very large. Similarly to Subsection 2.3.1, better access to inputs from the WTO members results in substantial consumer benefits and losses in total firm profits, with the former effect larger than the latter. The total domestic upstream wage bill reduces by about $17 mn. with $12.1 mn. lost at the intensive margin.[12]

Figure 2.3 shows that firms adjust to changes in sourcing potentials by actively switching sourcing locations. Many firms add the WTO members other than the WTO members from the western EU. Interestingly, although the sourcing potential of locations outside the WTO is held fixed during the exercise, in some sets of simulated SPNE, few firms remove locations outside the WTO from their sourcing strategies. Such dropping of locations should not happen under monopolistic competition under the parameter assumptions I make in Subsection 2.2.4. If sourcing locations were complements, firms would add locations outside of the WTO, as they would help them pay the fixed costs necessary to start sourcing from new locations. Stopping to source inputs from these countries can either be a best response to another firm adding the WTO members or a replacement deviation by the firm, for which sourcing locations are not complements.

[12]Taking into account increases in fixed cost paid by importing firms, reported numbers imply 3.7 th. manufacturing jobs destroyed.

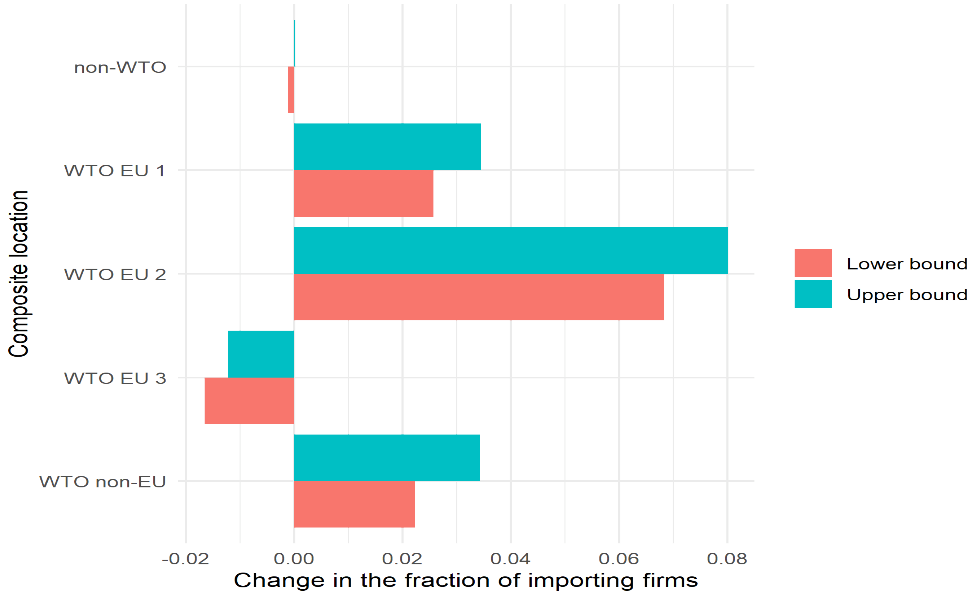


Figure 2.3: Adjustment of Sourcing Strategies in Response to the WTO Accession

Note: This figure shows, how firms adjusted their sourcing strategies across different sets of simulated SPNE. Names of the locations from Subsection 2.2.3 are on the y-axis; the x-axis shows changes in the percentage of firms sourcing inputs from a particular location. The blue and the red bars represent the largest and the smallest adjustment shares for each location across different sets of simulated SPNE.

2.3.3 The Accession to the WTO: Sensitivity Checks

In Subsection 2.3.2, I make several assumptions, some of them are quite strict. In the following, I implement additional exercises examining sensitivity of results to these assumptions.

Assumptions on σ: The first sensitivity check concerns the parametric assumption on the elasticity of substitution. The baseline analysis uses $\sigma = 5$. I recalculate the welfare effects by changing σ to 4, 5.5, and 10.5 (the estimate of Edmond et al. (2015)). Table 2.4 reveals that changing the parameter value does not starkly affect the total change in welfare. Therefore, the bias from the potential misspecification of σ should not be very large. One can observe that when I set $\sigma = 10.5$, the change in consumer surplus, resulting from changes in markups, changes the sign. Consumer gains from the reductions in markups of more efficient firms no longer outweigh the losses from increases in markups of firms, sourcing inputs from the WTO members, at the intensive margin.

Table 2.4: Effects of the WTO Accession, Sensitivity Checks to σ, th. USD

Margin Contribution	**dCS**	**dCS-MC**	**dCS-MA**	**dVP**	**dFC**	**dW**
$\sigma = 5$						
Intensive margin	8729.9	9618.2	-888.3	987.9	0	9717.9
Total Effect	13598.4	13505.2	93.2	-173.9	2537.2	10887.2
$\sigma = 4$						
Intensive margin	8878.8	9610.7	-731.9	758	0	9636.8
Total Effect	13226.4	13128.5	97.9	-152.7	2105.3	10968.4
$\sigma = 5.5$						
Intensive margin	8663.5	9622	-958.5	1093.3	0	9756.8
Total Effect	13702.1	13616.8	85.3	-181.1	2682.1	10838.9
$\sigma = 10.5$						
Intensive margin	8166.4	9659.4	-1493	1917	0	10083.4
Total Effect	14604.9	14678.2	-73.3	-222.1	3916.7	10466.1

Note:This table provides the estimates of the effects of the Ukraine's accession to the WTO, averaged over sets of simulated SPNE for 46 Ukrainian food-processing sectors for each matrix of fixed costs. Each panel calculates the effects for the different values of σ. In each panel, the upper row summarizes the effects, holding firms' sourcing strategies fixed at the ones observed in 2007. The lower row presents the total change in welfare, accounting for firms' readjusting of sourcing strategies. dCS represents the total change in consumer surplus which I further break down into the change from the reduction in marginal costs ($dCS - MC$) and the change due to the markup adjustments ($dCS - MA$). dVP represents the total change in the second stage variable profits, dFC represents the total change in fixed costs paid, dW evaluates the net change in welfare.

Assumptions on θ: Now I check what happens if I use the alternative value of θ. For this scenario analysis, I consider several parameter values: 1.072 from Li et al. (2023), 2.8 from the scenario analysis of Antràs et al. (2017), and 5 (the value of θ, which makes complementarity of sourcing locations impossible in the baseline model). I present the results in Table 2.5. Importantly, alternative values of θ do not affect the sign of any component of welfare change, instead they change the magnitude of the effects. The smaller the θ, the larger are the welfare gains from changes in input tariffs. Misspecification of θ is unlikely to change the direction of the effects. However, it will affect the scale of welfare effects of input trade liberalization, leading to biased results.

Table 2.5: Effects of the WTO Accession, Sensitivity Checks to θ, th. USD

Margin Contribution	**dCS**	**dCS-MC**	**dCS-MA**	**dVP**	**dFC**	**dW**
$\theta = 1.789$						
Intensive margin	8729.9	9618.2	-888.3	987.9	0	9717.9
Total Effect	13598.4	13505.2	93.2	-173.9	2537.2	10887.2
$\theta = 1.072$						
Intensive margin	14592.9	16084.8	-1491.8	1651.5	0	16244.4
Total Effect	23783.8	23680.9	102.9	-306.1	5103.4	18374.3
$\theta = 2.8$						
Intensive margin	5572.9	6138.5	-565.6	630.6	0	6203.5
Total Effect	8471.6	8409.5	62.1	-101.2	1450.5	6919.9
$\theta = 5$						
Intensive margin	3118.6	3434.5	-315.9	352.9	0	3471.5
Total Effect	4655.7	4618.7	37	-52.8	741.6	3861.3

Note: This table provides the estimates of the effects of the Ukraine's accession to the WTO, averaged over sets of simulated SPNE for 46 Ukrainian food-processing sectors for each matrix of fixed costs. Each panel calculates the effects for different values of θ*. In each panel, the upper row summarizes the effects, holding firms' sourcing strategies fixed at the ones observed in 2007. The lower row presents the total change in welfare, accounting for firms' readjusting of sourcing strategies.* dCS *represents the total change in consumer surplus, which I further break down into the change from the reduction in marginal costs* $(dCS-MC)$ *and the change due to the markup adjustments* $(dCS-MA)$*.* dVP *represents the total change in the second stage variable profits,* dFC *represents the total change in fixed costs paid,* dW *evaluates the net change in welfare.*

Assumptions on the distribution of fixed costs: In Subsection 2.3.2, I assume that the unidentified fixed cost bounds are constant multiples of the identified bounds. I perform additional sensitivity checks to verify whether alternative assumptions on the support of fixed costs might lead to different results. Similarly to Fan and Yang (2020), I use the alternative assumption that fixed cost intervals for every location and firm have a fixed range equal to the difference between the average identified upper and lower bounds. I use this assumption to obtain new sets of SPNE consistent with the five matrices of fixed cost draws. I present the results in Table 2.6.

Table 2.6: Effects of the WTO Accession, Sensitivity Checks to Fixed Costs Support Assumption, th. USD

Margin Contribution	dCS	dCS-MC	dCS-MA	dVP	dFC	dW
Baseline fixed costs						
Intensive margin	8729.9	9618.2	-888.3	987.9	0	9717.9
Total Effect	13598.4	13505.2	93.2	-173.9	2537.2	10887.2
Fixed range fixed costs						
Intensive margin	8729.9	9618.2	-888.3	987.9	0	9717.9
Total Effect	61271.5	65788	-4516.5	6106.6	43763.1	23615

Note: This table provides the estimates of the effects of the Ukraine's accession to the WTO, averaged over sets of simulated SPNE for 46 Ukrainian food-processing sectors for each matrix of fixed costs. Each panel presents welfare effects, estimated using different assumptions on the support of fixed costs. In each panel, the upper row summarizes the effects, holding firms' sourcing strategies fixed at the ones observed in 2007. The lower row presents the total change in welfare accounting for firms' readjusting of sourcing strategies. dCS *represents the total change in consumer surplus, which I further break down into the change from the reduction in marginal costs* ($dCS-MC$) *and the change due to the markup adjustments* ($dCS-MA$). dVP *represents the total change in the second stage variable profits,* dFC *represents the total change in fixed costs paid,* dW *evaluates the net change in welfare.*

The estimated welfare improvement is about twice as large under this alternative assumption. Firms are more active in switching sourcing locations, which I can infer from a much larger change in consumer surplus and a larger change in fixed costs paid. In contrast to the results in Subsection 2.3.2, the extensive margin contributes more to the welfare improvement, and the change in variable profits at the extensive margin is positive. Consumer surplus improves, as firms that already source reduce marginal costs, more efficient firms add new sourcing locations into sourcing strategies and expand output, while less efficient firms reduce output. Differences in results arise, as the baseline assumption on fixed cost intervals widens their ranges for more efficient firms relative to the ones for less efficient firms. Given the uniform drawing of fixed costs, such differences in intervals might cause greater occurrences of large fixed cost draws for more efficient firms compared to less efficient firms. If I assume instead that fixed cost intervals have identical ranges, the above-mentioned advantage for less efficient firms dissipates, and more efficient firms are now more likely to add new locations.

Clustering of composite locations: In Subsection 2.2.3, I partition the geography of sourcing locations of Ukrainian food-processing firms into five composite locations. Now, I check whether finer partitioning changes the welfare effects. I modify the baseline clustering in the following way: I use Germany as a single location and exclude it from the cluster of the WTO members from the western EU; I also break the WTO members outside of the EU into the WTO members from Asia and Oceania and the WTO members outside these regions. Table 2.7 lists the effects that I obtain using a different location partitioning.

Table 2.7: Effects of the WTO Accession, Sensitivity Checks to Location Clustering, th. USD

Margin Contribution	**dCS**	**dCS-MC**	**dCS-MA**	**dVP**	**dFC**	**dW**
Baseline clustering						
Intensive margin	8729.9	9618.2	-888.3	987.9	0	9717.9
Total Effect	13598.4	13505.2	93.2	-173.9	2537.2	10887.2
7 locations clustering						
Intensive margin	16281.2	17765.6	-1484.4	1650.3	0	17931.5
Total Effect	17785.2	17926.2	-141	92	-2361.6	20238.8

Note: This table provides the estimates of the effects of the Ukraine's accession to the WTO, averaged over sets of simulated SPNE for 46 Ukrainian food-processing sectors for each matrix of fixed costs. In each panel, I use a different approach to cluster sourcing geography of firms into composite locations. In each panel, the upper row summarizes the effects, holding firms' sourcing strategies fixed at the ones observed in 2007. The lower row presents the total change in welfare, accounting for firms' readjusting of sourcing strategies. dCS *represents the total change in consumer surplus, which I further break down into the change from the reduction in marginal costs (*$dCS-MC$*) and the change due to the markup adjustments (*$dCS-MA$*).* dVP *represents the total change in the second stage variable profits,* dFC *represents the total change in fixed costs paid,* dW *evaluates the net change in welfare.*

Alternative location clustering increases the average welfare effects across the sets of SPNE about two times. The difference arises not just from the larger contribution to consumer surplus at the intensive margin, but also from more firms removing locations rather than adding them. The latter changes result in negative or small positive changes in fixed costs paid across different simulated SPNE. Part of the reason behind such removal of sourcing locations is that there are at least two locations, sourcing potentials of which declined between 2007 and 2011. Provided firms mostly drop exactly these locations, the negative change in total fixed costs paid comoves with the improvements in consumer surplus. Unlike in Subsection 2.3.2, market shares reallocate to more efficient firms at the extensive margin.

2.3.4 The Role of Variable Markups and Strategic Sourcing

Subsection 2.3.2 reports that the Ukraine's accession to the WTO resulted in welfare improvement under oligopolistic competition and strategic sourcing. A more popular approach would assume monopolistic competition and CES demand with constant demand elasticity and no strategic behavior. In this section, I use the same quantitative routines to examine how different assumptions on firm behavior affect the estimated welfare effects.

I start by assuming monopolistic competition instead of oligopolistic competition. I use the same values of normalized a_i, estimated in Appendix 2.5.2. I estimate fixed cost bounds, using a similar approach to the baseline under oligopolistic competition with variable markups. With constant markups, I recover T_i for each firm using $T_i = \frac{a_i^{\frac{1}{\sigma}} q_i^{\frac{\sigma-1}{\sigma}}}{s_i^{\frac{\sigma-1}{\sigma}}}$. Given the small number of firms in each sector, I experience an equilibrium existence problem like the one reported in Head and Mayer (2019): when some firm starts to source from some location, the resulting decline in the price index sometimes makes it regret and wish to change its decision. I resolve this problem by assuming that each observed firm in the data represents a continuous measure of identical firms with the same $\hat{T}_i$ and having identical fixed cost values. I model decisions of many replicas for each firm and find an equilibrium in which no replica of any firm has unilateral incentives to deviate (see Appendix 2.5.5 for details).

Table 2.8 compares the estimates in Subsection 2.3.2 with the estimates that I receive, assuming monopolistic competition. The total welfare improvement is smaller under oligopolistic competition with variable markups. However, this result only appears when I account for readjusting of firms' sourcing strategies. At the intensive margin, welfare improvement is larger under oligopolistic competition with variable markups despite smaller changes in consumer surplus (larger effects happen due to the improvement in variable profits, as market shares reallocate towards more efficient firms, such reallocation also happens under monopolistic competition without changing total variable profits). When I allow firms to readjust their sourcing strategies, the increase in consumer surplus becomes 2.5 times larger. At the same time, firms pay larger fixed costs to access new members of the WTO. Nonetheless, the larger increase in consumer surplus dominates the additional fixed costs paid, and the resulting welfare improvement becomes more than 1.5 times larger under monopolistic competition. Another interesting observation is that despite the substantially larger reduction in the total upstream wage bill, the net job destruction is less severe under monopolistic competition due to larger fixed cost payments.

Table 2.8: Effects of the WTO Accession, Comparison with Monopolistic Competition, th. USD

Margin Contribution	**dCS**	**dCS-MC**	**dCS-MA**	**dVP**	**dFC**	**dW**
Oligopolistic Competition						
Intensive margin	8729.9	9618.2	-888.3	987.9	0	9717.9
Total Effect	13598.4	13505.2	93.2	-173.9	2537.2	10887.2
Monopolistic Competition						
Intensive margin	9618.2	9618.2	0	0	0	9618.2
Total Effect	25522	25522	0	0	7796.4	17725.6

Note: This table provides the estimated effects of the Ukraine's accession to the WTO under different market structure assumptions. The upper panel averages the effects across sets of simulated SPNE for 46 Ukrainian food-processing sectors for each matrix of fixed costs under oligopolistic competition with variable markups. The panel below averages effects across sets of simulated equilibria for each matrix of fixed costs under monopolistic competition. In each panel, the upper row summarizes the effects holding firms' sourcing strategies fixed at the ones observed in 2007. The lower row in each panel presents the total change, accounting for firms' readjusting of sourcing strategies. dCS *represents the total change in consumer surplus, which I further break down into the change from the reduction in marginal costs* ($dCS-MC$) *and the change due to the markup adjustments* ($dCS-MA$). dVP *represents the total change in the second stage variable profits,* dFC *represents the total change in fixed costs paid,* dW *evaluates the net change in welfare.*

To understand the reasons behind the larger welfare improvement under monopolistic competition, I undertake an additional exercise. I simulate sourcing decisions of firms in the data in a similar way to Subsection 2.3.2. However, I require firms to set constant and identical markups $\frac{\sigma}{\sigma-1}$. I present the results in Table 2.9. The resulting welfare improvement is slightly smaller than under monopolistic competition. The presented results highlight an important role of markup dispersion in generating smaller welfare improvement under oligopolistic competition. Markup dispersion results in less efficient firms wanting to source more, while more efficient firms wanting to source less. At the same time, consumer surplus improves by more, when a more efficient firm adds the same sourcing location. Reduced incentives to readjust by more efficient firms reduce welfare improvement under oligopolistic competition with variable markups, with smaller fixed costs paid not compensating for smaller gains in consumer surplus.

Table 2.9: Effects of the WTO Accession, Comparison with Oligopolistic Competition with Constant Markups, th. USD

Margin Contribution	dCS	dCS-MC	dCS-MA	dVP	dFC	dW
Oligopolistic Competition with constant markups						
Intensive margin	9618.2	9618.2	0	0	0	9618.2
Total Effect	25200.3	25200.3	0	0	7871.1	17329.2
Monopolistic Competition						
Intensive margin	9618.2	9618.2	0	0	0	9618.2
Total Effect	25522	25522	0	0	7796.4	17725.6

Note: This table provides the estimated effects of the Ukraine's accession to the WTO under different market structure assumptions. The upper panel averages effects across sets of simulated equilibria for 46 Ukrainian food-processing sectors for each matrix of fixed costs under oligopolistic competition with firms constrained to set identical markups. The panel below averages effects across sets of simulated equilibria for each matrix of fixed costs under monopolistic competition. In each panel, the upper row summarizes the effects holding firms' sourcing strategies fixed at the ones observed in 2007. The lower row in each panel presents the total change, accounting for firms' readjusting of sourcing strategies. dCS *represents the total change in consumer surplus, which I further break down into the change from the reduction in marginal costs* ($dCS-MC$) *and the change due to markup adjustments* ($dCS-MA$). dVP *represents the total change in the second stage variable profits,* dFC *represents the total change in fixed costs paid,* dW *evaluates the net change in welfare.*

Strategic sourcing itself does not contribute much to the smaller welfare improvement under oligopolistic competition. However, welfare effects are still larger under monopolistic competition. Technically, strategic sourcing makes more efficient firms more cautious, as they can precisely predict how the decrease in the price index, resulting from their decision, affects their profits. More efficient firms are less likely to start sourcing from new locations compared to firms that ignore the effects of their decisions on the price index under monopolistic competition. Since more efficient firms are more cautious in adding new sourcing locations, strategic sourcing leads to undersourcing by more efficient firms and oversourcing by best-responding less efficient firms, reducing welfare improvement relative to monopolistic competition.

In Figure 2.4 I compare how firms readjust their sourcing strategies under different market structure assumptions. Firms add new members of the WTO into their sourcing strategies much more actively under monopolistic competition. Importantly, there is no contradiction to Proposition 1 showing that firms are more aggressive in their sourcing decisions under oligopolistic competition. Under monopolistic competition, firms do not attempt to manipulate outputs of competitors; absence of such incentives makes them less aggressive. On the other hand, more aggressive sourcing behavior does not necessarily imply that, for each firm, readjustment will necessarily be more profitable under oligopolistic competition. Constant markups increase scale for more efficient firms, often leading to a larger direct cost reduction effect under monopolistic competition. For such firms, the difference in the size of the direct cost reduction effect might well be larger than the strategic effect under oligopolistic competition; as a consequence, they might find it more attractive to add a new sourcing location under monopolistic competition. Only under oligopolistic competition with variable markups, firms, on average, remove the composite location of countries outside the WTO despite an unchanged sourcing potential. In the other model versions, firms would like to keep this location, due to the complementarity of sourcing locations, the more members of the WTO firms add, the more attractive keeping locations outside the WTO becomes.

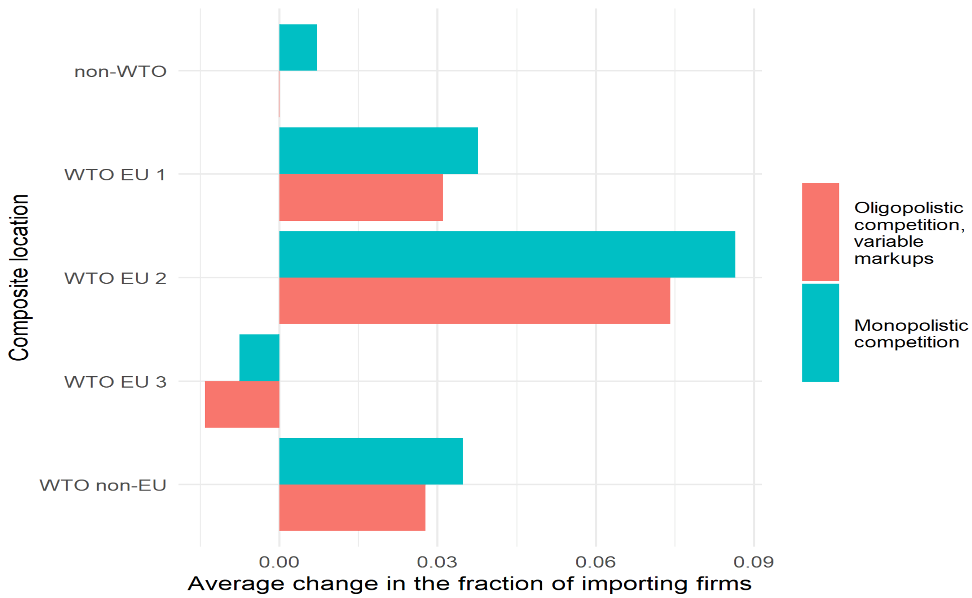


Figure 2.4: Changes in Firms' Sourcing Strategies under Oligopolistic Competition and Monopolistic Competition

Note: This figure shows average shares of firms, adding sourcing locations across the sets of simulated SPNE under oligopolistic competition with variable markups and monopolistic competition. I put names of the locations from Subsection 2.2.3 on the y-axis; the x-axis shows the share of firms starting to source from a particular location.

2.3.5 Discussion

The results of the previous sections are consistent with a sizable welfare improvement from the Ukraine's accession to the WTO. However, the quantitative gains are relatively small. Welfare gains do not exceed $18 mn even under monopolistic competition. There are many reasons why welfare gains are so small. First, I restrict attention to the Ukrainian food-processing sectors, which at that point heavily used domestic agricultural inputs. For this reason, changes in tariffs will unlikely reduce the domestic material expenditure share by much, as domestic agricultural inputs are still relatively cheaper. Second, my calculations of material expenditure shares on inputs from different countries do not reflect indirect input sourcing (the share of indirectly imported inputs could be substantial, according to Dhyne et al. (2020)). For this reason, the share of domestic material expenditures might be overestimated. Welfare gains could be larger, considering complementarity between exporting and importing decisions (my analysis abstracts from exporting). Had I taken exporting decisions into account, larger profits abroad would increase total variable profits by more, and firms could also be more active in adding sourcing locations in response to the accession of Ukraine into the WTO. Importantly, Ukraine already had MFN agreements with many members of the WTO before 2008, therefore, it is not very surprising that the resulting changes in sourcing potentials were not large.

A valid point of critique is that the difference in gains from input trade liberalization under monopolistic and oligopolistic competition might be large due to the assumed CES demand. In Subsection 2.3.4, I show that, to a large extent, the larger welfare improvement under monopolistic competition results from markups not reacting to input trade liberalization. For the exercise in this paper, I retain CES demand for easier comparability of results. Replacing lower-tier CES subutility with another subutility satisfying the Marshallian Second Law of Demand and generating variable markups in equilibrium could lead to a smaller difference in effects or reverse the ordering of effects. However, a clean comparison will require solving for oligopolistic equilibrium with a potentially different demand system. This exercise is beyond the objectives of this study and presents a good opportunity for future research. Empirical evidence for the presence of strategic behavior in firms' sourcing decisions is still missing and presents another fruitful area for future research.

2.3.6 Policy implications

The model in this paper cannot claim to be a perfect representation of reality. Partial equilibrium analysis abstracts from input price changes from input trade liberalization; I make many simplifying assumptions to ensure that I am able to solve for counterfactual within the realistic time frame. However, some implications of this work might be helpful for those responsible for trade policy decisions:

1. According to Proposition 3, from the perspective of consumers and firms, it might be better if more efficient firms actively expand sourcing strategies in response to changes in input tariffs. Under oligopolistic competition and strategic sourcing, less efficient firms might become more aggressive when confronted with new favorable sourcing opportunities. Aggressive response of less efficient firms might hinder more efficient firms to import inputs from new locations, which might lead to a less socially desirable outcome. Welfare improvement might be larger if uniform increases in fixed costs or fixed costs subsidies targeting firms with larger market shares complement input tariff cuts. Such policy measures might prevent an aggressive response of less efficient firms and fuel more active importing by more efficient firms as a best response to inaction by the former.

2. Studies quantifying welfare effects of input trade liberalization usually assume monopolistic competition with free entry or perfect competition. These assumptions allow to abstract from changes in total profits. Simplified view might engender a naive view that any input trade liberalization will be welfare-improving. However, when one assumes oligopolistic competition and assumes away free entry, consumer benefits may come at the expense of firms' profits. Ignoring oligopolistic market structure might bias consumer benefits upwards and underestimate firms' losses. The exercises in my paper show that sensitivity checks to market structure might be important when analyzing the effects of input tariff changes on consumers and firms in specific sectors.

2.4 Conclusion

In this paper, I study the implications of oligopolistic competition and strategic sourcing on welfare gains from input trade liberalization. I use Ukrainian linked trade and production data and methods from the literature on discrete games to study the effects of input trade liberalization in a model with oligopoly and strategic sourcing decisions. My results imply that input trade liberalization improves welfare, with consumer gains more than compensating the reduction in total profits by firms. In a counterfactual experiment, I evaluate the welfare effects from the accession of Ukraine into the WTO, taking into account firms' adjustment of sourcing strategies. I find that under oligopoly adjustment of sourcing strategies in response to input trade liberalization significantly contributes to overall welfare improvement. The resulting welfare improvement is smaller, and firms adjust sourcing strategies less actively than under monopolistic competition.

2.5 Appendix

2.5.1 Data Cleaning

Here I describe data cleaning routines I adopt:

1. I exclude firms with fewer than 10 employees;
2. I only include firms having non-zero records of output and revenue in the product-level data;
3. There are important discrepancies between revenue and output information in the product-level data and the transaction-level trade data. Product-level dataset records output and revenue information for goods sold, while the custom datasets records revenue and output information for products shipped abroad. Discrepancies between the shipped and the sold amounts often arise and lead to imprecise estimation of domestic revenues. Therefore, I exclude observations with small or negative values of domestic revenue if they arise during calculations. I also exclude firm-product pairs with domestic revenue less than \$2K and firms with total domestic revenues less than \$25K;
4. I exclude firms with a share of expenditures on imported intermediate inputs larger than 90%;
5. I exclude sectors with total domestic revenue less than 20 mln. USD.
6. I exclude food-processing sectors with outputs unfit for human consumption. The examples include "Animal feed" or "Animal products unfit for human consumption";
7. I exclude alcoholic beverages since the volume measure in trade and production datasets differs (tons vs. dkl).

2.5.2 Estimation of Autarky Types

To recover the estimates of fixed costs similarly to Eizenberg (2014) and Fan and Yang (2020), I compute counterfactual profits from adding or removing a particular location. Computing counterfactual profits requires estimating $\hat{T}_i$ from Subsection 1.2.2. I proceed as follows:

1. I normalize a_i for each sector z, similarly to Hottman et al. (2016),[13] and calculate it for each firm-product pair using firms' prices,[14] sectoral market shares, the value of the elas-

[13] More specifically, I normalize geometric average of values of appeal within the same sector to 1

[14] I proxy prices by unit values constructed as the per-product ratio of domestic revenues to domestically-sold output from the data

ticity of substitution from Subsection 2.2.4, and the model-consistent relationship between prices and market shares:

$$log(s^*_{zi}) - log(s^*_{zj}) = log(a_{zi}) - log(a_{zj}) + (1-\sigma)(log(p^*_{zi}) - log(p^*_{zj})) \tag{2.2}$$

2. Using the data for firms' output and the recovered values of appeal, I calculate T_i for each firm using the following formula:

$$T_i = \frac{{q_i^*}^{\frac{\sigma-1}{\sigma}} a_i^{\frac{1}{\sigma}}}{(s_i^*(1-s_i^*))^{\frac{\sigma-1}{\sigma}}} \tag{2.3}$$

3. Using sourcing strategies of firms in the data and estimates of sourcing potentials for 2007 from Subsection 2.2.3, I calculate sourcing capabilities ($\Theta_i(\mathcal{J}_i)$) for every firm i;

4. Using T_i and $\Theta_i(\mathcal{J}_i)$, I calculate $\hat{T}_i$ for every firm i:

$$\hat{T}_i = T_i \chi_{iH}^{\frac{\sigma-1}{\sigma\theta}} \tag{2.4}$$

2.5.3 Best-response Iteration Algorithm

I simulate subgame perfect Nash equilibrium using the heuristic algorithm based on Fan and Yang (2020):

1. I start from an initial strategy profile which I require to be a pure strategy SPNE;

2. Changing sourcing potentials, given the unchanged matrix of fixed costs, I search for profitable deviations for every firm in the decreasing order of $\hat{T}_i$. I check whether any firm has unilateral one-step incentives to deviate given sourcing strategies of other firms. If I fail to find profitable deviation for firm i, I implement this procedure for the next firm in the order. If firm i can profitably deviate, I search for a best response of firm i to sourcing strategies of competitors, replace the sourcing strategy for firm i in the initial sourcing strategy with this best response, and continue searching for unilateral one-step incentives to deviate starting from firm 1. The procedure stops when I do not find any firm having unilateral one-step incentives to deviate given the sourcing strategies of competitors;

3. From step 2, I have a candidate strategy profile, such that no firm has unilateral one-step incentives to deviate from it given sourcing strategies of other firms. Now, for each firm in the decreasing order of autarky types, I check whether its strategy is a best response to

other players' strategies. If that is true for all players, I conclude that the candidate strategy profile is a pure strategy SPNE, as no firm has unilateral incentives to deviate given sourcing strategies of other firms. If some firm i has unilateral multi-step incentives to deviate, I search for a best response of firm i to sourcing strategies of competitors, replace the sourcing strategy for firm i in the initial strategy profile with this best response, and implement step 2 again;

4. Procedure continues till I find an SPNE candidate, satisfying no unilateral profitable deviation criterion for any firm.

Robustness check to the order of the best response iteration: In similar discrete games, if the selected equilibrium allows some firms to move first, simulated SPNE might differ depending on who moves first. Therefore, I also conduct two sensitivity checks to verify whether different iteration order could affect the sets of simulated SPNE. First, I perform best response iteration in the increasing order of autarky types. Second, I generate a uniformly distributed random variable and use ranking by this variable within the sector to perform best response iteration. A change in the order of best response iteration in all cases results in the same set of SPNE.

2.5.4 Estimation of Input Trade Elasticity

The size of welfare gains from input trade liberalization crucially depends on the value of θ. The typical approach to estimating θ adopted in Eaton and Kortum (2002), Antràs et al. (2017) and Li et al. (2023) relies on estimating sourcing potentials for many locations and then regressing these sourcing potentials on country-level proxies for transportation costs and the state of technology. Data limitations prevent me from using this strategy, even if I use the data on country-level material shares for all manufacturing firms in the data, I can only identify sourcing potentials for 17 locations. For this reason, I use a strategy closer to Hoang (2022). I estimate θ by running the following regression equation at the firm-level:

$$log\left(\frac{\chi_{il}}{\chi_{iH}}\right) = b_c - \theta log(W_l) - \theta log(f^{\tau}_{Hl}) + log(f^{T}_{l}) + f_{cl} + \xi_{Hl} + \xi_{il} \tag{2.5}$$

In (2.5) $log\left(\frac{\chi_{il}}{\chi_{iH}}\right)$ represents natural logarithm of firm i's expenditure share on inputs from location l relative to expenditures on inputs produced domestically. b_c represents the regression intercept. $log(W_l)$ measures the logarithm of the human-capital adjusted monthly wage in location l for 2007 year.[15] $log(f^{\tau}_{Hl})$ is a function of proxies for transportation costs from l to H (I use distance and contiguity from CEPII (see Conte et al. (2022)) as proxies for transportation

[15] Similarly to Antràs et al. (2017) and Bils and Klenow (2000), I multiply monthly wages from ILO by $\exp(-0.06*$ Years of schooling) where years of schooling come from Barro and Lee (2013)

costs). f_l^T is a function of proxies for the state of technology. I use capital per worker in 2007 from Penn World Tables 10.1 (see Groningen Growth and Development Centre (2023)), as well as a country's R&D stock, control of corruption, and a number of listed firms from the World Development Indicators (WDI) as proxies for the state of technology. f_{cl} represent composite location fixed effects, where composite locations are defined in Subsection 2.2.3. ξ_{il} represents mean-zero error term which could include measurement error, accounting for the observed differences in $log\left(\frac{\chi_{il}}{\chi_{iH}}\right)$ for firms with identical sourcing strategies. ξ_{Hl} represent unobserved technology and transportation cost factors which I fail to account for in f_l^T and f_{Hl}^τ.

A potential threat to identification comes from factors in ξ_{Hl} potentially affecting w_H. In order to consistently estimate θ in the presence of potential omitted variable bias, I instrument $log(W_l)$ with $log(\text{Pop}_l)$ where Pop_l represents l's population in 2007 year coming from Conte et al. (2022).[16] Table 2.10 presents the results of estimating this equation using OLS and 2SLS, with the latter using $log(\text{Pop}_l)$ as an instrument for $log(W_l)$. The OLS coefficient on $log(W_l)$ is of a positive sign and imprecisely estimated. When I apply the instrumental variable strategy, I receive a negative and statistically significant estimate of θ, which aligns with the theoretical model. Surprisingly, the estimate I receive is close to the estimate in Antràs et al. (2017) (1.789) despite the differences in estimation strategies. The first-stage F-statistic is 178.34 implying that the instrument is sufficiently strong. Table 2.11 and Figure 2.5 show that when I replace θ from the baseline value of 1.789 to the estimate in the Table 2.10, I obtain very close results to the ones reported in Subsection 2.3.4. However, I use the former estimate from Antràs et al. (2017) since I consider it better identified.

[16]Note that this strategy requires an additional assumption that country-firm-specific measurement error is uncorrelated with $log(\text{Pop}_l)$

Table 2.10: Estimation of Input Trade Elasticity

	$log\left(\frac{\chi_{il}}{\chi_{iH}}\right)$	
	OLS	**2SLS**
b_c	17.11^{**}	16.06^{**}
	(3.16)	(3.25)
$log(W_l)$	0.15	-1.84^{**}
	(0.26)	(0.8)
$log R\&D$	0.29^{**}	0.42^{**}
	(0.08)	(0.09)
$log\frac{K}{L}$	-1.2^{**}	0.07
	(0.25)	(0.54)
Control corrupt	-0.12	0.6^{*}
	(0.16)	(0.31)
log(number of firms)	-0.25^{**}	-0.25^{**}
	(0.1)	(0.1)
log(distance)	-0.79^{**}	-1.18**
	(0.24)	(0.29)
Contiguity	-4.46^{**}	-5.88**
	(1.72)	(1.83)
Observations	1459	1459
First-stage F-statistic		178.34

Note: This table presents the results of estimating (2.5) *using firm-level data on expenditure shares on inputs imported from different countries. The left column presents the results of estimating* (2.5) *using OLS, and the right column presents the results of estimating* (2.5)*, using the logarithm of population in country l as an instrument for W_l. Country's R&D stock ($log R\&D$), country's level of capital per worker ($log\frac{K}{L}$), level of control of corruption (Control corrupt), and number of firms (log(number of firms)) proxy country-specific state of technology, while Contiguity and log(distance) proxy iceberg-type transportation costs between locations H and l. Composite location fixed effects are included in each estimating equation.*

Table 2.11: Effects of the WTO Accession, Comparison with Monopolistic Competition, $\theta = 1.84$, th. USD

Margin Contribution	**dCS**	**dCS-MC**	**dCS-MA**	**dVP**	**dFC**	**dW**
Oligopolistic Competition						
Intensive margin	8487.4	9350.8	-863.4	960.4	0	9447.8
Total Effect	13209.7	13117.4	92.3	-169.3	2457.7	10582.7
Oligopolistic Competition with constant markups						
Intensive margin	9350.8	9350.8	0	0	0	9350.8
Total Effect	24462.3	24462.3	0	0	7641	16821.3
Monopolistic Competition						
Intensive margin	9350.8	9350.8	0	0	0	9350.8
Total Effect	24765.8	24765.8	0	0	7527.4	17238.4

Note: This table provides the estimated effects of the Ukraine's accession to the WTO under different market structure assumptions. The upper panel averages the effects across sets of simulated SPNE for 46 Ukrainian food-processing sectors for each matrix of fixed costs under oligopolistic competition with variable markups. The central panel averages effects across sets of simulated equilibria for 46 Ukrainian food-processing sectors for each matrix of fixed costs under oligopolistic competition with firms constrained to set identical markups. The panel below averages effects across sets of simulated equilibria for each matrix of fixed costs under monopolistic competition. In each panel, the upper row summarizes the effects, holding firms' sourcing strategies fixed at the ones observed in 2007. The lower row in each panel presents the total change, accounting for firms' readjusting of sourcing strategies. dCS *represents the total change in consumer surplus, which I further break down into the change from the reduction in marginal costs* ($dCS - MC$) *and the change due to the markup adjustments* ($dCS - MA$). dVP *represents the total change in the second stage variable profits,* dFC *represents the total change in fixed costs paid,* dW *evaluates the net change in welfare.*

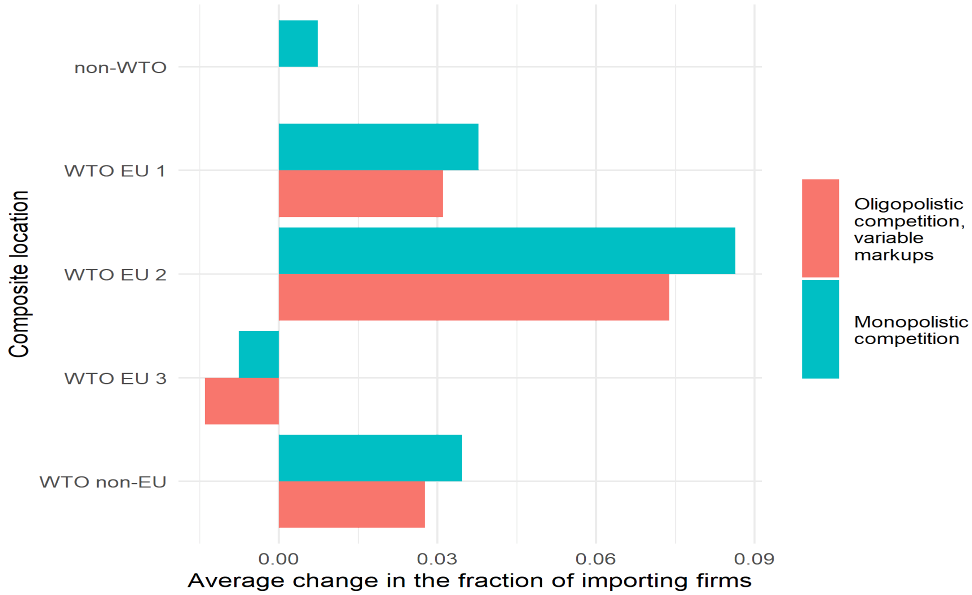


Figure 2.5: Changes in Firms' Sourcing Strategies, $\theta = 1.84$

Note: This figure shows average shares of firms, adding sourcing locations across the sets of simulated SPNE under oligopolistic competition with variable markups and monopolistic competition. I put names of the locations from Subsection 2.2.3 on the y-axis; the x-axis shows the share of firms starting to source from a particular location.

2.5.5 Finding Monopolistically-competitive Equilibrium with a Small Number of Firms

To present a neat comparison of welfare effects under oligopolistic competition and monopolistic competition, I simulate post-liberalization equilibria with a fixed number of firms for each market structure assumption through the best-response iteration algorithm. While the existence of Nash equilibria is guaranteed under oligopolistic competition with a small number of firms, there are no guarantees that monopolistically competitive equilibrium exists with a small number of firms. Best-response cycles might result from the firm not internalizing the effects of its decision on the sectoral output aggregator. For example, suppose firm i with autarky-type $\hat{T}_i$ chooses between sourcing strategy $\mathcal{J}_i^1$ and $\mathcal{J}_i^2$. Suppose, $\Theta(\mathcal{J}_i^2) > \Theta(\mathcal{J}_i^1)$. It is not difficult to show that changing $\mathcal{J}_i^1$ to $\mathcal{J}_i^2$ will increase $\mathcal{H}^1 = \hat{T}_i^\sigma \Theta(\mathcal{J}_i^1)^{\frac{\sigma-1}{\theta}} + \sum_{j \neq i} \hat{T}_j^\sigma \Theta(\mathcal{J}_j)^{\frac{\sigma-1}{\theta}}$ to $\mathcal{H}^2 = \hat{T}_i^\sigma \Theta(\mathcal{J}_i^2)^{\frac{\sigma-1}{\theta}} + \sum_{j \neq i} \hat{T}_j^\sigma \Theta(\mathcal{J}_j)^{\frac{\sigma-1}{\theta}}$. Profits of firm i from using a particular sourcing strategy $\mathcal{J}_i$

is $\frac{1}{\sigma}\frac{\hat{T}_i^\sigma \Theta(\mathcal{J}_i)^{\frac{\sigma-1}{\theta}}}{\mathcal{H}}\alpha E - \sum_{l\in\mathcal{J}_i} f_{il}$. Non-existence happens if both conditions hold:

$$\begin{aligned}
\frac{1}{\sigma}\frac{\hat{T}_i^\sigma \Theta(\mathcal{J}_i^2)^{\frac{\sigma-1}{\theta}}}{\mathcal{H}^1}\alpha E - \sum_{l\in\mathcal{J}_i^2} f_{il} \geq \frac{1}{\sigma}\frac{\hat{T}_i^\sigma \Theta(\mathcal{J}_i^1)^{\frac{\sigma-1}{\theta}}}{\mathcal{H}^1}\alpha E - \sum_{l\in\mathcal{J}_i^1} f_{il} \\
\frac{1}{\sigma}\frac{\hat{T}_i^\sigma \Theta(\mathcal{J}_i^1)^{\frac{\sigma-1}{\theta}}}{\mathcal{H}^2}\alpha E - \sum_{l\in\mathcal{J}_i^1} f_{il} > \frac{1}{\sigma}\frac{\hat{T}_i^\sigma \Theta(\mathcal{J}_i^2)^{\frac{\sigma-1}{\theta}}}{\mathcal{H}^2}\alpha E - \sum_{l\in\mathcal{J}_i^2} f_{il}
\end{aligned} \tag{2.6}$$

In this situation, firm cannot decide whether to use $\mathcal{J}_i^2$ or $\mathcal{J}_i^1$, since it does not have complete control over the effect of its decision on the sectoral output aggregator. The firm wishes to choose $\mathcal{J}_i^2$ given the $\mathcal{H}^1$, but when its decision shifts $\mathcal{H}^1$ to $\mathcal{H}^2$, it wishes to source from $\mathcal{J}_i^1$. Technically, a firm reaches a best-response cycle; even if equilibrium exists, this cycle hinders my ability to find it. However, I am able to find a number $p \in (0,1)$ s.t.

$$\frac{1}{\sigma}\frac{\hat{T}_i^\sigma \Theta(\mathcal{J}_i^1)^{\frac{\sigma-1}{\theta}}}{\mathcal{H}_p}\alpha E - \sum_{l\in\mathcal{J}_i^1} f_{il} = \frac{1}{\sigma}\frac{\hat{T}_i^\sigma \Theta(\mathcal{J}_i^2)^{\frac{\sigma-1}{\theta}}}{\mathcal{H}_p}\alpha E - \sum_{l\in\mathcal{J}_i^2} f_{il}, \tag{2.7}$$

with $\mathcal{H}_p = \hat{T}_i^\sigma(1-p)\Theta(\mathcal{J}_i^2)^{\frac{\sigma-1}{\theta}} + \hat{T}_i^\sigma p\Theta(\mathcal{J}_i^1)^{\frac{\sigma-1}{\theta}} + \sum_{j\neq i}\hat{T}_j^\sigma\Theta(\mathcal{J}_j)^{\frac{\sigma-1}{\theta}}$ Provided that no other firm has incentives to deviate, given $\mathcal{H}_p$, the choices of firms are consistent with the equilibrium since firm i is indifferent between the two strategies. Now, suppose that rather than containing the fixed number of firms I observe, the sector contains a fixed number of sets of varieties ω of single-product firms $\Omega(\hat{T})$. For each $\hat{T}$, there is a continuous measure of firms, each producing distinct $\omega \in \Omega(\hat{T})$, having autarky type $\hat{T}$, making identical input sourcing decisions and facing identical fixed costs. The measure of these firms is equal to $\mu_T(\hat{T})$.[17] Given the optimal sourcing decisions of each type of firms and the CDF of firm's productivities $F(\omega)$, the associated expression of the output aggregator is the following:

$$\mathcal{H}^{\frac{1}{\sigma}} = \left[\sum_{\hat{T}_i}\int_{\omega\in\Omega(\hat{T})}\hat{T}_i^\sigma\Theta(\mathcal{J}_i)^{\frac{\sigma-1}{\theta}}\mu_T(\hat{T})dF(\omega)\right]^{\frac{1}{\sigma}}$$

Now in the situation described above, the equilibrium is reached if fraction $(1-p)$ of mass of firms with autarky type $\hat{T}_i$ choose $\mathcal{J}_i^2$, while fraction p of mass of these firms choose $\mathcal{J}_i^1$. In this equilibrium, all firms with autarky type $\hat{T}_i$ are indifferent between $\mathcal{J}_i^1$ and $\mathcal{J}_i^2$. However, I can no longer find this equilibrium using the best-response iteration algorithm from Appendix 2.5.3. Below, I modify the best-response iteration algorithm used in Fan and Yang (2020) to find

[17] for each type $\hat{T}$, $\mu_T(\hat{T})$ represents the mass of firms with autarky type equal to $\hat{T}$

equilibria in such situations:

1. Define number N,[18] for each firm in the data, generate N replicas with autarky type of replica of firm i equal to $\frac{\hat{T}_i}{N^{\frac{1}{\sigma}}}$ and fixed costs of sourcing from location l equal to $\frac{f_{il}}{N}$;

2. In the decreasing order of $\hat{T}$, for each replica of each firm find optimal $\mathcal{J}$ given updated trade costs. If $\mathcal{J}$ is the same as in the data, I leave decision of this firm unchanged. If for any replica of firm i $\mathcal{J}$ differs and stays optimal even if all replicas of firm i use $\mathcal{J}$, I change sourcing strategy for all replicas of firm i to $\mathcal{J}$ and start iteration again. If for any replica of firm i $\mathcal{J}$ differs but the optimal sourcing strategy changes when all replicas of firm i choose $\mathcal{J}$, I include this firm in the set Λ, temporarily keep sourcing strategy for its replicas unchanged, and continue iterating;

3. If after the last iteration, Λ is empty, I define the profile of sourcing strategies as monopolistically-competitive equilibrium and finish the iteration. If Λ is non-empty, I implement iteration for each replica of each firm in Λ till all replicas are indifferent between old and new sourcing potentials.[19] When no replica of firms in Λ has incentives to deviate and no replica of no firm outside of Λ has incentives to deviate, I define the profile of sourcing strategies as monopolistically competitive equilibrium and finish iteration.

[18] In practice, N should be sufficiently large to ensure proper approximation of proportions of decision-making firms. However, N should not be too large to reduce time requirements for solving the problem. I use $N = 100$ for exercises in this paper

[19] Note that finding such allocation in practice is very difficult. Rounding routines by computational packages and low N result in best-response cycles between replicas with the fraction of firms with new sourcing strategy very close to p. I deal with this issue by allowing replicas for each firm to make decisions in a particular order. If the order interrupts because some earlier replica wants to change the decision, I interpret this as the firm becoming indifferent between past and new sourcing strategies, then I finish iteration for all replicas of this firm.

Chapter 3

Financial Frictions, Markups, and Unilateral Trade Liberalization

WITH MYKOLA RYZHENKOV AND VOLODYMYR VAKHITOV

3.1 Introduction

Developed countries often use trade policy to facilitate economic growth in developing countries. The member states of the European Union (EU), Canada, and the US often agree to unilaterally reduce import tariffs on exporters from developing countries conditionally on the recipient countries implementing legal and economic reforms.[1] Such policies often poorly meet the intended objectives. Partially, the program design is to blame: even if the allocation of resources in the recipient country is efficient, unilateral trade liberalization will not necessarily expand sectors engendering positive spillovers on the economy and showing higher growth potential. If the allocation of resources is inefficient, the designers of policies should take into account their effects on misallocation. Its bolstering might occur not only due to an expansion of sectors with heavier distortions, but also due to an increase in resource misallocation within sectors. In the case of amplification of distortions, the growth of the recipient country will slow down due to the lower aggregate productivity in the recipient country.

In this work, we focus on the aggregate and distributional implications of a unilateral trade liberalization when the recipient economy experiences distortions due to credit constraints and variable markups. Due to credit constraints, many efficient firms are unable to acquire enough capital to operate at an efficient scale. Consequently, less efficient firms with abundant access to credit produce too much compared to more productive firms facing restricted access to credit. If more efficient firms face less elastic demand, they produce too little and set larger markups. The associated distortions result in too many active firms and too much output produced by less efficient firms. Unilateral trade liberalization might either amplify or weaken the resulting resource misallocation, directly affecting productivity and welfare in the recipient's economy. We are interested in how both sources of distortions shape welfare effects of unilateral trade liberalization and its effects on the within-sector allocation of resources in the recipient country.

In 2014, members of the EU partially established the Deep and Comprehensive Free Trade Area (DCFTA) with Ukraine granting Autonomous Trade Preferences (ATP). The enacted measures unilaterally eliminated import tariffs on a large share of manufacturing product nomenclature in 2014 and postponed reciprocal measures till the start of 2016. The unilateral improvement in market access granted to Ukraine is one of the recent examples of unilateral trade liberalization. We believe that the enactment of ATP serves as a good application for our research question. At that point, Ukraine lacked well-developed financial markets. Many Ukrainian manufacturing firms reported difficulties in acquiring enough credit for production and export-

[1] Notable examples include CARIBCAN between Canada and Commonwealth Caribbean countries, the Andean Trade Preference Act, and the EU generalized system of preferences. See Ornelas (2016) for a comprehensive review

ing. At the same time, the ATP provisions did not specify measures improving the access of firms to finance, as DCFTA provisions containing the roadmap for financial reforms only came into force in 2016. Therefore, we consider the enactment of ATP as a unilateral trade liberalization between a developed donor and a recipient who faces product and credit market distortions.

Empirical analysis of matched production and trade data for Ukrainian manufacturing firms provides suggestive evidence that exporters to the EU in 2013 were significantly more capital-intensive than other firms within the same sectors. We also observe that the enactment of ATP coincided with a significant within-sector reallocation of export sales towards more capital-intensive firms. Lastly, we document a negative correlation between labor shares and capital intensity among Ukrainian non-exporters. The existing open economy general equilibrium models with credit constraints by Kohn et al. (2016), Kohn et al. (2020), and Kohn et al. (2023) can explain the first two facts; however, they are unable to explain the third fact, as they assume away markup and labor share dispersion between firms within the same sector. In this paper, we propose a quantitative dynamic general equilibrium model capable of accommodating these stylized facts.

The model features two countries: a donor and a recipient country. A donor country has an efficient allocation of factors, and a recipient faces distortions due to credit constraints and variable markups. Similarly to Kohn et al. (2020), we populate both countries with a large number of entrepreneurs who make production, consumption, and saving decisions and face idiosyncratic productivity shocks. Unlike in Kohn et al. (2020), we allow the demand elasticities for firms in the recipient country to vary with their relative prices; the resulting differences in demand elasticities bring about the dispersion in markups and labor shares in equilibrium. We also assume that the recipient country faces a debt-elastic interest rate, similarly to Schmitt-Grohé and Uribe (2003). We calibrate this model to the Ukrainian linked production and customs dataset and use it to quantify the effects of a unilateral improvement in market access by the more efficient donor on welfare and allocative efficiency of the developing recipient.

We compare two stationary equilibria before and after unilateral trade liberalization. The resulting changes benefit agents in the recipient economy, modestly improving their welfare. At the same time, better market access magnifies resource misallocation in the recipient economy. Factor terms of trade improve, and effective cost of capital increases for constrained firms; higher marginal costs reduce markup dispersion through competitive pressure of importing firms. On the other hand, constrained exporters face greater foreign demand without access to additional credit finance. They respond by hiring a suboptimal amount of labor and face a higher effective cost of capital. The latter results in greater capital misallocation, which worsens allocative efficiency. Losses in allocative efficiency due to higher capital misallocation exceed gains due to lower markup dispersion. In the absence of credit constraints, the allocation of resources improves at the expense of smaller welfare gains. Less productive non-producing entrepreneurs enjoy relatively larger benefits from unilateral trade liberalization. Reductions in transportation costs result in a higher real wage, growth in real GDP and consumption, exchange rate appreciation, and a lower real interest rate.

Literature review. This paper contributes to a large and growing literature studying how product and credit market distortions shape the effects of trade liberalization. This literature is particularly interesting due to a significantly larger role of product and factor-market distortions in developing countries, consistently with Hsieh and Klenow (2009). Bhagwati (1971) shows that in the second-best environments trade liberalization can improve welfare, while reforms directly addressing distortions will have a higher priority in the list of available instruments.[2] Chang et al. (2009) show empirically that institutions and policies improving efficiency are conducive to larger welfare gains; adopting them, countries could benefit more from trade liberalization. Intuitively, in the presence of distortions, trade liberalization will affect the economy through direct and indirect effects, with the latter happening through changes in distortions from trade liberalization. Baqaee and Farhi (2024) study responses of economies to shocks in a flexible class of static models with international production networks and arbitrary wedge-like distortions. They show that to the first-order approximation, the effect of shocks (including changes in trade costs) on real GDP decomposes into a direct effect and a reallocation effect, with the latter relevant only in models with the inefficient allocation of resources (they provide the same decomposition for the effects of shocks on welfare, however, reallocation effect is no longer irrelevant in the absence of distortions). Atkin and Donaldson (2022) use model by Baqaee and Farhi (2024) to decompose the local change in welfare from trade liberalization into the "mechanical" effect from changes in technology, changes in the factor terms of trade, change in distortion revenue, and the indirect effects from changes in distortions. The latter two effects are not present in the first-best efficient environments, however, they generate first-order welfare effects in environments with distortions. Atkin and Donaldson (2022) use simulations to show that a reduction in distortions resulting from regulation and crime increases welfare gains from trade liberalization. At the same time, the reductions of distortions due to markups and differences in access to resources do not necessarily increase gains from trade. The literature does not provide a definite answer as to whether trade liberalization is welfare-improving in the second-best environments. Bai et al. (2024) analyze implications of distortions resulting from government taxing or subsidizing individual firms, they show that trade liberalization in such an environment can generate negative fiscal externality, reducing

[2] Krueger (1984) and Dixit (1985) provide a comprehensive review of the literature discussing optimality of trade policies in second-best environments.

welfare gains or even generating welfare losses from better market access. Święcki (2017) argues that in the presence of labor market distortions trade liberalization might reallocate labor towards sectors with marginal product of labor distorted down amplifying misallocation and reducing welfare gains from trade liberalization. Dix-Carneiro et al. (2021) analyze the response of the economy with more distorted formal and less distorted informal sectors to trade liberalization. Authors show that reallocation of resources to formal firms might amplify gains from trade liberalization. Numerous works including Costa-Scottini (2017), Berthou et al. (2020), and Chung (2020) use static international trade models with distortions and show that gains from trade liberalization in such environments can be larger or lower than those derived in Arkolakis et al. (2012) for the first-best efficient environments. Unlike these authors, we do not study the general implications of resource misallocation. We rather focus on two specific sources of resource misallocation and study their individual and joint implications for dynamic welfare and allocative efficiency effects from unilateral trade liberalization.

This paper contributes to a stream of literature studying the response of the economy to trade integration and allowing for markup dispersion. The existing literature does not provide an unambiguous answer as to whether markup dispersion increases or reduces associated gains. Edmond et al. (2015) show that welfare increases by more than in Arkolakis et al. (2012) under oligopolistic competition in intermediate good markets. Larger welfare gains occur, as declining markup dispersion increases aggregate productivity. Arkolakis et al. (2018) study a general class of models with monopolistic competition and demand systems with variable demand elasticities. They show that under a number of assumptions, trade integration increases welfare by less than in Arkolakis et al. (2012). Holmes et al. (2014) and Feenstra (2018) show that the latter result requires the markup distribution to be invariant to trade costs; this condition holds in the case of unbounded Pareto distribution of productivity but does not need to hold generally. For instance, de Blas and Russ (2015) use model of Bernard et al. (2003) to derive the effects of trade openness on the distribution of markups. Melitz and Ottaviano (2008), Zhelobodko et al. (2012), Feenstra and Weinstein (2017), Parenti et al. (2017), Feenstra (2018) emphasize that in models with variable markups and firm heterogeneity, trade integration can sizably improve welfare through pro-competitive effects from changes in markup distribution. In contrast, Demidova (2017) finds that the pro-competitive effects of trade integration can be negative in the model with revenue-generating import tariffs and without the linear outside good. Cavenaile et al. (2022) study the response of trade liberalization in the dynamic model with variable markups and firms' innovation activities; they show that trade integration might increase market concentration and polarization of markup and productivity distributions (Impullitti and Licandro (2018) and Aghion et al. (2022) arrive at similar findings in the dynamic model with variable markups and firms' innovation activities). Pro-competitive effects in these models arise, as the importing country reduces import tariffs, making importers more competitive relative to domestic firms. In our paper, we show that pro-competitive effects might happen in an exporting country even if the importing country reduces trade barriers and the exporting country does not. In this case, domestic firms become less competitive due to rising factor terms of trade, these changes fuel indirect pro-competitive effects reducing markup dispersion. We show that such indirect pro-competitive effects serve as a primary driver behind the allocative efficiency improvement from a unilateral trade liberalization in a recipient economy with credit constraints and variable markups.

This paper also contributes to the substantial literature that studies how credit constraints shape the effects of trade liberalization. Antràs and Caballero (2009) show that in the presence of financial frictions, trade liberalization can bring about additional capital inflows from capital-poor to capital-scarce countries, which reverses the predictions of the Heckscher-Ohlin-Mundell paradigm. Buera and Shin (2013), Moll (2014), and Kohn et al. (2023) show that credit constraints can slow down the reallocation of resources in response to efficiency-improving events like trade liberalization. Manova (2012) and Leibovici (2021) show that credit constraints can distort the comparative advantage of countries away from capital-intensive sectors, changing their response to trade liberalization. Berman and Héricourt (2010), Midrigan and Xu (2014), Muûls (2015), and Kohn et al. (2016) show that credit constraints can create additional obstacles for firms when they want to start selling to a new market, as the associated opportunity costs are greater for firms facing binding borrowing constraints. Greater opportunity costs distort entry into the exporting market and weaken the reallocation of market shares towards more productive firms. Kohn et al. (2016) show that credit constraints slow down the response of trade flows to trade liberalization, they grow gradually, as firms invest in new assets. Kohn et al. (2020) show that the model with credit constraints can replicate the observed sluggish response of exports of Mexican firms to episodes of large devaluations. Brooks and Dovis (2020) compare the effects of trade liberalization in models featuring backward-looking and forward-looking collateral constraints. They show that trade liberalization increases misallocation in models with backward-looking collateral constraints, however, models with forward-looking collateral constraints reverse these predictions. Alfaro et al. (2022) examine responses of firms making decisions on exporting, importing, and R&D investments to exchange rate shocks in a dynamic model with credit constraints. Greater reliance on imported intermediate inputs results in a weaker response of innovation and exporting activities to exchange rate devaluation, when exporting and importing decisions affect firms' cash flow and credit constraints. Tetenyi (2022) shows that if capital markets are integrated, financial liberalization increases gains from trade liberalization. We contribute to this literature by studying how differences in demand elasticities between firms can modify the effects of unilateral trade liberalization in the presence of credit constraints.

Our paper is the first one studying the implications of two sources of resource misallocation (credit constraints and variability in markups) and their interactions on the long-run effects of the unilateral trade liberalization. Most papers allowing for both sources of resource misallocation[3] analyze their implications on aggregate total factor productivity (TFP) in a closed-economy environment and abstract from international trade. Kim and Lee (2022) allow for trade in intermediate inputs, but they abstract from trade in goods. We also contribute to a large and important literature studying the effects of unilateral trade liberalization on developing recipients.[4]

Structure of a paper. We organize the rest of the paper as follows. In Section 3.2, we describe the data used for the analysis and document several stylized facts on the patterns of resource allocation between Ukrainian manufacturing firms exporting to the EU. In Section 3.3, we develop a small open economy model motivated by the stylized facts we outline in Section 3.2. Sections 3.4 and 3.4.2 describe the calibration approach and contain a description of the economy in a calibrated steady state. In Subsection 3.4.3, we study the long-run effects of a unilateral trade liberalization and look at the way credit constraints and variable markups affect the long-run response to these changes. In Subsection 3.4.3, we examine changes across stationary equilibria before and after trade liberalization.

3.2 Motivating Evidence

3.2.1 Institutional Background

In 2014, Ukraine and member countries of the European Union signed an Association Agreement (AA). The economic provisions of the Agreement were signed in June 2014. The agreement has established The Deep and Comprehensive Free Trade Area (DCFTA) between Ukraine and countries of the EU. AA contained provisions on bilateral trade liberalization as well as a roadmap for reforms in a number of sectors, including the financial one. The economic provisions of the DCFTA became active in January 2016, while the full scope of the AA came into force since September 2017.[5]

In early spring 2014, Ukraine faced an annexation of Crimea and the onset of the war in Donbas. These events motivated the governments of the EU member states to launch ATP to

[3] including Giuliano and Zaourak (2017), Galle (2020), Boar and Midrigan (2024), Tsiflis (2022)

[4] An interested reader can examine comprehensive literature reviews by Ornelas (2016), Goldberg and Pavcnik (2016), Atkin and Khandelwal (2020), Atkin and Donaldson (2022)

[5] An interested reader can find more information by the link EU trade relations with Ukraine. Facts, figures and latest developments.

help Ukraine stabilize the economy.[6] ATP reduced import tariffs on Ukrainian goods partially implementing the provisions of the DCFTA agreement two years earlier than planned (see Landesmann et al. (2024)). We consider the time interval between April 2014 and December 2015 as a period of an unexpected unilateral trade liberalization introduced for an emerging recipient by a more economically-developed bloc of donor countries.

Back then, Ukraine did not have a well-developed financial sector, and firms considered scarce access to credit as one of the major obstacles for exporting and production.[7] Reported struggles to attain sufficient financial resources motivate our choice to model Ukrainian firms facing credit constraints.

3.2.2 Firm-level Data

Data description. We construct a firm-level dataset by matching the universe of Ukrainian manufacturing firms' financial statements with information on exporting and importing transactions from the official customs data from 2011 to 2019. The first dataset contains information on annual balance sheets, income statements, the annual average number of employees, and an industry identifier. For every firm, customs records contain shipment-level information on the exporter, value, date, destination, and a 10-digit Harmonized System (HS) product code.

Scientists working with Ukrainian firm-level datasets make a number of standard sample restrictions. In accordance with them, we filter out some groups of firms. We keep only firms that operate in manufacturing, that is, the industry identifier of which corresponds to Section C of KVED classification (divisions 10-33),[8] and did not change their primary 4-digit KVED industry during the years of the sample. We drop firms registered in the Autonomous Republic of Crimea, Sevastopol, Donetsk, and Luhansk regions[9] to avoid bias from reporting problems experienced by these firms after 2014. We restrict sample to firms with net after-tax revenue no smaller than 500 th. 2012 UAH (~ EUR 50 th. in 2012), book value of tangible assets no smaller

[6]The European Commission declared in its press release on March 11, 2014: "Following the recent unprecedented events in the country and the security, political and economic challenges faced by Ukraine, on 6 March 2014 the European Council stated its support to help stabilize Ukraine's economy with a package of measures. One of these was the granting of autonomous trade preferences, set out in today's proposal for an EU Council/Parliament Regulation." Source: European Commission proposes temporary tariff cuts on Ukrainian exports to the EU, Press Release, Brussels, 11 March 2014

[7]According to the Business Tendency Survey by the Institute for Economic Research and Policy Consulting, the share of manufacturing firms that mentioned a shortage of external financing as the obstacle for international trade varied between 34% and 42% in 2010-2012 (see, e.g., Chenash and Kuziakiv, 2013). At the beginning of 2014, 38.5% of manufacturing firms in Ukraine mentioned that lack of credit and investment had been the main obstacle to full utilization of the benefits provided by the DCFTA (see, e.g., IER, 2014).

[8]Ukrainian Classification of Types of Economic Activities, 2010 edition, (KVED-2010) based on NACE Rev. 2 that has been implemented since January 1, 2012.

[9]The regions of Ukraine that were fully or partially occupied since 2014

than 100 th. 2012 UAH (~ EUR 10 th. in 2012), and at least 10 employees.[10] Finally, we keep only firms with a single activity spell during the years of our analysis.

Construction of variables. We measure capital using the book value of tangible assets. We construct a measure of capital in period t as the average of a deflated book value of tangible assets at the beginning of t and the end of t. We deflate net after-tax sales using the Consumer Price Index, we deflate the book value of tangible and total assets using sectoral producer price indices.[11] We convert export values into Ukrainian hryvnia (UAH) using the USD/UAH exchange rate on the transaction day, and we further deflate them using the consumer price index[12]. We categorize a firm as an exporter to the EU in year t if this firm has sold a positive amount to at least one of the EU member countries in year t.

Descriptive statistics. We analyze developments affecting Ukrainian firms between 2013 and 2015; Table 3.1 contains the average values for the selected variables over the period of interest. An average firm in 2013 generated 99 UAH mn. in revenues and possessed 104 UAH mn. in assets, employed 194 workers, and utilized capital with the average book value of 38 UAH mn. The descriptive statistics from Table 3.1 highlight that the changes due to the enactment of ATP were associated with a more active export participation of Ukrainian manufacturing firms. The share of firms exporting to the EU increased from 24.7% to 33.0%, while exporters to the EU increased their ratio of total EU export revenues to total revenues from 17.6% to 18.8%.

Table 3.1: Selected Descriptive Statistics of a Sample

Indicator	**2013**	**2014**	**2015**
Main characteristics			
Sales net of tax, mean, UAH th.	99,373.2	110,126.9	99,994.2
Book value of tangible assets, mean, UAH th	37,973.6	40,560.7	36,949.3
Book value of total assets, mean, UAH th	104,284.6	114,769.1	114,613.3
Employment, mean, persons	194.3	191.0	184.8
International trade			
Share of exporters to the EU members, %	24.7	29.5	33.0
Share of exports to EU members in total sales, %	17.6	17.3	18.8
Financial conditions			
Leverage, mean	0.150	0.158	0.158

Note: This table provides average values of selected variables in the constructed dataset between 2013 and 2015.

[10]Financial statements of Ukrainian firms provide information on the number of employees at the start and by the end of the year. We use reported numbers to construct an annual average number of employees for the firm

[11]Both consumer and producer price indices come from the State Statistic Service of Ukraine, we use 2012 as a base year

[12]using 2012 as a base year

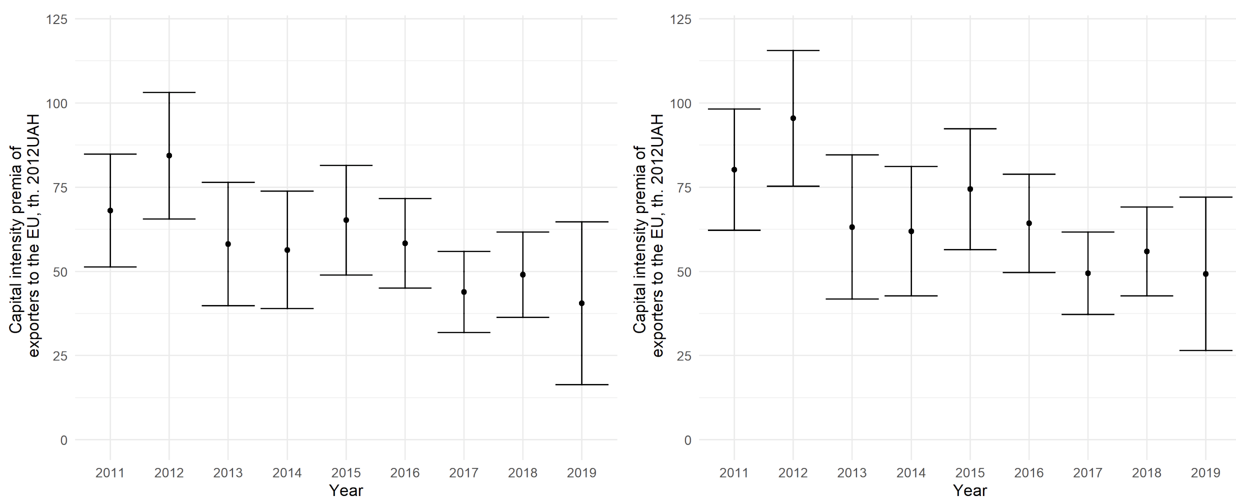
3.2.3 Stylized Facts

In this subsection, we document a number of stylized facts that motivate our study.

Fact 1. Exporters to the EU members were more capital-intensive in comparison to other firms. In panel (a) of Figure 3.5, we plot the coefficients of a regression of the capital-labor ratio for each firm on the export status to the EU. We find that throughout the years of the sample, manufacturing exporters to the EU were, on average, more capital-intensive compared to firms not exporting to the EU. Bernard and Jensen (1999) report similar results for the US, Ukrainian exporters are more capital intensive despite Ukraine not well-known for comparative advantage in capital-intensive production. In fact, between-sector technology differences do not suffice to explain the observed capital-intensity premium. In panel (b) of Figure 3.5, we plot the coefficients of the same regression estimated adding sectoral fixed effects. The capital intensity premium of exporters to the EU remains statistically significant, implying that more capital-intensive firms were more likely to export to the EU members within the same sectors.

Figure 3.1: Capital Intensity Premia: Exporters to the EU vs. Non-exporters to the EU

(a) Excluding industry fixed effects (b) Including industry fixed effects



Note: The charts show the coefficients from regressing capital-labor ratio on the indicator of the firm exporting to the EU for each year in the sample. We construct 90% confidence bands using heteroskedasticity-robust standard errors.

It is difficult to explain such differences in capital intensities between firms within the same sectors using models assuming efficient resource allocation. Firms might have differed in marginal revenue products of factors, such differences are plausible in light of the results in Hsieh and Klenow (2009). One way to rationalize such differences in capital intensity is by allowing for credit constraints. When firms face credit constraints, they often fail to obtain enough capital to produce at their optimal scale. As a result, the marginal revenue product of capital (MRPK) is greater than the efficient opportunity cost of capital for these firms. In the model with firm heterogeneity, credit constraints bring about between-firm differences in MRPK.[13] Models with credit constraints predict that credit-constrained firms face additional opportunity costs when they access a new market. At the same time, firms serving foreign consumers might face tighter credit constraints. The capital intensity for such firms will decline, as they can only meet greater demand by hiring workers.

Fact 2. Across Ukrainian continuing exporters to the EU member countries, we observe a reallocation of export revenues to the EU member countries towards more capital-intensive firms from 2014 to 2015

We perform an event-study analysis and run the following regression for a set of continuing exporters to the EU between 2011 and 2016:

$$\log Y_{ijt} = \beta_i + \beta_{jt} + \sum_{\substack{\tau \in \{2011,2016\} \\ \tau \neq 2013}} \beta^{\tau} \mathbb{1}\{\tau = t\} \times \widetilde{CapLab}_{ij}^{2013} + \Gamma X_{ijt} + \varepsilon_{ijt}, \tag{3.1}$$

In (3.1), Y_{ijt} denotes volume of export sales to the EU member country of firm i in industry j in year t, β_i is a firm fixed effect, β_{jt} is an industry-year fixed effect, $\mathbb{1}\{\tau = t\}$ is an indicator function equal to one if year t is equal to τ (reference year is 2013), $\{\beta^{\tau}\}_{\tau=2011}^{2016}$ is a sequence of coefficients representing EU exports sales premia of more capital-intensive firms, $\widetilde{CapLab}_{ij}^{2013}$ is a standardized measure of capital intensity for firm i in industry j in 2013, X_{ijt} is a matrix of controls that includes log of total sales, while ε_{ijt} is the error term. We standardize capital intensity by subtracting the average capital intensity in industry j in 2013 from the firm i's capital intensity in 2013, and dividing it by a standard deviation of the capital intensities of firms in industry j in 2013. We perform such a standardization to account for sectoral differences in input mix. The null hypothesis is $\{\beta^{\tau}\}_{\tau=2011}^{2016} = 0$, export sales premium of a firm with one standard deviation higher capital intensity relative to its peers in 2013 was not significantly different during the 2011-2016 years. We cluster standard errors at the firm level.

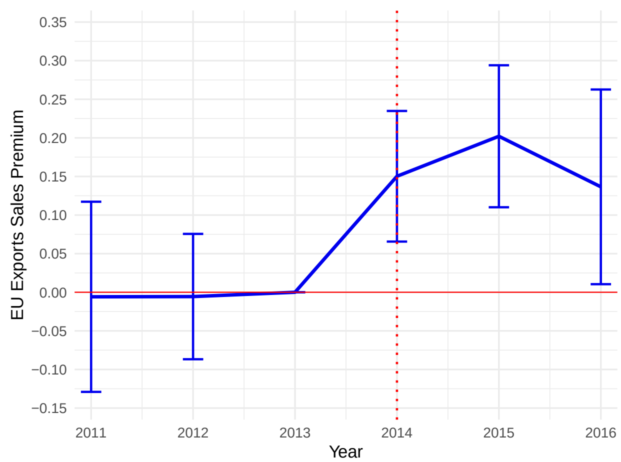
We look at the sequence of $\{\beta^{\tau}\}_{\tau=2011}^{2016}$ in Figure 3.2. Each member of this sequence shows the difference between the EU export sales premium during the 2011-2016 years and 2013 for firms with one standard deviation higher capital intensity relative to the industry mean in 2013. Figure 3.2 plots these coefficients with the corresponding 90% confidence intervals. The results

[13] Theoretically, dispersion of capital intensities might result from differences in marginal revenue product of labor due to firing and hiring constraints or due to dispersion in wage markdowns. Unfortunately, data limitations do not allow us to obtain convincing evidence of these forces at work. Therefore, we attribute differences in capital intensities between firms to differences in MRPK

suggest that firms continuing to export to the EU with a one standard deviation higher capital intensity relative to peers experienced significantly higher growth in export revenues to the EU member countries one year after the establishment of ATP. In particular, exporters with one standard deviation higher capital intensity expanded export sales to the EU member countries by 15% more than exporters with the average capital intensity, while the estimated premium increased further to 20% in 2015. If more capital-intensive firms are less credit-constrained, our findings imply that such exporters responded to unilateral trade liberalization with faster growth in export sales to the EU members.

In panel (a) of Figure 3.6, we perform the placebo experiment, in which instead of 2013

Figure 3.2: EU Export Sales Premium of Firms with Higher Capital Intensity



Note: Figure plots a set of identified $\{\beta^{\tau}\}_{\tau=2011}^{2016}$ in regression (3.1). We cluster standard errors at the firm level. The sample includes only firms continuously exporting to the EU member countries from 2011 to 2016. We plot 90% confidence bands. The reference year is 2013. The red dotted line indicates a year of implementing ATP.

we use 2012 as a reference year. We also recalculate $\widetilde{CapLab}_{ij}^{2013}$ using 2012 instead of 2013. The placebo exercise does not show that export revenues from the EU member countries were growing significantly faster before 2014 for more capital-intensive firms. Even if firms faced differential trends, there is no indication that capital intensities might have affected these trends. A potential threat to identification arises if firms anticipated the enactment of ATP and strategically invested to benefit more in terms of their export revenues. However, this critique is hardly consistent with the fact that no one expected the annexation of Crimea and a start of the Donbas war in 2014; ATP was among the measures to support Ukraine going through these events (see Subsection 3.2.1 for more details). One might argue that more capital-intensive firms were growing faster only because more capital-intensive firms were more efficient. It is important to note that the regression (3.1) controls for the total sales of the firms. Therefore, we can conclude that two exporters to the EU countries of the same size still experienced different growth in export sales to the EU members depending on their capital intensity. Given that the enactment of ATP coincided with additional non-tariff trade barriers imposed by the Russian Federation on Ukrainian products, the resulting firm-level reallocation of Russian exports to the EU members might contaminate our findings. Firms selling to Russia might have kept greater capacity, which in its turn could simultaneously make them more capital-intensive and more likely to redirect sales to the EU member countries. In panel (b) of Figure 3.6 we split the sample into two sub-samples based on the firms' exporting status to Russia in 2013. We do not see significant differences in the effects between the two groups. Therefore, we can conclude that the simultaneously imposed trade barriers by Russia did not play a significant role in explaining the observed reallocation of export sales to the EU members towards more capital-intensive firms.

It is hardly surprising that trade liberalization might reallocate market shares towards more capital-intensive firms due to trade liberalization. Heckisher-Ohlin-Vanek theory predicts that trade liberalization leads to the expansion of sectors more intensive in factors with greater relative abundance. However, this theory cannot explain the reallocation of market shares towards more capital-intensive firms within the sectors we observe in Figure 3.2. The model in which firms face credit constraints (e.g., Manova (2012), Midrigan and Xu (2014), Kohn et al. (2020)) might help explain both within-sector heterogeneity in capital intensities across firms and the reallocation of export sales to the EU members towards more capital-intensive firms. Within the same sectors, the observed reallocation might happen if not credit-constrained firms have larger capital intensities and face smaller difficulties in meeting an increase in demand due to unilateral trade liberalization.

Fact 3. We observe a statistically significant negative cross-sectional relationship between labor shares and capital intensities across non-exporters at the firm level.

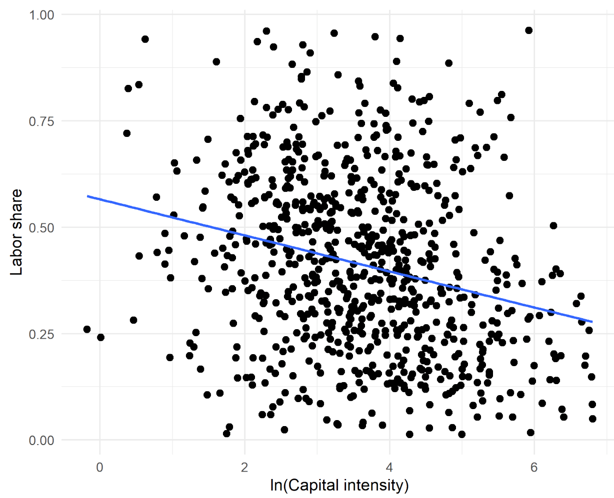
Economic theory predicts that the ratio of wage bill to value added for a non-exporting single-product firm constitutes an inverse measure of markup in the absence of differences across firms in labor output elasticities and labor adjustment costs. If α_j is a labor output elasticity for an industry j, we can express markup of firm i working in sector j in the period t as

$$\mu_{ijt} = \frac{VAD_{ijt}}{W_{ijt}L_{ijt}} \times \alpha_j, \tag{3.2}$$

where VAD_{ijt} represents the firm's value added (total revenues net of material expenditures), while $W_{ijt}L_{ijt}$ represents the firm's wage bill.

In models of Melitz (2003) or Kohn et al. (2023), differences in labor shares only reflect differences in technologies between sectors. However, the cross-sectional variation in labor shares that we observe within sectors is inconsistent with this prediction.

Figure 3.3: Cross-sectional Relationship Between Capital Intensity and Labor Share at the Firm Level in 2013



Note: The chart scatters the logarithm of firm-level capital intensity against the firm-level ratio of the firm's wage bill to value added for Ukrainian non-exporting firms in 2013. Logarithm of capital intensity is on the horizontal axis, labor share is on the vertical axis.

Figure 3.3 reveals a substantial dispersion in labor shares among Ukrainian non-exporting firms in 2013. What is more interesting is that labor shares negatively correlate with the logarithm of capital intensity. Importantly, technology differences between sectors do not fully explain this relationship. In Table 3.2, we plot the results of regressing labor share of non-exporting firms in 2013 on the natural logarithm of capital intensity. The coefficient is negative and retains statistical significance even after controlling for regional and sectoral fixed effects. We can explain this cross-sectional relationship if we allow for preferences satisfying the Marshallian Second Law of Demand (MSLD). In this case, labor shares might be smaller for more capital-intensive firms because they are more efficient and, therefore, set larger markups in equilibrium.

3.3 Quantitative Model

Motivated by the stylized facts presented in Section 3.2, we build a small open economy model with credit constraints and variable markups. The model features two countries, foreign and domestic. We denote them by, respectively, f and d. We assume that country f has an efficient allocation of resources, while country d experiences distortions due to credit constraints

Table 3.2: Cross-sectional Relationship Between Capital Intensity and Labor Share for not Exporting Firms in 2013

	Labor share		
Intercept	0.57**	0.52**	0.46**
	(0.023)	(0.047)	(0.074)
$log\left(\frac{K}{L}\right)$	−0.042**	−0.038**	−0.021**
	(0.006)	(0.006)	(0.008)
Industry FE	No	2d	4d
Region FE	No	Yes	Yes
N	764	764	764

Note: The table above presents coefficients of regressing labor shares on the natural logarithm of capital intensity for Ukrainian non-exporting firms in 2013. We put heteroskedasticity-robust standard errors in parentheses. The second equation includes regional and 2-digit industry fixed effects. The third equation includes regional and 4-digit industry fixed effects (FE). ** implies that the coefficient is statistically-significant at the 95% level.

and variable markups. The setup shares similarities with Kohn et al. (2020); however, we differentiate from them by allowing for variable demand elasticities with the demand system similar to Gopinath et al. (2020); we also allow for steady-state trade imbalances. Similarly to Kohn et al. (2020), the numeraire in this economy is the domestic final good. The real exchange rate, RER_t, is the price of the foreign final good expressed in units of the domestic final good, $\text{RER}_t = \frac{P_{ft}}{P_{dt}}$. There are three types of agents in this economy: entrepreneurs, final good producers, and non-profit making financial intermediary trading assets on foreign financial markets.

3.3.1 Entrepreneurs

Preferences. Domestic economy houses a unit measure of infinitely-lived risk-averse entrepreneurs, which are heterogeneous in the level of predetermined assets (a_{it}) and idiosyncratic productivity (z_{it}). Each entrepreneur maximizes expected lifetime utility from consuming final goods. Entrepreneurs maximize a constant relative risk aversion (CRRA) utility function from consuming a final good with a coefficient of relative risk aversion ν:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{C_{it}^{1+\nu}}{1+\nu}, \tag{3.3}$$

where C_{it} represents an individual consumption of a final good by a domestic entrepreneur i in period t, and $\beta < 1$ is a discount factor.

Technology. Each entrepreneur i owns an intermediate good firm producing variety ω. We do not model occupational choice and assume that each entrepreneur i each period supplies a unit of labor to a competitive labor market. We assume that each firm produces a single product. Therefore, the model allows for a one-to-one mapping between individual i and variety ω.

Intermediate good producers use Cobb-Douglas production function with labor and capital to produce variety ω with labor $l_t(\omega)$ and capital $k_t(\omega)$:

$$y_t(\omega) = z_t(\omega) k_t(\omega)^{\alpha} l_t(\omega)^{1-\alpha}, \tag{3.4}$$

where $y_t(\omega)$ represents the firm's output of ω, $\alpha < 1$ is capital output elasticity, $z_t(\omega)$ denotes the productivity level of the producer of ω.

$k_t(\omega)$ has the following law of motion:

$$k_{t+1}(\omega) = (1-\delta) k_t(\omega) + x_t(\omega) \tag{3.5}$$

with $\delta < 1$ denoting a depreciation rate and $x_t(\omega)$ denoting the entrepreneur's investment.

Productivity $z_t(\omega)$ follows log-normal AR(1) process with the standard deviation of productivity shocks (ε_t) σ_ε and persistence parameter ρ_ε:

$$\log z_t(\omega) = (1-\rho_z)\mu_z + \rho_z \log z_{t-1}(\omega) + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \sigma_\varepsilon^2) \tag{3.6}$$

We assume that each entrepreneur owns a predetermined amount of assets $a_t(\omega)$. Labor is not subject to any hiring constraints or frictions, firms can hire as much labor as they need. Entrepreneurs finance capital using assets or issuing one-period uncontingent bonds.

$$d_t(\omega) = (1 + R_{dt-1})(k_t(\omega) - a_t(\omega)) \tag{3.7}$$

In addition to a natural borrowing limit, each producer can borrow up to a fraction of its capital according to a backward-looking collateral constraint:

$$d_t(\omega) \leq \theta k_t(\omega), \tag{3.8}$$

where θ represents a fraction of capital that can serve as collateral and measures the degree of enforceability of financial contracts in the economy. In the limit, as $\theta \to \infty$, credit constraints dissipate.

International Trade. The entrepreneur can sell intermediate goods at home or abroad. It is up to the entrepreneur to decide whether to sell only to home consumers or to sell both at home and abroad. We denote the exporting indicator as $e_t(\omega)$: if $e_t(\omega) = 1$, the entrepreneur exports abroad; exporting requires fixed costs $F > 0$ in units of labor. Exporters also have to pay iceberg-type transportation costs $\tau_{df} > 1$ for each unit of output sold to foreign consumers. $y_t(\omega) = y_{dt}(\omega)$ for a non-exporting firm, $y_t(\omega) = y_{dt}(\omega) + \tau_{df} y_{ft}(\omega)$ for an exporting firm.

Timing. We adopt timing assumptions similar to those in Kohn et al. (2020). Entrepreneurs start the period, already aware not only of their random realizations of $z_t(\omega)$, but also of the predetermined levels of $a_t(\omega), d_t(\omega), k_t(\omega)$. Based on this knowledge, entrepreneurs decide on $l_{dt}(\omega), e_t(\omega), y_{dt}(\omega), y_{ft}(\omega), p_{dt}(\omega), p_{ft}(\omega)$, and pay the fixed costs of exporting if $e_t(\omega) = 1$. When entrepreneurs receive revenues from consumers, they pay the principal and interest on debt, collect profits, wages, and interest on assets invested in securities of other entrepreneurs, and allocate the proceeds into C_{it} and $a_{t+1}(\omega)$. At the end of each period, entrepreneurs observe realizations of next period's productivities, given the predetermined $a_{dt+1}(\omega)$, they decide on their capital needs next period and issue securities $\frac{d_{t+1}(\omega)}{1+R_{dt}}$.

3.3.2 Final Good Producers

The final good comes from perfectly competitive final good producers that assemble it using imported and domestically produced varieties (respectively, ω_f, ω). We denote the aggregate production of the final good in country d at time t by Y_{dt} and assume its use either for consumption or investment in capital. Final good producers use a bundle of differentiated intermediate inputs $y_{dt}(\omega)$ with $\omega \in \Omega_{dt}$, we denote Ω_{dt} as the set of intermediate input varieties available for purchase in country d at time t. Similarly to Gopinath et al. (2020), we partition Ω_{dt} into the set of domestically-produced varieties Ω_{ddt} and the set of imported varieties Ω_{dmt}. We normalize $|\Omega_{ddt}| = 1$.

Final good producers aggregate varieties using the aggregator from Kimball (1995):

$$\frac{1}{|\Omega_{ddt}|}\int_{\Omega_{ddt}} \Upsilon\left(\frac{|\Omega_{ddt}| y_{dt}(\omega)}{Y_{dt}}\right) d\omega + \frac{1}{|\Omega_{dmt}|}\int_{\Omega_{dmt}} \Upsilon\left(\frac{|\Omega_{dmt}| y_{dt}(\omega_f)}{Y_{dt}}\right) d\omega_f = 1, \tag{3.9}$$

where $y_{dt}(\omega_f)$ is the volume of ω_f a foreign firm exports to domestic consumers. We denote $q_{dt}(\omega) = \frac{y_{dt}(\omega)}{Y_d}$ and make use of the specification of $\Upsilon(q)$ from Klenow and Willis (2016):

$$\Upsilon(q) = 1 + (\sigma - 1)\exp\left(\frac{1}{\varepsilon}\right)\varepsilon^{\frac{\sigma}{\varepsilon}-1}\left[\Gamma\left(\frac{\sigma}{\varepsilon}, \frac{1}{\varepsilon}\right) - \Gamma\left(\frac{\sigma}{\varepsilon}, \frac{q^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right)\right] \tag{3.10}$$

We assume that $\sigma > 1$, $\varepsilon \geq 0$ and $\Gamma(s,x)$ being the incomplete Gamma function:

$$\Gamma(s,x) := \int_x^\infty t^{s-1} e^{-t} dt \tag{3.11}$$

If $\varepsilon \geq 0$, the demand system satisfies MSLD: firms with lower prices face lower demand elasticities.

Taking the prices of ω, ω_f as given, final good producers choose outputs of intermediate goods $y_{dt}(\omega)$ to maximize profits:[14]

$$\max_{y_{dt}(\omega_f),y_{dt}(\omega)} P_{dt}Y_{dt} - \int_{\Omega_{ddt}} p_{dt}(\omega)y_{dt}(\omega)d\omega - \text{RER}_t\int_{\Omega_{dmt}} p_{dt}(\omega_f)y_{dt}(\omega_f)d\omega_f \tag{3.12}$$

s.t. (3.13)

$$\frac{1}{|\Omega_{ddt}|}\int_{\Omega_{ddt}} \Upsilon\left(\frac{|\Omega_{ddt}|y_{dt}(\omega)}{Y_{dt}}\right)d\omega + \frac{1}{|\Omega_{dmt}|}\int_{\Omega_{dmt}} \Upsilon\left(\frac{|\Omega_{dmt}|y_{dt}(\omega_f)}{Y_{dt}}\right)d\omega_f = 1, \tag{3.14}$$

We can derive the following expression for the price index P_{dt}

$$P_{dt} := \int_{\Omega_{ddt}} p_{dt}(\omega)\frac{y_{dt}(\omega)}{Y_{dt}}d\omega + RER_t\int_{\Omega_{dmt}} p_{dt}(\omega_f)\frac{y_{dt}(\omega_f)}{Y_{dt}}d\omega_f \tag{3.15}$$

When final good producer maximizes profits, (3.16) provides the expression for inverse demand for variety ω:

$$p_{dt}(\omega) = \Upsilon'\left(\frac{y_{dt}(\omega)}{Y_{dt}}\right)\frac{P_{dt}}{D_{dt}} = \frac{\sigma-1}{\sigma}\exp\left(\frac{1-\left[\frac{y_{dt}(\omega)}{Y_{dt}}\right]^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right)\frac{P_{dt}}{D_{dt}} \tag{3.16}$$

In (3.16), D_{dt} is the demand index defined by:

$$D_{dt} = \int_{\Omega_{ddt}} \Upsilon'\left(|\Omega_{ddt}|\frac{y_{dt}(\omega)}{Y_{dt}}\right)\frac{y_{dt}(\omega)}{Y_{dt}}d\omega + \int_{\Omega_{dmt}} \Upsilon'\left(|\Omega_{dmt}|\frac{y_{dt}(\omega_f)}{Y_{dt}}\right)\frac{y_{dt}(\omega_f)}{Y_{dt}}d\omega_f \tag{3.17}$$

3.3.3 Foreign Country

We assume that a domestic economy is a small open economy (SOE), therefore, changes in factor and final good prices there do not affect foreign equilibrium prices and aggregates.[15]

We assume that entrepreneurs abroad are unconstrained. We further abstract from markup dispersion abroad. We use $\Upsilon(q) = q^{\frac{\sigma-1}{\sigma}}$, resulting in the constant elasticity of substitution (CES) demand function.[16] We assume that foreign producers do not have to pay fixed costs of exporting when they sell goods to domestic consumers. Nonetheless, there is still a significant measure of foreign entrepreneurs who do not export, as their marginal costs are above the choke

[14] Producers set prices in producer currency, price of domestic intermediate good in domestic currency is equal to $p_{ddt}(\omega)$, price of imported intermediate good in domestic currency is $RER_t p_{dt}(\omega_f)$

[15] Since our model targets characteristics of Ukrainian manufacturing sectors and abstracts from agriculture, we find SOE a reasonable assumption.

[16] These assumptions seem restrictive at first sight. However, removing either of them would allow changes in the domestic economy to affect decisions of foreign firms through competitive forces. SOE assumption would no longer hold in this case.

price.

Final good producers abroad solve the following problem

$$\max_{y_{ft}(\omega_f), y_{ft}(\omega)} P_{ft} Y_{ft} - \int_{\Omega_{fft}} p_{ft}(\omega_f) y_{ft}(\omega_f) d\omega_f - \int_{\Omega_{fet}} p_{ft}(\omega) y_{ft}(\omega) d\omega \tag{3.18}$$

s.t.

$$\frac{1}{|\Omega_{fft}|} \int_{\Omega_{fft}} \left[\frac{y_{ft}(\omega_f)}{Y_{ft}} |\Omega_{fft}| \right]^{\frac{\sigma-1}{\sigma}} d\omega_f + \frac{1}{|\Omega_{fet}|} \int_{\Omega_{fet}} \left[\frac{y_{ft}(\omega)}{Y_{ft}} |\Omega_{fet}| \right]^{\frac{\sigma-1}{\sigma}} d\omega = 1 \tag{3.19}$$

Again, we assume that the measure of varieties available at the foreign market is Ω_{ft}, we partition it into the set of varieties coming from the foreign location (Ω_{fft}) and the set of varieties coming from the domestic location (Ω_{fet}). The resulting demand for variety ω produced in d and exported to f equals $y_{ft}(\omega) = \frac{Y_{ft}}{P_{ft}^{-\sigma}} p_{ft}^{-\sigma}(\omega)$, in this expression, Y_{ft} represents the aggregate output index in the foreign country, $p_{ft}(\omega)$ is an export price of ω in foreign currency.

3.3.4 Balance of Payments and Financial Sector

We assume that financial markets are not financially-integrated, domestic entrepreneurs do not directly borrow from abroad.[17] We assume that a non-profit bank has access to international financial markets and faces no transaction costs while transforming securities issued by domestic entrepreneurs into foreign securities. Finally, we assume that buyers on the foreign market of securities perceive sellers as subject to default risk. The perceived risk of default rises with the amount of debt scaled by Y_{dt}. Holding Y_{dt} fixed, the larger the amount of sold securities, the higher risk premium the seller has to offer, as in Schmitt-Grohé and Uribe (2003) and Alessandria et al. (2024):

$$R_{dt} = R_{ft} + \psi \left(e^{\frac{\int_{\Omega_{dt}} (k_t(\omega) - a_t(\omega)) d\omega}{Y_{dt}}} - 1 \right) \tag{3.20}$$

In (3.20), R_{ft} represents a nominal yield on the securities of entrepreneurs in the country f, ψ is a parameter governing the debt elasticity of interest rate. The positive risk premium implies that absent bank activities, the supply of securities would exceed the demand given R_{dt}. At R_{dt}, a non-profit making bank agrees to buy these securities and sell them on international financial markets. The amount of bonds sold to international buyers determines the size of the

[17] In Kohn et al. (2020), entrepreneurs can sell one-period uncontingent bonds to buyers from foreign financial markets. In the steady state, equilibrium requires balanced trade and bonds in zero net supply given the exogenous interest rate. If we follow the same assumptions, we have to assume that the interest rate on domestic bonds does not differ from the interest rate on foreign bonds. However, we have to account for substantially higher interest rates in Ukraine than in many EU members in 2014.

risk premium.

Intuitively, if a bank borrows from abroad, the balance of payments should record the associated transactions. The current account has to account for trade balance and net interest payment:

$$ca_{dt} = tb_{dt} - \text{RER}_t R_{dt-1} * \frac{d_{dt}}{1 + R_{dt-1}} \tag{3.21}$$

In (3.21), $\frac{d_{dt}}{1+R_{dt-1}}$ represents the total volume of outstanding bonds of domestic entrepreneurs in foreign currency issued and placed on international market in $t-1$.[18] In the presence of trade deficit, current account could turn negative, making the country a net debtor and resulting in the positive financial account. The current account could also turn positive, with the country becoming a net creditor. As the associated changes in the net international investment position comove with the corresponding changes in the financial account, we require

$$tb_{dt} - \text{RER}_t R_{dt-1} * \frac{d_{dt}}{1 + R_{dt-1}} = \text{RER}_t \frac{d_{dt}}{1 + R_{dt-1}} - \text{RER}_t \frac{d_{dt+1}}{1 + R_{dt}} \tag{3.22}$$

In (3.22), $\frac{d_{dt}}{1+R_{dt-1}}$ and $\frac{d_{dt+1}}{1+R_{dt}}$ represent the volume of outstanding bonds in the foreign currency in periods $t-1$ and t respectively. In the steady state, $d_{dt} = d_{dt-1}$ and $R_{dt-1} = R_{dt}$; therefore, trade balance should be equal to negative of net interest-rate payments abroad

$$tb_d = \text{RER} R_d \frac{d_d}{1 + R_d} \tag{3.23}$$

3.3.5 Recursive Formulation of Domestic Entrepreneur's Problem

Assume that $V(k, d, z)$ is the value function of the entrepreneur with capital k, debt d, and productivity z, who makes consumption and saving decisions and maximizes profits from selling intermediate goods. Denote the next period value function as $g(a', z')$ with $a' = k' - \frac{d'}{1+R_d}$. Next, assume that $\pi(k, z)$ is the profit function of an intermediate good producer with capital k and productivity z that allocates the mix of production inputs, makes exporting decisions, and chooses production levels and prices for both domestic and foreign markets. At the end of the period, an entrepreneur with assets a observes a new productivity realization z, makes a choice of capital k' and debt $\frac{d'}{1+R_d}$ for the next period.

[18] Net interest payment amount in domestic currency equals $-\frac{\text{RER}_t}{\text{RER}_{t-1}} R_{dt-1} * \int_{\Omega_{dt}} (k_t(\omega) - a_t(\omega)) d\omega$

The problem of a domestic entrepreneurs has the following recursive formulation:

$$V(k,d,z) = \max_{c,a'>0} \frac{c^{1+\nu}}{1+\nu} + \beta\mathbb{E}[g(a',z')] \tag{3.24}$$

$$\text{s.t. } c + a' + d = W_d + (1-\delta)k + \pi(k,z) \tag{3.25}$$

where

$$\pi(k,z) = \max_{p_d,p_f,y_d,y_f,k,l,e} p_d y_d + e\text{RER} p_f y_f - W_d l - (R_d+\delta)k - eFW_d \tag{3.26}$$

$$\text{s.t. } \tau_{df} y_f + y_d = zk^\alpha l^{1-\alpha} \tag{3.27}$$

$$y_f = \frac{Y_f}{(P_f \text{RER})^{-\sigma}} p_f^{-\sigma} \tag{3.28}$$

$$y_d = \left[1 - \varepsilon \ln\left(\frac{p_d D_d}{P_d} \frac{\sigma}{\sigma-1}\right)\right]^{\frac{\sigma}{\varepsilon}} Y_d \tag{3.29}$$

and

$$g(a',z') = \max_{k',d'} V(k',d',z') \tag{3.30}$$

$$\text{s.t. } k' - \frac{d'}{1+R} = a' \tag{3.31}$$

$$d' \le \theta k' \tag{3.32}$$

3.3.6 Stationary Competitive Equilibrium

Let $S := Z \times A$ denote the state space of entrepreneurs. Each $s \in S$ represents a tuple of productivity and asset values, $Z = R^+$ and $A = R^+$. We assume that all markets in the foreign economy clear; therefore, domestic agents can view R_f, W_f, P_f, Y_f, D_f as exogenous. The sizes of sets Ω_{dd} and Ω_{dm} are given.

Definition of equilibrium. A *recursive stationary competitive equilibrium* consists of prices $\{W_d, R_d\}$, policy functions $\{c, d', k'_d, l_d, e_d, y_d, y_f, p_d, p_f, Y_d, D_d, P_d\}$, value functions v and g, and a measure $\phi : S \to [0,1]$ such that

1. policy and value functions solve the domestic entrepreneurs' problem

2. policy functions solve the problem of domestic final good producers

3. domestic labor market clears

$$\int_{s\in S} [l(s) + e(s)F]\phi(s)ds = 1 \tag{3.33}$$

4. domestic final good market clears

$$\int_{s\in S}[c(s)+x(s)]\phi(s)ds = Y_d - tb_d \tag{3.34}$$

5. given R_d, domestic debt is in zero net supply;

6. the current account is balanced:[19]

$$tb_d - R_d * \int_{s\in S}(k_d(s)-a_d(s))\phi(s)ds = 0 \tag{3.35}$$

7. the measure ϕ is stationary

Appendix 3.7.3 contains a numerical algorithm to find a stationary equilibrium of the model.

3.3.7 Theoretical Mechanism

First of all, we describe the solution to the firm's problem in a stationary equilibrium keeping assets predetermined and taking product and factor prices as well as a stationary measure of entrepreneurs as given. We denote firm's marginal cost on the domestic market as $MC_d(\omega)$ and derive the system of first-order conditions for cost minimization with respect to capital and labor:

$$\begin{aligned} W_d &= MC_d(\omega)(1-\alpha)k(\omega)^{\alpha}l(\omega)^{-\alpha} \\ R_d &= MC_d(\omega)\alpha k(\omega)^{\alpha-1}l(\omega)^{1-\alpha} - \delta - \lambda(\omega) \end{aligned} \tag{3.36}$$

$\lambda(\omega)$ represents the shadow price of relaxing borrowing constraint satisfying the following complementary slackness condition:

$$\lambda(\omega)\left(\frac{1+R_d}{1+R_d-\theta}a(\omega)-k(\omega)\right)=0 \tag{3.37}$$

For an unconstrained firm, $\lambda(\omega) = 0$, but for a firm facing binding collateral constraint, $\lambda(\omega) > 0$. The effective cost of capital for constrained firms equals $R_d+\delta+\lambda(\omega)$, a sum of the interest rate, the depreciation rate, and the shadow price of relaxing the borrowing constraint. Constrained firms face an upper bound on the capital they can use in production growing with the amount of their assets ($k(\omega) \le \frac{1+R_d}{1+R_d-\theta}a(\omega)$). Export demand shock requires this firm to hire more workers without acquiring more equipment; suboptimal factor allocation drives up unit

[19] Note that this condition does not contradict the previous one, as we separate the domestic and foreign financial markets. Activities of the bank clear the market for the domestic securities; however, by selling the converted securities abroad, the bank generates the economy's negative or positive net asset position

costs and makes this firm less efficient compared to firms with identical productivity but larger assets.

Following (3.36), a firm with a higher effective cost of capital faces smaller capital-labor ratio:

$$\frac{W_d}{R_d + \delta + \lambda(\omega)} = \frac{(1-\alpha)k(\omega)}{\alpha l(\omega)} \tag{3.38}$$

Cost-minimization also allows obtaining a closed-form expression for the domestic marginal costs of the firm:

$$MC_d(\omega) = \left(\frac{W_d}{1-\alpha}\right)^{1-\alpha} \left(\frac{R_d + \delta + \lambda(\omega)}{\alpha}\right)^{\alpha} \frac{1}{z(\omega)} \tag{3.39}$$

Given its marginal costs, the firm maximizes profits on both markets facing inverse demand in (3.16) on the domestic market and $y_f(\omega) = \frac{Y_f}{P_f^{-\sigma}} p_f^{-\sigma}(\omega)$ on the foreign market (p_d is in the domestic currency, p_f is in the foreign currency). Profit maximization yields an optimal foreign price equal to the product of a constant markup $\frac{\sigma}{\sigma-1}$ and marginal costs. Equalizing profit-maximizing price with the inverse demand, we arrive at a closed-form expression for the demand for a variety ω in the foreign market:

$$y_f(\omega) = \frac{Y_f}{(\text{RER}P_f)^{-\sigma}} \left[\frac{\sigma}{\sigma-1} \frac{W_d^{1-\alpha}(R_d + \delta + \lambda(\omega))^{\alpha}}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}} \frac{\tau_{df}}{z(\omega)}\right]^{-\sigma} \tag{3.40}$$

On the domestic market, firms face demand curves with variable demand elasticities declining in firm's relative size, $q_d(\omega)$. Profit-maximizing firms set variable markups increasing in $q_d(\omega)$, $\frac{p_d(\omega)}{MC_d(\omega)} = \frac{\sigma}{\sigma - q_d(\omega)^{\frac{\varepsilon}{\sigma}}}$.

Now, consider the short-run effects of a reduction in τ_{df} (keeping the prices of final goods and factors as well as the stationary measure of the entrepreneurs unchanged). Notice that the demand for ω abroad declines with $\lambda(\omega)$ and with τ_{df} ceteris paribus. $y_d(\omega)$ declines in $\lambda(\omega)$.[20] Falling τ_{df} shifts $\lambda(\omega)$ for constrained exporters up, weakly reducing $q_d(\omega)$ and $\mu_d(\omega)$. Falling $y_d(\omega)$ for constrained exporters reduces Y_d, increasing $\mu_d(\omega)$ and $q_d(\omega)$ for unconstrained ex-

[20] Intuitively, the first-order condition for profit-maximization of the firm producing variety ω on the market d is:

$$\frac{\sigma-1}{\sigma} \exp\left(\frac{1-q_d^{\frac{\varepsilon}{\sigma}}(\omega)}{\varepsilon}\right) \frac{P_d}{D_d} \frac{\sigma - q_d^{\frac{\varepsilon}{\sigma}}(\omega)}{\sigma} = MC_d(\omega)$$

Provided $y_d(\omega)$ is not too large, the left-hand side of this equation is a product of two monotonically declining functions in $q_d(\omega)$. An increase in $\lambda(\omega)$ shifts the right-hand side up, $y_d(\omega)$ should decline to equalize both sides of the equation.

porters, non-exporting firms, and producers from f.[21]

When W_d and R_d respond to a greater factor demand, domestic firms experience spikes in their marginal costs. When domestic firms experience an increase in marginal costs, their markups and outputs go down, at the same time, markups and outputs increase for foreign producers. The resulting changes in the distribution of markups might either amplify or weaken the markup dispersion. At the same time, spikes in $\lambda(\omega)$ for constrained exporters increase capital misallocation (note that increasing W_d and R_d relax credit constraints for constrained firms, weakening an increase in capital misallocation). Our model does not unambiguously predict whether unilateral trade liberalization improves or worsens allocation of resources given its effects on markup dispersion and capital allocation. In Section 3.4, we use computational techniques to isolate the effects of these forces and analyze the allocative efficiency implications of unilateral trade liberalization.

3.4 Quantitative Results

3.4.1 Calibration

We calibrate the model to match selected characteristics of Ukrainian manufacturing sectors in 2013, a year before the ATP enaction.

Externally-Calibrated Parameters. We calibrate the first set of parameters externally, using estimates from the literature or our own estimates (see Table 3.4 for a summary). We set the foreign interest rate to 0.01. We set the discount rate β to 0.81, similarly to Kohn et al. (2023). We set the depreciation rate to a standard value of 0.1. We set capital output elasticity to 1/3. We set the coefficient of relative risk aversion to -2 as in Kohn et al. (2020). Next, we use data for firms selling only domestically to recover ρ_z and $\frac{\varepsilon}{\sigma}$. Assuming $\alpha = \frac{1}{3}$, for such firms, we are

[21] The fact that $\lambda(\omega)$ decreases with τ_{df} for constrained exporters is not surprising. For exporting firms that do not sell to the domestic market, we can directly write $\lambda(\omega)$ as a declining function of τ_{df}:

$$\lambda(\omega) = \alpha\left(\frac{\sigma-1}{\sigma}\right)^{\frac{\sigma}{\alpha\sigma+1-\alpha}}\left(\frac{1-\alpha}{W_d}\right)^{\frac{(1-\alpha)(\sigma-1)}{\alpha\sigma+1-\alpha}} z(\omega)^{\frac{\sigma-1}{\alpha\sigma+1-\alpha}}\left(\frac{Y_f(P_f RER)^{\sigma}}{\frac{1+R_d}{1+R_d-\theta}a(\omega)\tau_{df}^{\sigma-1}}\right)^{\frac{1}{\alpha\sigma+1-\alpha}} - R_d - \delta$$

For firms selling to both markets, we can derive $\frac{\partial(R_d+\delta+\lambda(\omega))}{\partial\tau_{df}}$ by implicitly differentiating $y_d(\omega)+\tau_{df}y_f(\omega) = z(\omega)a(\omega)\frac{1+R_d}{1+R_d-\theta}\left[\frac{W_d\alpha}{(R_d+\delta+\lambda(\omega))(1-\alpha)}\right]^{\alpha-1}$, resulting in

$$\frac{d(R_d+\delta+\lambda(\omega))}{d\tau_{df}} = -\frac{(1-\sigma)y_f(\omega)}{\tau_{df}\frac{\partial y_f(\omega)}{\partial(R_d+\delta+\lambda(\omega))}+\frac{\partial y_d(\omega)}{\partial(R_d+\delta+\lambda(\omega))}-(1-\alpha)\frac{y_d(\omega)+\tau_{df}y_f(\omega)}{R_d+\delta+\lambda(\omega)}} < 0$$

able to recover the markups paid by domestic consumers from labor shares.[22] Next, we use the implied markup μ_{ist} for firm i in sector s in period t to estimate $\frac{\varepsilon}{\bar{\sigma}}$ following Edmond et al. (2023). We estimate the following regression equation:

$$\frac{1}{\mu_{ist}} + \log\left(1 - \frac{1}{\mu_{ist}}\right) = b_0 + b_1 \log(s_{ist}) \tag{3.41}$$

In (3.41), s_{ist} approximates $\Upsilon'(q_{ist})q_{ist}$ up to a constant, b_1 is a coefficient capturing super-elasticity. We present the estimates we obtain in Table 3.3. We use $\frac{\varepsilon}{\bar{\sigma}} = 0.138$ as a baseline estimate; it is precisely estimated and is only slightly smaller than the estimates by Edmond et al. (2023). We set the value of the average demand elasticity, $\bar{\sigma}$, equal to 5, following Gopinath and Itskhoki (2010) and Klenow and Willis (2016). Using $\frac{\varepsilon}{\bar{\sigma}} = 0.138$ and $\alpha = 0.33$, for each non-exporting firm in 2013, we derive a normalized productivity measure consistent with the model. Then, we recover $\rho_z = 0.894$ as an autoregression coefficient of these normalized productivity values (see Appendix 3.7.2 for details).

Table 3.3: Estimation of Super-elasticity

	$\frac{1}{\mu_{ist}} + \log\left(1 - \frac{1}{\mu_{ist}}\right)$	
Intercept	-2.02^{**}	-1.88^{**}
	(0.209)	(0.236)
$log(s_{ist})$	0.151^{**}	0.138^{**}
	(0.021)	(0.022)
Industry FE	No	Yes
N	687	687

Note: The table above presents the results of estimating (3.41) for the sample of non-exporters in 2013. Observations with labor share below $1-\alpha$ are excluded. The left column presents the results without controls, the right column presents the results controlling for 2-digit industry fixed effects.

Finally, we determine the measure of varieties available in the domestic market, $|\Omega_{dt}|$. Similarly to Gopinath and Itskhoki (2010), we normalize $|\Omega_{ddt}| = 1$, $|\Omega_{dt}| = 1 + \gamma_{dmt}$ with γ_{dmt} of varieties coming from f to home consumers. We calibrate γ_{dmt} using data on domestic absorption of manufacturing goods and imports of manufacturing goods from the EU. The estimated share of imported goods in total absorption equals 0.08. We recover γ_{dmt} from $0.08 = \frac{\gamma_{dmt}}{1+\gamma_{dmt}}$ and obtain a value of γ_{dmt} equal to 0.09.

Internally-Calibrated Parameters. We calibrate a number of parameters internally. The set of internally-calibrated parameters includes the fixed cost of exporting, F, the iceberg-type transportation costs from home to the foreign location, τ_{df}, cost shifter of foreign producers, $\tau_{fd}W_f^{1-\alpha}$, standard deviation of productivity shocks, σ_ε, the tightness parameter of the col-

[22]For a firm exporting to other countries, labor share becomes a function of markups firm charges on both domestic and foreign consumers, the approach we adopt is no longer valid for these firms.

Table 3.4: Externally-calibrated Parameters

Name	Parameter	Value	Source
Real interest rate, foreign	R_f	0.01	Zero-lower bound
Depreciation rate	δ	0.1	Standard
Capital output elasticity	α	0.33	Kohn et al. (2020)
Coefficient of relative risk aversion	ν	-2	Kohn et al. (2020)
Average demand elasticity	$\bar{\sigma}$	5	Gopinath and Itskhoki (2010), Klenow and Willis (2016)
Superelasticity	$\frac{\varepsilon}{\bar{\sigma}}$	0.138	Data
Measure of imported varieties	γ_{dm}	0.09	Data
Persistence parameter of a productivity process	ρ_z	0.894	Data
Discount factor	β	0.81	Kohn et al. (2023)

lateral constraint, θ, and the foreign output aggregator, Y_f. We calibrate these parameters by matching the moments from the model to the respective counterparts from the data (see Table 3.5 for a summary).

Table 3.5: Internally-calibrated Parameters

Parameter	Value	Target moment	Data	Model
F	0.00025	Share of exporters	0.25	0.256
τ_{df}	3.89	$\frac{\text{Total EU export revenues}}{\text{Total domestic and EU revenues of EU exporters}}$	0.14	0.14
$\tau_{fd} W_f^{1-\alpha}$	31.38	Import penetration	0.08	0.08
σ_ϵ	0.712	Standard deviation of log export sales	2.39	2.36
θ	0.822	Credit/GDP	0.46	0.46
Y_f	722.2	Relative absorption	32.0	32.2
ψ	0.188	Real interest rate	0.06	0.06

Our calibration targets a number of moments in the firm-level dataset and a number of aggregate statistics. We target the share of firms exporting to the EU countries among active firms in 2013 (25%). We target the standard deviation of log export sales to the European Union countries in 2013 (2.39). We target the share of total EU export revenues to total revenues among exporters to the EU member countries (14%).[23] We target import penetration as the ratio of manufacturing imports from the EU member countries to the sum of total domestic manufacturing absorption in Ukraine and manufacturing imports from the EU member countries (8%). We target relative absorption as the ratio of the sum of total domestic manufacturing absorption in the EU and total manufacturing exports from Ukraine to the EU countries to the sum of domestic manufacturing absorption in Ukraine and total manufacturing imports to Ukraine

[23]Calculating this moment in the data, we subtract non-EU export revenues from the denominator to make this ratio consistent with the respective moment in the model

from the EU countries (32).[24] We target Credit-to-GDP ratio as the share of short-term credit of Ukrainian manufacturing firms in 2013 to the contribution of manufacturing sector to GDP (46%). We also target the real interest rate in Ukraine in 2013 (6%).[25]

Our estimates accurately capture the targeted moments. In order to target a large standard deviation of log export sales, we use larger σ_z than usual estimates in the literature. Dispersed productivity shocks result in a substantial measure of credit-constrained firms in a steady state equilibrium. Credit constraints lead to additional opportunity costs for constrained exporters; we require low fixed costs in wage units to maintain the share of exporting firms of 25%. At the same time, trade costs should be large enough to maintain a small share of export revenues from the EU member countries to total sales of firms to the EU countries, given the substantial differences in manufacturing absorption between the EU and Ukraine. Importantly, $\tau_{df} = 3.89$ accounts not only for tariffs on Ukrainian exporters. A substantially large τ_{df} may reflect numerous barriers to trade that we do not model.[26] The estimated size of the cost shifter of foreign producers is 31.38 reflecting substantial real wage differences between the EU and Ukraine.

3.4.2 Steady State

Production. Although we do not model fixed costs of entry, some entrepreneurs do not sell anything at home. Intermediate good producers with marginal costs exceeding the choke price do not produce. In the calibrated steady state, only 35% of the entrepreneurs produce, while other entrepreneurs only supply labor and buy bonds from the producing entrepreneurs. Since exporting requires firms to pay fixed costs and incur additional opportunity costs, only about 9% of the entrepreneurs sell varieties both to domestic and foreign consumers.

Exporters. Our model reproduces a similar non-linear selection cutoff as in Kohn et al. (2016): it is easier to start exporting with more assets. At the same time, exporters are less capital-intensive, strong increase in demand following export entry sharply increases cost of capital. Without additional modifications, the model fails to reproduce the stylized facts re-

[24]Domestic manufacturing absorption in the EU comes from the World Input-Output Database (see Timmer et al. (2015) for a description). Domestic manufacturing absorption comes from the Input-Output Table of Ukraine. We calculate total manufacturing exports from Ukraine to the EU using the firm-level data. We calculate manufacturing imports from the EU to Ukraine using aggregate trade flows from the UN Comtrade.

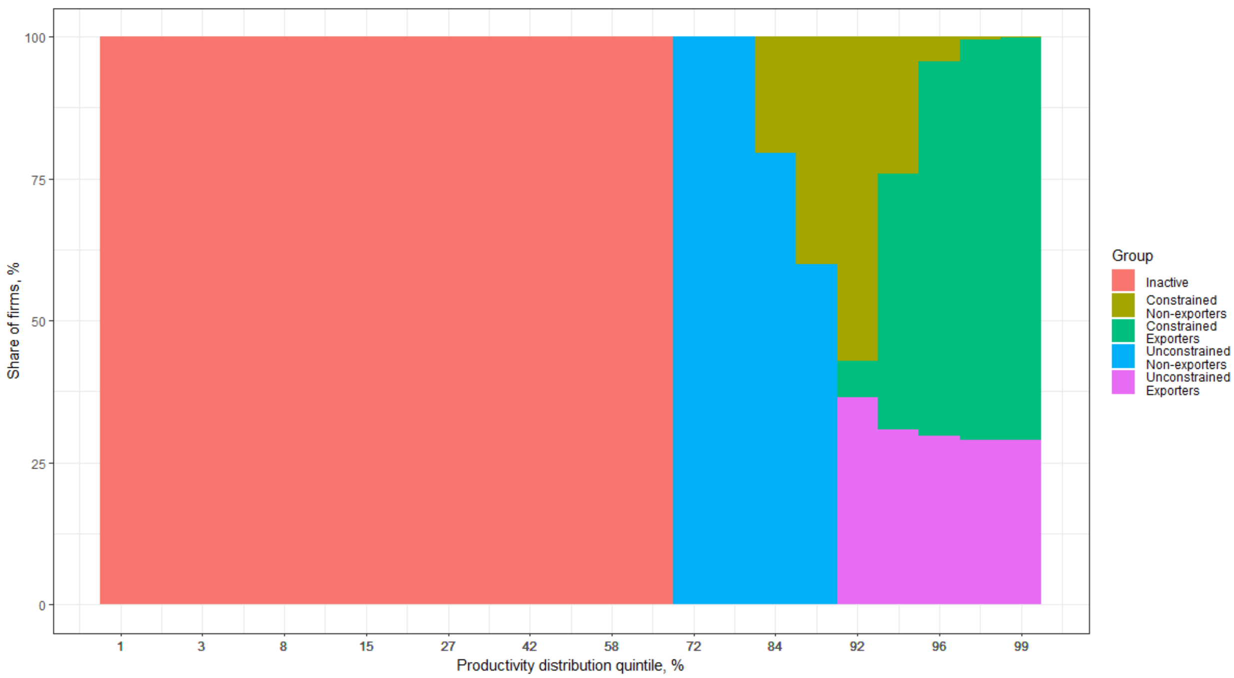
[25]This value is consistent with the refinancing rate in 2013 in real terms (policy rate net of inflation rate), on the one hand, and the sum of the J.P. Morgan Emerging Markets Bond (EMBI) Spread for Ukraine and the real return on the US 1-year Treasury Bill, on the other hand.

[26]The set of potential candidates includes a significant home bias of consumers in the EU member states, across-destination markup differences, frictions and bribes at the border, shipping costs, wage premia paid by exporters to the EU members, differences in technology for products sold on the Ukrainian and the EU markets. The last candidate might be of utmost importance; IER (2015b) report substantial difficulties Ukrainian firms faced trying to adjust their production to the EU quality standards. Firms report compliance with these standards as the largest barrier they had to overcome to start selling to the European Union countries.

ported in Section 3.2. Due to a relatively higher productivity, exporters set on average 22% higher markups than non-exporters, consistent with Melitz and Ottaviano (2008) and De Loecker and Warzynski (2012). The effective cost of capital of exporters is, on average, 2 times higher, while the average level of assets is about 7 times larger for exporting firms compared to non-exporters. Figure 3.4 shows the proportions of different groups of firms for different quintiles of the productivity distribution.

Effective cost of capital. 32% of producing firms in the steady state face binding borrowing

Figure 3.4: Proportions of Different Groups of Firms in the Steady State Equilibrium



Note: The presented chart shows proportions of different groups of firms (y axis) for different quintiles of productivity distribution (x axis) in the calibrated steady state. To simplify exposition, we trim the 1st and the 99th quintiles of productivity distribution.

constraints. The standard deviation of MRPK of 0.49 implies a substantial capital misallocation. The variance of the effective cost of capital is about 6 times larger for exporters than for non-exporters, implying larger capital misallocation across exporters. Combined with on average larger effective cost of capital for exporters, our findings reveal that exporters experience heavier distortions due to credit constraints. We also observe a positive covariance between productivity and effective cost of capital, as more productive firms are more likely to face binding borrowing constraints due to larger capital needs to meet foreign demand. The average effective cost of capital across producing firms is 29%, about 12.5% above the effective cost of capital of an unconstrained firm.

Markups. The average domestic markup is 1.13, which is smaller than the assumed markup of 1.25 abroad. At the same time, on average, exporters set higher markups for domestic consumers than to foreign consumers. In the absence of credit constraints, the between-firm differences in markups would be larger for exporters. The standard deviation of domestic markups is 0.131. The standard deviation of markups is about 6 times larger for exporters compared to non-exporters due to significant productivity differences. The average domestic markup for exporters is about 22% larger compared to non-exporters. We also observe a positive covariance between assets and markups; agents have large incentives to forego current consumption in exchange for a larger competitive advantage in the future and the ability to increase markups. The fact that markups of credit-constrained firms are on average 13% larger than markups of firms not facing binding borrowing constraint is consistent with credit constraints exerting greater pressure on more efficient firms. The average markup is about 4% smaller for foreign producers active in the domestic market compared to domestic producers.

Markups and effective cost of capital. We observe a positive covariance between markups and the effective cost of capital.[27] More efficient firms set higher domestic markups and, at the same time, face larger capital needs. Even though more efficient firms, who are poor in assets, might face a reduction in markups due to a higher effective cost of capital, this force is too weak to break the counteracting force due to the positive covariance between the effective cost of capital and productivity.

3.4.3 Effects of Unilateral Trade Liberalization

We assume that f is a donor, and d is a recipient. We model unilateral trade liberalization as a unilateral proportional reduction in τ_{df} by 4%.[28] We compare outcomes across the two steady states, one with high transportation costs and another - with reduced transportation costs. To better understand the contribution of credit constraints and markups, we undertake a similar experiment in several alternative versions of the model.

Cuts in transportation costs sharply increase the demand for exported varieties. On the one hand, the rising labor demand of exporters pushes up wages. On the other hand, constrained exporters face tighter credit constraints. In the following, we list several important economy-wide results focusing on welfare and allocative efficiency implications of unilateral trade liberalization.

[27] Reported correlation is highly important. Such a correlation shows that without additional adjustments the model with backward-looking collateral constraint and demand satisfying MSLD fails to capture the negative correlation between capital intensities and labor shares documented in 3.2. The positive correlation between MRPK and size is also not in line with a number of empirical studies.

[28] According to calculations of the Ukrainian Institute of Economic Research in IER (2015a), this number roughly represents the proportional change in average import tariff on Ukrainian products exported to the EU countries.

Welfare effects. Unilateral trade liberalization increases the real wage by 1.6%, average real profits by 1.7%, and real interest income by 0.5%. As a result, consumption jumps by 3.2%.

To calculate changes in welfare, we follow Leibovici (2021) and Edmond et al. (2023). We calculate changes in welfare in consumption-equivalent units (CEU).[29] Conceptually, we calculate the size of a permanent state-invariant increase in consumption making an average entrepreneur in d indifferent between moving to a steady state with the reduced transportation costs and remaining in a steady state with the original transportation costs. Following Leibovici (2021), we assume an alternative one-period utility function $u(c) = \log((1+\Delta)c)$ and calculate change in welfare as:

$$\Delta = \exp\left\{(1-\beta)\left[\int_{s\in S} g_1(s)\phi(s)ds - \int_{s\in S} g_0(s)\phi(s)ds\right]\right\} - 1, \tag{3.42}$$

where Δ measures a proportional change in lifetime consumption that makes a randomly chosen individual indifferent between staying in two steady states, $g_0(s)$ denotes the value function in the initial steady state, and $g_1(s)$ denotes the value function in the steady state after trade liberalization. After trade liberalization, welfare improves, as entrepreneurs would require a 0.26% higher increase in consumption to give up staying in the economy with the lower transportation costs.

Table 3.6: Effects of Unilateral Trade Liberalization on Welfare

Name	Δ Welfare	$\Delta\frac{W_d}{P_d}$	$\Delta\frac{R_d}{P_d}$	ΔC_d	ΔY_d
Baseline	+0.26%	+1.6%	-0.54%	+3.2%	+3.1%
NFF	+0.05%	+2.16%	+0.4%	+2.01%	+2.09%
CM	+0.24%	+1.22%	-0.97%	+2.57%	+2.53%
NFF + CM	+0.05%	+2.59%	+0.3%	+2.7%	+2.77%

Note: The table shows the selected proportional changes in factor prices, consumption, and aggregate absorption following trade liberalization in the baseline model compared with the alternative versions of the model. NFF denotes the version of the model without credit constraints; CM denotes the version of the model with constant and unchanged markups, and CM+NFF presents a version of the model with no markup dispersion and no credit constraints.

Table 3.6 compares selected changes before and after unilateral trade liberalization with the effects in alternative versions of the model. In one of them (NFF), we allow firms to obtain unrestricted access to credit. In another (CM), we impose the restriction that firms' markups on the domestic market are equal to equilibrium markup in foreign country ($\frac{\sigma}{\sigma-1}$). In the last version (NFF+CM), we remove both credit constraints and firms' ability to vary markups. The welfare improvement in the baseline model is the largest across the compared versions of the model

[29] We do not use traditional measures of gains from trade from static models, since they do not capture dynamic effects. We measure changes in welfare in consumption-equivalent units.

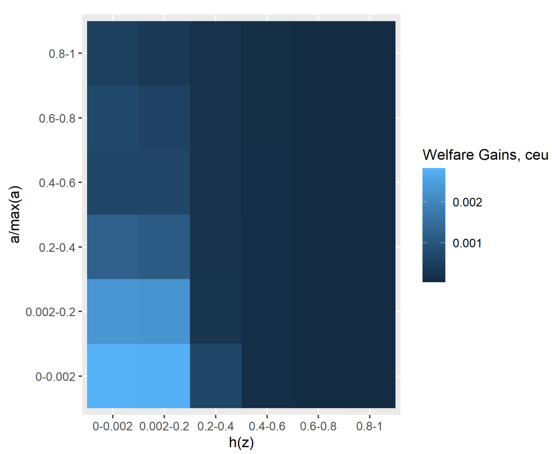
due to the largest proportional growth in consumption.

The fact that the absence of markup dispersion reduces consumption response is not surprising given the smaller increase in real wages and real profits. It is less clear, though, why the presence of credit constraints increases consumption response (additional precautionary savings incentives and lower real wage growth should dampen it instead). When rising debt pushes domestic interest rate up, international financial markets yield an additional propagation channel of trade liberalization to consumption-saving decisions of entrepreneurs. When agents do not face credit constraints, the demand for bonds increases faster after the reduction in τ_{df}. The higher increase in debt drives the real interest rate up, leading to smaller consumption growth through the intertemporal substitution channel. In the baseline version of the model, steady state interest rate increases. At the same time, the rate of increase is much lower, as credit constraints weaken the debt responsiveness. A smaller increase in interest rate strengthens consumption response despite a less pronounced rise in the real wage and additional incentives to accumulate assets to relax borrowing constraint in the future.

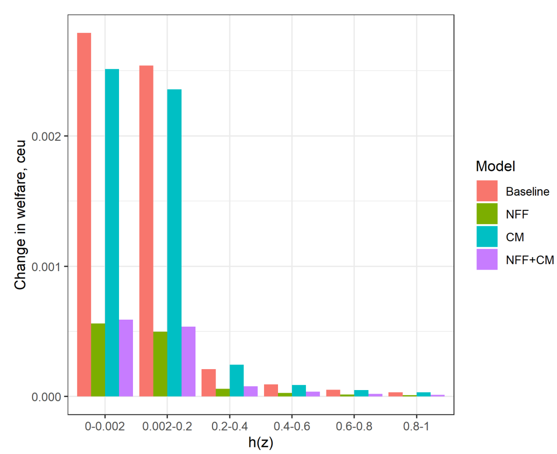
In our model, an improvement of market access for firms also has distributional implica-

Figure 3.5: Distributional Implications of Unilateral Trade Liberalization

(a) Changes in welfare for entrepreneurs with different levels of assets and productivity



(b) Changes in welfare for entrepreneurs with different levels of productivity



Note: The left chart shows changes in welfare we calculate for different groups of entrepreneurs, with groups formed depending on the levels of assets and normalized productivity relative to maximal grid values. The y-axis shows bounds on asset level, while the x-axis shows bounds on the level of normalized productivity for entrepreneurs of a particular group. The right chart shows changes in welfare we calculate in different versions of the model for different groups of entrepreneurs, with groups formed based on the levels of normalized productivity relative to the upper bound of the productivity grid. The y-axis shows changes in welfare in consumption equivalent units, while the x-axis shows bounds on the level of normalized productivity for entrepreneurs from different groups. Productivity is normalized using function $h(z) = \frac{\log(1+z)}{\log(1+\hat{z})}$, in which $\hat{z}$ denotes an upper bound of productivity grid.

tions. To analyze how unilateral trade liberalization affects different agents, we organize entrepreneurs into different groups and evaluate the average changes in welfare for each of them.

For each entrepreneur, we calculate $h(z(\omega)) = \frac{\log(1+z(\omega))}{\log(1+\hat{z})}$, $\hat{z}$ denotes an upper bound on the productivity grid we use to approximate an auto-regressive productivity process. We also divide assets of entrepreneurs by an upper bound of an asset grid. We form groups based on the levels of assets relative to the asset upper bound and $h(z(\omega))$. Our calculations reveal that less productive entrepreneurs gain the most from better market access. Welfare improves by relatively more for agents, who only receive wage income, they enjoy an increase in wages and increase consumption. More productive agents benefit relatively less, first of all, due to a smaller proportional growth in consumption, secondly, as they use an increase in income to purchase more assets to benefit from greater export profits during favorable productivity states. Less productive agents benefit relatively more from unilateral trade liberalization, also in the absence of credit constraints or variable markups.

Implications for allocative efficiency. Hsieh and Klenow (2009) analytically show that aggregate TFP declines with the magnitude of TFPR (total revenue factor productivity) dispersion in a closed economy. TFPR dispersion reflects the extent of misallocation. In the baseline steady state, three main components generate TFPR dispersion: dispersion in markups, dispersion in MRPK, and the covariance between the two. Dispersion in markups results in more efficient firms using too little labor, while less efficient firms using too much labor. Dispersion in MRPK results in constrained firms using too much labor for production; providing these firms with an additional unit of capital increases labor productivity for constrained firms and, in this way, increases aggregate TFP. If covariance between MRPK and markups is positive, misallocation exacerbates, as more efficient firms hire too little labor and acquire too little capital relative to entrepreneurs who are less productive but richer in assets. If covariance between MRPK and markups is negative, misallocation weakens, as credit constraints dampen excessive output from less efficient firms.

Table 3.7 provides an overview of the way changes in economy-wide aggregates and prices affect factor allocation. The growing labor demand of exporters increases wages and drives marginal costs up, making domestic firms less competitive on the domestic market relative to foreign producers. In addition, markups and relative output of constrained domestic exporters decline due to additional foreign demand pressure tightening their credit constraints and increasing effective cost of capital. Average markup and markup dispersion decline due to downward pressures on markups. At the same time, increases in effective cost of capital for exporters intensify capital misallocation. The resulting changes increase the TFPR dispersion and decrease aggregate TFP. An increase in the TFPR dispersion worsens allocative efficiency in the recipient's economy, which contrasts with the results of Edmond et al. (2015), who model bilateral trade liberalization in a model with variable markups and without credit constraints.

To isolate the contributions of all of the above mentioned channels on allocative efficiency,

Table 3.7: Effects of Unilateral Trade Liberalization

Name	Before	After	Change
τ_{df}	3.89	3.74	-4%
Change in welfare			+0.26 %
Real wage	10.19	10.35	+1.6%
Real GDP	22.51	22.87	+1.6 %
Real Interest Rate	0.0605	0.0602	-0.5 %
Real Exchange Rate	0.94	0.926	-1.51%
Aggregate TFP	46.56	46.71	+0.32%
Consumption	19.24	19.85	+3.2%
Aggregate Output	21.1	21.8	+3.1%
Real total profits	21.03	21.39	+1.7%
Real total revenues	64.81	65.87	+1.6%
Investment	1.53	1.56	+2%
Credit/GDP, %	0.46	0.455	-0.3%
Share of producers, %	0.35	0.35	0
Share of exporters, %	0.256	0.253	-1.17%
Share of constrained, %	0.321	0.318	-1%
Average K/L	27.21	27.96	+2.76%
Average MRPK	0.29	0.292	+0.5%
Standard deviation of MRPK	0.487	0.49	+0.6%
Average domestic markup	1.1324	1.1319	-0.04%
Standard deviation of domestic markups	0.131	0.1307	-0.2%
Covariance between markups and MRPK, %	0.0172	0.0173	+0.6%
Standard deviation of log(TFPR), %	0.0648	0.065	+0.3%

Note: The table shows the results of an exercise modeling a unilateral trade liberalization. Column "Before" contains moments, equilibrium prices, and policy functions for the initial, pre-liberalization, steady state. Column "After" contains moments, equilibrium prices, and policy functions for the post-liberalization steady state. Column "Change" shows differences in values between post- and pre-trade liberalization steady states. For ratios with %, "Change" calculates absolute percentage change, we report proportional changes for other variables.

we compare changes in Aggregate TFP across steady states in the four versions of the model. We present our results in Table 3.8. Intuitively, changes in aggregate TFP in NFF+CM could only reflect improvements in production efficiency. Changes in other versions also reflect changes in allocative efficiency. The results we obtain are consistent with the previous literature. In the model with variable markups but without credit constraints, unilateral trade liberalization improves allocative efficiency by reducing markup dispersion, as in Edmond et al. (2015). For this reason, TFP changes by more than in the version of the model without credit constraints and markup dispersion. However, credit constraints reverse changes in allocative efficiency, TFP declines due to strengthened capital misallocation. Changes in aggregate TFP are negative in both versions of the model with credit constraints. Markup dispersion exacerbates allocative efficiency losses from unilateral trade liberalization in the presence of credit constraints. Unilateral trade liberalization increases the covariance between markups and effective costs of capital for firms pushing up TFPR dispersion. Rising costs for domestic firms reallocate sales towards more constrained firms with larger markups, increasing thereby the amount of output foregone due to distortions.

Table 3.8: Effects of Unilateral Trade Liberalization on Allocative Efficiency

Name	ΔTFP	$\Delta Var(log(TFPR))$	$\Delta SD(MRPK)$	$\Delta SD(\mu)$	$\Delta Cov(\mu, MRPK)$
Baseline	-2.1%	+0.3%	+0.6%	-0.2%	+0.6%
NFF	+5.6%	-0.3%	0	-0.5%	0
CM	-1.3%	+0.34%	+1.4%	0	0
NFF + CM	+3.9%	0	0	0	0

Note: The table presents a number of statistics, describing proportional changes in the TFPR components in different versions of the model. Baseline denotes the version of the model described in 3.3, NFF denotes the version of the model without credit constraints, CM denotes the version of the baseline model without markup dispersion. NFF+CM denotes the baseline model without credit constraints and variable markups.

Other responses. There are several other effects that we observe in the recipient economy. The nominal interest rate rises by less than the price level. Therefore, the real interest rate declines. Domestic currency appreciates, as the real exchange rate goes down. A larger level of foreign debt causes an increase in trade surplus, but the ratio of credit to GDP declines, as GDP grows faster than the level of outstanding debt. Investment activity accelerates due to the larger demand for capital from exporters. In contrast to the data, the share of exporters declines, and the average export intensity goes down. In contrast to the data, we do not see a decline in average capital intensity, as the wage grows faster than the interest rate. Share of exporters slightly declines, while the share of producing firms does not significantly change.

3.5 Discussion

The model we propose is rich, it allows for within-sector differences in capital intensities and variable markups. However, this model cannot accurately explain all the observed patterns in the reallocation of factors following the implementation of the Autonomous Trade Preferences in 2014. For instance, the model fails to reproduce the negative relationship between labor shares and capital intensities that we observe in the data. We abstract from monetary tightening undertaken by the National Bank of Ukraine during this period, which might explain a decline in capital intensities within firms. For simplicity, the model abstracts from exporting decisions to other countries even though Ukrainian manufacturing firms exported to many markets outside the EU (with Russia remaining the main buyer before 2014).[30] Structural exercise provides a simplified environment to study the effects of a unilateral improvement in market access, considering firm's difficulties in receiving finance and distortions due to markup dispersion.

While we do not explicitly model government decisions, tariff revenues collected from the EU producers should affect government budget. An increase in imports from the EU as a result of a unilateral trade liberalization should increase government revenues and welfare if proceeds increase the lump-sum subsidies. Another benefit of incorporating government would be to model various policy interventions, which could bolster the response of the recipient economy to unilateral trade liberalization.

3.6 Conclusions

In this paper, we use a two-country model with heterogeneous agents to study the response of a developing recipient to a reduction in import tariff by a more efficient donor country. We allow for credit constraints and variable markups in a distorted recipient. We find that unilateral trade liberalization improves welfare but worsens allocative efficiency due to an increase in capital misallocation. Welfare improves due to rising consumption and greater aggregate profits. Allocative efficiency worsens, as negative effects from an increase in capital misallocation dominate positive effects due to declining markup dispersion. Unilateral trade liberalization might improve allocative efficiency with better access to credit.

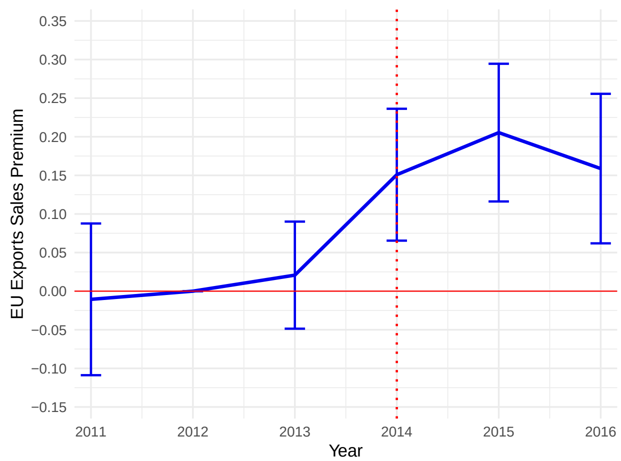
[30] A cleaner but significantly more complicated exercise should model Russia and the rest of the World as separate locations and somehow account for the changes induced by protectionist measures imposed by Russia in 2014. However, we abstract from these changes since, according to our results in Appendix 3.6, we do not see significant differences in growth of export sales to the EU members across firms exporting to Russia and firms who did not do that.

3.7 Appendix

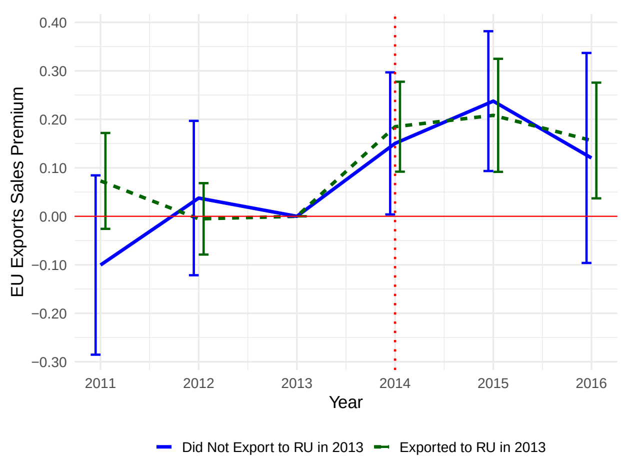
3.7.1 Additional Empirical Results

Figure 3.6: EU Export Sales Growth Premium of Firms with Higher Capital Intensity: Robustness Checks

(a) Placebo exercise



(b) Role of exporting to Russia



Note: Figure shows a set of coefficients $\{\beta^{\tau}\}_{\tau=2011}^{2016}$ in regression (3.1). Standard errors are clustered at the firm level. The sample only includes firms which continuously exported to the EU in 2011-2016. We plot 90% confidence bands around each member of $\{\beta^{\tau}\}_{\tau=2011}^{2016}$. In panel (a), reference year is 2012 and treatment occurs in 2014. In panel (b), reference year is 2013 and treatment occurs in 2014. The line "Did Not Export to RU in 2013" presents coefficients in regression (3.1) when the sample is restricted to firms not exporting to the Russian market in 2013. The line "Exported to RU in 2013" presents coefficients in regression (3.1) when the sample is restricted to firms that exported to the Russian market in 2013.

3.7.2 Calibrating Productivity Process

To calibrate the model, we require two parameters of a log-normal productivity process σ_z and ρ_z in (3.43):

$$\log z_t = (1-\rho_z)\mu_z + \rho_z \log z_{t-1} + \epsilon_t, \quad \mathcal{N} \sim (0, \sigma_\epsilon^2) \tag{3.43}$$

We use structural model in 3.3 to estimate productivity, normalizing its geometric average to 1. Next, we express the domestic revenue of firm i, relative to firm j as in 3.44:

$$\log\left(\frac{p_{idt}y_{idt}}{p_{jdt}y_{jdt}}\right) = \log\left(\frac{\mu_{idt}}{\mu_{jdt}}\right) + \log\left(\frac{MC_{idt}}{MC_{jdt}}\right) + \log\left(\frac{y_{idt}}{y_{jdt}}\right) \tag{3.44}$$

Now recall that for firms i and j, producing only domestically,

$$\begin{aligned}
\frac{\mu_{idt}}{\mu_{jdt}} &= \frac{\frac{W_d l_{jdt}}{p_{jdt}y_{jdt}}}{\frac{W_d l_{idt}}{p_{idt}y_{idt}}} \\
\frac{MC_{idt}}{MC_{jdt}} &= \frac{z_{jdt}}{z_{idt}}\left[\frac{R_d+\delta+\lambda_{idt}}{R_d+\delta+\lambda_{jdt}}\right]^\alpha = \frac{z_{jdt}}{z_{idt}}\left[\frac{\frac{k_{jdt}}{l_{jdt}}}{\frac{k_{idt}}{l_{idt}}}\right]^\alpha \\
\frac{y_{idt}}{y_{jdt}} &= \left[\frac{1-\frac{1}{1-\alpha}\frac{W_d l_{idt}}{p_{idt}y_{idt}}}{1-\frac{1}{1-\alpha}\frac{W_d l_{jdt}}{p_{jdt}y_{jdt}}}\right]^{\frac{\sigma}{\epsilon}}
\end{aligned} \tag{3.45}$$

We make use of these facts to express firm i's productivity, relative to firm j as:

$$\begin{aligned}
\log\left(\frac{z_{jdt}}{z_{idt}}\right) = \log\left(\frac{p_{idt}y_{idt}}{p_{jdt}y_{jdt}}\right) - \log\left(\frac{\frac{W_d l_{jdt}}{p_{jdt}y_{jdt}}}{\frac{W_d l_{idt}}{p_{idt}y_{idt}}}\right) - (1-\alpha)\log\left(\frac{\frac{k_{jdt}}{l_{jdt}}}{\frac{k_{idt}}{l_{idt}}}\right) - \\
-\frac{\sigma}{\epsilon}\log\left(\frac{1-\frac{1}{1-\alpha}\frac{W_d l_{idt}}{p_{idt}y_{idt}}}{1-\frac{1}{1-\alpha}\frac{W_d l_{jdt}}{p_{jdt}y_{jdt}}}\right)
\end{aligned} \tag{3.46}$$

Now we use (3.46) and the assigned parameter values to recover normalized productivity with the following sequence of steps:

1. Use the data for 2012-2013 year, removing from the sample all exporting firms and all firms with missing wage bill or labor share exceeding $1-\alpha$;

2. Using firm with the smallest revenue as i, compute $\log\left(\frac{z_{jdt}}{z_{idt}}\right)$ using (3.46) for every firm in

the data;

3. Normalizing geometric average of productivities to 1 for a sample with K firms, calculate

$$\log \bar{z}_{jdt} = \log\left(\frac{z_{jdt}}{z_{idt}}\right) - \frac{1}{K}\sum_k \log\left(\frac{z_{kdt}}{z_{idt}}\right), \tag{3.47}$$

where $\bar{z}_{jdt} = \frac{z_{jdt}}{[\prod_k z_{kdt}]^{\frac{1}{K}}}$

Now we show that AR(1) regression of $\log \bar{z}_{jdt}$ on $\log \bar{z}_{jdt-1}$ delivers a consistent estimate of ρ_z. To show this, we re-express (3.43) as:

$$\begin{aligned}\log \bar{z}_{jdt} &= (1-\rho_z)\mu_z - \frac{1}{K}\log\left[\prod_k z_{kdt}\right] + \rho_z \log z_{t-1} + \varepsilon_t = \\ &= (1-\rho_z)\mu_z - \frac{1}{K}\log\left[\prod_k z_{kdt}\right] + \rho_z \log z_{t-1} - \frac{\rho_z}{K}\log\left[\prod_k z_{kdt-1}\right] + \\ &+ \frac{\rho_z}{K}\log\left[\prod_k z_{kdt-1}\right] + \varepsilon_t = \\ &= \underbrace{(1-\rho_z)\mu_z - \frac{1}{K}\log\left[\prod_k z_{kdt}\right] + \frac{\rho_z}{K}\log\left[\prod_k z_{kdt-1}\right]}_{\text{Intercept}} + \rho_z \log \bar{z}_{jdt-1} + \varepsilon_t\end{aligned} \tag{3.48}$$

Estimating this regression equation on the balanced panel of non-exporters between 2012 and 2013 year, we obtain the estimate ρ_z equal to 0.894.

3.7.3 Algorithm to Solve for the Steady State

We describe an algorithm to solve a benchmark model from Section 3.3. We start by discretizing the state space for domestic entrepreneurs using the productivity grid G_z and asset grid G_a.[31]. $G_a \times G_z$ produces the domain for solving the optimal policy functions of domestic entrepreneurs. We approximate the autoregressive productivity process through the procedure in Rouwenhorst (1995). We add subscripts e and d to distinguish between policy functions of exporters and entrepreneurs selling only at home for each point in $G_a \times G_z$. At this stage, we are endowed with guesses of P_d, Y_d, R_d, W_d, D_d which are not necessarily part of the stationary equilibrium. We index imported varieties with ω_f. We proceed using the following steps:

1. For each point in $G_a \times G_z$, we determine the solutions to 2 problems: the problem of the domestic exporter and the problem of the domestic non-exporter. Given the knowledge of W_d, Y_d, P_d, R_d, D_d, for each value of productivity($z_d(\omega)$) and assets($a_d(\omega)$), the solution to the problem of non-exporter gives numerical solutions to markup the relative and absolute values of output($y_{dd}(\omega)$, $q_{dd}(\omega)$), the marginal cost of a firm $MC_{dd}(\omega)$, domestic profits ($\pi_{dd}(\omega)$), domestic markup($\mu_{dd}(\omega)$), optimal levels of labor and capital ($l_d(\omega)$, $k_d(\omega)$) and the effective cost of capital ($CC_d(\omega)$), needed to serve domestic demand. For an unconstrained firm, $CC_d(\omega) = R_d + \delta$, but it is larger for the constrained firm. Solution to the exporter problem, given the knowledge of Y_d, P_d, R_d, D_d, W_d, Y_f, P_f, τ_{df} for each value of productivity($z_d(\omega)$) and assets($a_d(\omega)$) provides the numerical solutions to the absolute value of foreign and domestic output ($y_{ef}(\omega), y_{ed}(\omega)$), domestic relative output($q_{ed}(\omega)$), foreign and domestic price ($p_{ef}(\omega), p_{ed}(\omega)$), foreign and domestic marginal costs($MC_{ef}(\omega)$, $MC_{ed}(\omega)$), domestic and export profits ($\pi_{ed}(\omega), \pi_{ef}(\omega)$), domestic and export markups ($\mu_{ed}(\omega)$, $\mu_{ef}(\omega)$), optimal levels of labor and capital ($l_e(\omega)$, $k_e(\omega)$) and the effective cost of capital ($CC_e(\omega)$), consistent with profit maximization on two markets;

2. For each point of a G_z, we only solve the foreign producer problem on the domestic market, as unconstrained foreign firms make production decisions across markets independently. Given $\tau_{fd}W_f^{1-\alpha}$, Y_d, D_d, R_f, P_f, and P_d for each value of $z(\omega_f)$ in G_z, we numerically solve for absolute and relative exported outputs of foreign producers ($y_d(\omega_f)$, $q_d(\omega_f)$), price ($p_d(\omega_f)$), marginal costs ($MC_d(\omega_f)$), profits on the domestic market ($\pi_d(\omega_f)$), domestic markup($\mu_d(\omega_f)$) and the optimal value of labor and capital ($l(\omega_f)$, $k(\omega_f)$).

3. Knowing $\pi_e(\omega) = \pi_{ed}(\omega) + \pi_{ef}(\omega) - F$, $\pi_d(\omega) = \pi_{dd}(\omega)$, we solve for the policy function of domestic firm. The resulting profits are $\pi(z_d(\omega), a_d(\omega)) = \max(\pi_e(\omega), \pi_d(\omega))$. Entrepreneurs

[31] Since asset holdings are irrelevant for production decisions of foreign entrepreneurs, we only determine their static policy functions given the productivity grid G_z

from f with $MC_d(\omega_f)$ less than the choke price sell to domestic consumers; other foreign entrepreneurs do not sell anything to consumers from d.

The solution to the static problem for each point in $G_a \times G_z$ policy functions for each domestic producer and exporter from d and producers from f selling to d. After that, we proceed with solving the dynamic problem of the entrepreneur:

1. We make the initial guess of the value function, $\hat{g}(a_d, z_d)$

2. For any point on $G_a \times G_z$, given profits from the static problem, we numerically solve for the policy function of domestic entrepreneur $a'(a_d, z_d)$ as a solution to:

$$a'(a_d, z_d) = \arg\max_{a' \in G_a} \mathbf{O}(a'; a_d, z_d), \tag{3.49}$$

   where

$$\mathbf{O}(a'; a_d, z_d) = \frac{1}{1+\nu}\left[W_d + \pi(z_d, a_d) + a_d(1+R_d) - a'\right]^{1+\nu} + \beta\mathbb{E}_{z'}[\hat{g}(a', z')] \tag{3.50}$$

3. Given the optimal net-worth policy $(a'(a_d, z_d))$, we solve for the optimal consumption policy for every point on $G_a \times G_z$:

$$c(a_d, z_d) = W_d + \pi(z_d, a_d) + a_d(1+R_d) - a'(a_d, z_d) \tag{3.51}$$

4. Knowing $c(a_d, z_d)$ and $a'(a_d, z_d)$, we derive the value function:

$$g(a_d, z_d) = \frac{1}{1+\nu} c(a_d, z_d)^{1+\nu} + \beta\mathbb{E}_{z'}[g(a'(a_d, z_d), z')] \tag{3.52}$$

5. If the difference between $g(a_d, z_d)$ and $\hat{g}(a_d, z_d)$ is small enough, we treat $c(a_d, z_d)$ and $a'(a_d, z_d)$ as solutions to the dynamic problem of the domestic entrepreneur. In another case, we set $\hat{g}(a_d, z_d) = g(a_d, z_d)$ and iterate through 1-4 again.

We use solutions to the static and dynamic problems of the entrepreneur as well, as the known aggregate prices and quantities to construct stationary distribution of individuals, $\varphi : \mathcal{S} \longrightarrow [0,1]$:

1. We guess an arbitrary distribution $\hat{\varphi}(a, z)$;

2. We calculate the next period's measure of firms $\varphi(a'(a, z), z')$ according to the policy function of individuals $(a'(a, z))$ and their productivity distribution: $\varphi(a'(a, z), z') = \varphi(a'(a, z), z') +$

$\hat{\varphi}(a,z)\mathbb{P}_Z(z,z')$ where $\mathbb{P}_Z(z,z')$ is a transition matrix showing a fraction of entrepreneurs with productivity z transitioning to state z';

3. We compare $\varphi(a'(a,z),z')$ and $\hat{\varphi}(a,z)$. If the norm of the difference between them is smaller than the chosen tolerance level, we exit the loop. Otherwise, we update $\hat{\varphi}(a,z) = \varphi(a'(a,z),z')$ and go to step 2.

Given the stationary measure computed above, the assumed values of P_d, Y_d, R_d, W_d, D_d should satisfy the equilibrium conditions. Next, we construct the set of counterparts of these conditions, which we use for verifying the extent of satisfaction of these conditions on the grid of $G_a \times G_z$. In particular, we require that:

1. Final good market clears:

$$Y_d = \int_{G_a\times G_z} c_d(s)\varphi(s)ds + \delta\int_{G_a\times G_z} k_d(s)\varphi(s)ds + R_d * \int_{G_a\times G_z}(k_d(s)-a_d(s))\varphi(s)ds \tag{3.53}$$

2. Labor market clears:

$$\int_{G_a\times G_z} l_d(s)\varphi(s)ds + F\int_{G_a\times G_z} e_d(s)\varphi(s)ds = 1 \tag{3.54}$$

3. Policy function of final good producer maximizes its profits given:

$$\begin{aligned} \frac{1}{|\Omega_{dd}|}\int_{G_a\times G_z}\Upsilon\left(\frac{|\Omega_{dd}|y_d(s)}{Y_d}\right)\varphi(s)ds + \frac{1}{|\Omega_{dm}|}\int_{G_z}\Upsilon\left(\frac{|\Omega_{dm}|y_d(s_f)}{Y_d}\right)\varphi_f(s_f)ds_f = 1 \\ \int_{G_a\times G_z} p_d(s)\frac{y_d(s)}{Y_d}\varphi(s)ds + RER\int_{G_z} p_d(s_f)\frac{y_d(s_f)}{Y_d}\varphi_f(s_f)ds_f = P_d \end{aligned} \tag{3.55}$$

4. The interest rate premium $R_d - R_f$ is consistent with the level of foreign debt:

$$R_d - R_f = \psi\left(e^{\frac{\int_{G_a\times G_z}(k_d(s)-a_d(s))\varphi(s)ds}{Y_d}} - 1\right) \tag{3.56}$$

If the norm of the differences between the left and the right sides of these equations is larger than the tolerance threshold, given the P_d, Y_d, R_d, W_d, D_d, we update the guesses and proceed to the start of the section. Otherwise, we conclude that P_d, Y_d, R_d, W_d, D_d are steady-state equilibrium prices and quantities.

3.7.4 Numerical Solution of the Static Problem

Static problem of a domestic non-exporting firm

We start describing the solution procedure by writing down the static problem of a non-exporting firm:

$$\begin{aligned}
\pi(a_d(\omega), z_d(\omega)) = &\max_{y_{dd}(\omega), p_{dd}(\omega), k_d(\omega), l_d(\omega)} p_{dd}(\omega) y_{dd}(\omega) - W_d l_d(\omega) - (R_d + \delta) k_d(\omega) \\
&\text{s.t.} \\
y_{dd}(\omega) &= \left[1 - \varepsilon \ln\left(\frac{\sigma}{\sigma - 1} p_{dd}(\omega) \frac{D_d}{P_d}\right)\right]^{\frac{\sigma}{\varepsilon}} Y_d \qquad (3.57) \\
y_{dd}(\omega) &= z_d(\omega) k_d^{\alpha}(\omega) l_d^{1-\alpha}(\omega) \\
k_d(\omega) &\leq \frac{1 + R_d}{1 + R_d - \theta} a_d(\omega)
\end{aligned}$$

(3.58) provides the system of first-order conditions for the domestic producer:

$$\begin{aligned}
&\frac{\sigma - 1}{\sigma} \exp\left(\frac{1 - q_{dd}^{\frac{\varepsilon}{\sigma}}(\omega)}{\varepsilon}\right) \frac{P_d}{D_d} = \frac{\sigma}{\sigma - q_{dd}^{\frac{\varepsilon}{\sigma}}(\omega)} MC_{dd}(\omega) \\
&W_d = (1 - \alpha) MC_{dd}(\omega) z_d(\omega) k_d^{\alpha}(\omega) l_d^{-\alpha}(\omega) \qquad (3.58) \\
&R_d + \delta + \lambda_d(\omega) = \alpha MC_{dd}(\omega) z_d(\omega) k_d^{\alpha-1}(\omega) l_d^{1-\alpha}(\omega)
\end{aligned}$$

Similarly to Kohn et al. (2020) and Edmond et al. (2023), we define three associated complementary slackness conditions:

$$\begin{aligned}
&MC_{dd}(\omega)(z_d(\omega) k_d^{\alpha}(\omega) l_d^{1-\alpha}(\omega) - y_{dd}(\omega)) = 0 \\
&q_{dd}(\omega)\left(\frac{\sigma - 1}{\sigma} \exp\left(\frac{1 - q_{dd}^{\frac{\varepsilon}{\sigma}}(\omega)}{\varepsilon}\right) \frac{P_d}{D_d} - \frac{\sigma}{\sigma - q_{dd}^{\frac{\varepsilon}{\sigma}}(\omega)} MC_{dd}(\omega)\right) = 0 \qquad (3.59) \\
&\lambda_d(\omega)\left(\frac{1 + R_d}{1 + R_d - \theta} a_d(\omega) - k_d(\omega)\right) = 0
\end{aligned}$$

Since it is ex-ante ambiguous whether the entrepreneur is constrained given the level of assets and productivity, the first step in solving the problem is to determine the effective cost of capital, at which the firm would serve profit-maximizing output. For a firm producing non-zero output, this value is equal to $\max(R_d + \delta, \overline{CC}(\omega))$ with $\overline{CC}_d(\omega)$ solving (3.60):

$$\frac{\sigma - q(\overline{CC}_d(\omega))^{\frac{\varepsilon}{\sigma}}}{\sigma} \frac{\sigma - 1}{\sigma} \exp\left(\frac{1 - q(\overline{CC}_d(\omega))^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right) \frac{P_d}{D_d} = \left(\frac{\overline{CC}_d(\omega)}{\alpha}\right)^{\alpha} \left(\frac{W_d}{1 - \alpha}\right)^{1-\alpha} \frac{1}{z_d(\omega)}, \qquad (3.60)$$

where

$$q(\overline{CC}_d(\omega)) = \left[\frac{\overline{CC}_d(\omega)}{\phi_d(\omega)}\right]^{1-\alpha}, \tag{3.61}$$

$$\phi_d(\omega) = W_d \frac{\alpha}{1-\alpha}\left[\frac{Y_d}{z_d(\omega)k(a_d(\omega))}\right]^{\frac{1}{1-\alpha}}, \tag{3.62}$$

$$k(a_d(\omega)) = a_d(\omega)\frac{1+R_d}{1+R_d-\theta} \tag{3.63}$$

In essence, $\overline{CC}_d(\omega) \in [R_d+\delta, +\infty)$ provides the level of the effective cost of capital of the entrepreneur producing profit-maximizing output given the binding borrowing constraint. The fraction of the level of assets provides an upper bound for the capital this entrepreneur can acquire; knowing this, such an entrepreneur solves the profit maximization problem with marginal costs increasing with firm's output. Rising effective cost of capital increases output and in this way increases marginal costs and decreases marginal revenue.

Note that there are also entrepreneurs with marginal cost above the choke price even if $\overline{CC}_d(\omega) = R_d+\delta$. For these entrepreneurs, the right-hand side of (3.60) is larger than the left-hand side. If this is the case, for these firms, we set $\overline{CC}_d(\omega) = R_d+\delta$, as a collateral constraint cannot bind for a non-producing firm. For the constrained firm producing non-zero output, the unique solution to (3.60) determines $MC_d(\omega)$ and $y_d(\omega)$. If the firm is constrained, the solution to this equation lies within $(R_d+\delta; +\infty)$. If the firm is unconstrained, the solution to (3.60) is weakly less than $R_d+\delta$; in this case, we set $\overline{CC}_d(\omega) = R_d+\delta$.

Knowing $\overline{CC}_d(\omega)$, we calculate $MC_{dd}(\omega) = \frac{1}{z_d(\omega)}\frac{W_d^{1-\alpha}\overline{CC}_d^{\alpha}(\omega)}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}}$. Then, similarly to Edmond et al. (2023), we solve for the optimal $y_{dd}(\omega)$ implicitly defined as a non-zero root of (3.7.4) if $q_{dd}(\omega) > 0$ or 0 if non-zero solution does not exist:

$$q_{dd}(\omega)\left(\frac{\sigma-1}{\sigma}\exp\left(\frac{1-q_{dd}^{\frac{\varepsilon}{\sigma}}(\omega)}{\varepsilon}\right)\frac{P_d}{D_d} - \frac{\sigma}{\sigma-q_{dd}^{\frac{\varepsilon}{\sigma}}(\omega)}\frac{1}{z_d(\omega)}\frac{W_d^{1-\alpha}\overline{CC}_d^{\alpha}(\omega)}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}}\right) = 0 \tag{3.64}$$

Monotonicity of the term in brackets implies that if strictly positive root to , it is unique given $z_d(\omega)$ and $\overline{CC}_d(\omega)$. Knowing $q_{dd}(\omega)$ is sufficient to calculate $\mu_{dd}(\omega) = \frac{\sigma}{\sigma-q_{dd}^{\frac{\varepsilon}{\sigma}}(\omega)}$ and $p_{dd}(\omega) = \frac{\sigma}{\sigma-q_{dd}^{\frac{\varepsilon}{\sigma}}(\omega)}MC_{dd}(\omega)$. Knowing Y_d, we can recover $y_{dd}(\omega)$, $k_d(\omega) = \frac{\alpha y_{dd}(\omega)MC_{dd}(\omega)}{R_d+\delta}$, and $l_d(\omega) = \frac{(1-\alpha)y_{dd}(\omega)MC_{dd}(\omega)}{W_d}$ for an unconstrained firm, and $l_d(\omega)$ for a constrained firm (recall, that binding borrowing constraint for a constrained firm implies that constrained firm exhausts its borrowing limits, which uniquely determines its level of capital). We calculate profits using $\pi_{dd}(\omega) = y_{dd}(\omega)(p_{dd}(\omega) - MC_{dd}(\omega))$.

Static problem of a domestic exporter

We start describing the solution procedure by writing down the static problem of exporting firm:[32]

$$\begin{aligned}
\pi(a_d(\omega), z_d(\omega)) = \max_{\substack{y_{ed}(\omega), p_{ed}(\omega), y_{ef}(\omega),\\ p_{ef}(\omega), k_d(\omega), l_d(\omega)}} \; & p_{ed}(\omega) y_{ed}(\omega) + \text{RER} p_{ef}(\omega) y_{ef}(\omega) \\
& - W_d l_e(\omega) - (R_d + \delta) k_e(\omega) - W_d F \\
\text{s.t.} \quad & \\
& y_{ed}(\omega) = \left[1 - \varepsilon \ln\left(\frac{\sigma}{\sigma - 1} p_{ed}(\omega) \frac{D_d}{P_d}\right)\right]^{\frac{\sigma}{\varepsilon}} Y_d \qquad (3.65) \\
& y_{ef}(\omega) = p_{ef}^{-\sigma}(\omega) \frac{Y_f}{P_f^{-\sigma}} \\
& \tau_{df} y_{ef}(\omega) + y_{ed}(\omega) = z_d(\omega) k_e^{\alpha}(\omega) l_e^{1-\alpha}(\omega) \\
& k_e(\omega) \le \frac{1 + R_d}{1 + R_d - \theta} a_d(\omega)
\end{aligned}$$

(3.66) provides the system of first-order conditions for an exporter of ω:

$$\begin{aligned}
& \frac{\sigma - 1}{\sigma} \exp\left(\frac{1 - q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)}{\varepsilon}\right) \frac{P_d}{D_d} = \frac{\sigma}{\sigma - q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)} MC_{ed}(\omega) \\
& P_f Y_f^{\frac{1}{\sigma}} y_{ef}^{-\frac{1}{\sigma}}(\omega) = \frac{\sigma}{\sigma - 1} MC_{ef}(\omega) \qquad (3.66) \\
& W_d = (1 - \alpha) MC_{ed}(\omega) z_d(\omega) k_e^{\alpha}(\omega) l_e^{-\alpha}(\omega) \\
& R_d + \delta + \lambda_e(\omega) = \alpha MC_{ed}(\omega) z_d(\omega) k_e^{\alpha - 1}(\omega) l_e^{1-\alpha}(\omega)
\end{aligned}$$

[32] here, $MC_{ef}(\omega)$ and $p_{ef}(\omega)$ are expressed in foreign currency

The associated complementary slackness conditions share similarities with the ones for the domestic producer:

$$\begin{aligned}
&MC_{ed}(\omega)(z_d(\omega)k_e^{\alpha}(\omega)l_e^{1-\alpha}(\omega) - \tau_{df}y_{ef}(\omega) - y_{ed}(\omega)) = 0 \\
&q_{ed}(\omega)\left(\frac{\sigma-1}{\sigma}\exp\left(\frac{1-q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)}{\varepsilon}\right)\frac{P_d}{D_d} - \frac{\sigma}{\sigma - q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)}MC_{ed}(\omega)\right) = 0 \\
&\lambda_e(\omega)\left(\frac{1+R_d}{1+R_d-\theta}a_d(\omega) - k_e(\omega)\right) = 0
\end{aligned} \tag{3.67}$$

Similarly to 3.7.4, we start solving the problem by determining the effective cost of capital, consistent with profit maximization by a constrained firm. We denote its value by $\max(R_d + \delta, \overline{CC}_e(\omega))$. Consider now the firm selling goods both on the domestic and foreign market and facing binding borrowing constraints. If the effective cost of capital is $\overline{CC}_e(\omega)$, the total output it produces after exhausting its borrowing constraint is

$$\tau_{df}y_{ef}(\omega) + y_{ed}(\omega) = z_d(\omega)k(a_d(\omega))\left[\frac{k(a_d(\omega))}{l_e(\omega)}\right]^{\alpha-1} = z_d(\omega)k(a_d(\omega))\left[\frac{\overline{CC}_e(\omega)(1-\alpha)}{W_d\alpha}\right]^{1-\alpha} \tag{3.68}$$

CES demand on the foreign market enables exporters to calculate the exact value of profit-maximizing exported output:

$$y_{ef}(\omega) = \frac{Y_f}{(P_f\text{RER})^{-\sigma}}\left[\frac{\sigma}{\sigma-1}\frac{W_d^{1-\alpha}\overline{CC}_e^{\alpha}(\omega)}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}}\frac{\tau_{df}}{z_d(\omega)}\right]^{-\sigma} \tag{3.69}$$

(3.69) enables us to express the residual relative output of exporters on the domestic market as

$$q(\overline{CC}_e(\omega)) = \frac{z_d(\omega)k(a_d(\omega))}{Y_d}\left[\frac{\overline{CC}_e(\omega)(1-\alpha)}{W_d\alpha}\right]^{1-\alpha} - \frac{Y_f\tau_{df}^{1-\sigma}}{(P_fRER)^{-\sigma}Y_d}\left[\frac{\sigma}{\sigma-1}\frac{W_d^{1-\alpha}\overline{CC}_e^{\alpha}(\omega)}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}z_d(\omega)}\right]^{-\sigma} \tag{3.70}$$

With this in mind, we can implicitly define $\overline{CC}_e(\omega)$ as a solution to the following equation:

$$\frac{\sigma - q(\overline{CC}_e(\omega))^{\frac{\varepsilon}{\sigma}}}{\sigma}\frac{\sigma-1}{\sigma}\exp\left(\frac{1-q(\overline{CC}_e(\omega))^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right)\frac{P_d}{D_d} = \left(\frac{\overline{CC}_e(\omega)}{\alpha}\right)^{\alpha}\left(\frac{W_d}{1-\alpha}\right)^{1-\alpha}\frac{1}{z_d(\omega)} \tag{3.71}$$

where again $\overline{CC}_e(\omega) \in [R_d + \delta; \infty)$. The logic behind determining the effective cost of capital for a constrained producer is similar to a domestic producer; a constrained firm has its $\overline{CC}_e(\omega) \in$

$(R_d + \delta; \infty)$, while unconstrained firm pays $R_d + \delta$ for capital. Now we consider several important cases which might arise:

- There might be firms with $MC_{ed}(\omega)$ larger than the choke price at $\overline{CC}_e(\omega) = R_d + \delta$. Nonetheless, these firms might still obtain enough export profits to pay out the fixed costs of exporting. For such firms, we set

$$\overline{CC}_e(\omega) = \max\left(\alpha\left(\frac{\sigma-1}{\sigma}\right)^{\frac{\sigma}{\alpha\sigma+1-\alpha}}\left(\frac{1-\alpha}{W_d}\right)^{\frac{(1-\alpha)(\sigma-1)}{\alpha\sigma+1-\alpha}} z_d(\omega)^{\frac{\sigma-1}{\alpha\sigma+1-\alpha}}\left(\frac{Y_f(P_f RER)^{\sigma}}{k(a_d(\omega))\tau_{df}^{\sigma-1}}\right)^{\frac{1}{\alpha\sigma+1-\alpha}}, R_d + \delta\right) \tag{3.72}$$

- There might be entrepreneurs with $MC_{ed}(\omega)$ larger than the choke price at $\overline{CC}_e(\omega) = R_d + \delta$ for whom productivity is not sufficient to break even the fixed costs of exporting. For these firms, we set $\overline{CC}_e(\omega) = R_d + \delta$, as they do not produce anything and thus cannot face binding borrowing constraints.

- There might be entrepreneurs who face positive demand on the domestic market if $\overline{CC}_e(\omega) = R_d + \delta$ but for whom $q(R_d + \delta) \leq 0$. In this case, the firm's demand on the exporting market is so large that current production possibilities do not allow this firm to satisfy it. The resulting non-monotonicities in (3.71) might prevent finding a root to (3.71) consistent with joint profit maximization on both markets. In this case, we know that joint profit maximization in both markets requires the following relationships between marginal revenues in both markets:

$$\frac{\sigma - q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)}{\sigma}\frac{\sigma-1}{\sigma}\exp\left(\frac{1-q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)}{\varepsilon}\right)\frac{P_d}{D_d} = \frac{\text{RER}}{\tau_{df}}\frac{\sigma-1}{\sigma}P_f Y_f^{\frac{1}{\sigma}} y_{ef}^{-\frac{1}{\sigma}}(\omega) \tag{3.73}$$

  Using (3.73), we can obtain a closed-form expression of $y_{ef}(\omega) = f(q_{ed}(\omega))$. We use numerical algorithm to find $\overline{CC}_e(\omega)$ solving

$$\tau_{df}(f(q_{ed}(\omega))) + q_{ed} * Y_d = z_d(\omega)k(a_d(\omega))\left[\frac{\overline{CC}_e(\omega)(1-\alpha)}{W_d\alpha}\right]^{1-\alpha} \tag{3.74}$$

Knowing $\overline{CC}_e(\omega)$, we can compute the marginal cost of the firm on the domestic market

$$MC_{ed}(\omega) = \frac{1}{z_d(\omega)}\frac{W_d^{1-\alpha}\overline{CC}_e^{\alpha}(\omega)}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}} \tag{3.75}$$

and on the exporting market

$$MC_{ef}(\omega) = \frac{\tau_{df}}{RER} MC_{ed}(\omega) \tag{3.76}$$

This information is sufficient to calculate $y_{ef}(\omega)$ using (3.69). We compute $y_{ed}(\omega)$ as a product of Y_d and $q_{ed}(\omega)$ as a non-zero solution to:

$$q_{ed}(\omega)\left(\frac{\sigma-1}{\sigma}\exp\left(\frac{1-q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)}{\varepsilon}\right)\frac{P_d}{D_d} - \frac{\sigma}{\sigma - q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)}\frac{1}{z_d(\omega)}\frac{W_d^{1-\alpha}\overline{CC}_d^{\alpha}(\omega)}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}}\right) = 0 \tag{3.77}$$

Knowledge of $y_{ed}(\omega)$ enables us to calculate relative domestic output $q_{ed}(\omega)$, domestic markup $\mu_{ed}(\omega) = \frac{\sigma}{\sigma - q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)}$ and price $p_{ed}(\omega) = \frac{\sigma}{\sigma - q_{ed}^{\frac{\varepsilon}{\sigma}}(\omega)} MC_{ed}(\omega)$. Foreign markup is constant and equal to $\frac{\sigma}{\sigma-1}$, foreign price in foreign currency is $p_{ef}(\omega) = \frac{\sigma}{\sigma-1}\frac{\tau_{df}}{RER} MC_{ed}(\omega)$. Knowing both outputs, we can calculate total output as $\tau_{df} y_{ef}(\omega) + y_{ed}(\omega)$. In its turn, total output enables calculating the total value of labor and capital for the unconstrained firm $k_e(\omega) = \frac{\alpha(\tau_{df} y_{ef}(\omega) + y_{ed}(\omega)) MC_{ed}(\omega)}{R_d+\delta}$, $l_e(\omega) = \frac{(1-\alpha)(\tau_{df} y_{ef}(\omega)+y_{ed}(\omega)) MC_{ed}(\omega)}{W_d}$. For a constrained firm, we determine $l_e(\omega)$ similarly, while we choose capital binding the borrowing constraint. The profit the exporter obtains on the domestic market equals $\pi_{ed}(\omega) = y_{ed}(\omega)(p_{ed}(\omega) - MC_{ed}(\omega))$, the profits from exporting to f are equal to $\pi_{ef}(\omega) = y_{ef}(\omega)\text{RER} * (p_{ef}(\omega) - MC_{ef}(\omega)) - FW_d$.

Static problem of the foreign producer, selling to domestic consumers

Recall that we abstract from the fixed cost of exporting for foreign entrepreneurs selling to d.[33] Therefore, exporters to d sell to domestic consumers if their marginal costs do not exceed the choke price on the domestic market. The problem for these firms on the domestic market

[33] In the following, we still call the domestic market from the perspective of domestic consumers, from the standpoint of foreign firms in view, domestic market is exporting market

thus takes the following form:[34]

$$
\begin{aligned}
\pi(z(\omega_f)) = \max_{\substack{y_d(\omega_f), p_d(\omega_f), y_f(\omega_f),\\ p_f(\omega_f), k(\omega_f), l(\omega_f)}} & \frac{1}{RER} p_d(\omega_f) y_d(\omega_f) + p_f(\omega_f) y_f(\omega_f) - \\
& - W_f l(\omega_f) - (R_f + \delta) k(\omega_f) - W_f F \\
\text{s.t.} & \\
& y_d(\omega_f) = \left[1 - \varepsilon \ln\left(\frac{\sigma}{\sigma-1} p_d(\omega_f) \frac{D_d}{P_d}\right)\right]^{\frac{\sigma}{\varepsilon}} Y_d \\
& y_f(\omega_f) = p_f^{-\sigma}(\omega_f) \frac{Y_f}{P_f^{-\sigma}} \\
& \tau_{fd} y_d(\omega_f) + y_f(\omega_f) = z(\omega_f) k^{\alpha}(\omega_f) l^{1-\alpha}(\omega_f)
\end{aligned}
\tag{3.78}
$$

(3.79) provides first-order conditions for profit maximization of exporter to d relevant to the decisions on the domestic market:[35]

$$
\begin{aligned}
& \frac{\sigma-1}{\sigma} \exp\left(\frac{1 - q_d^{\frac{\varepsilon}{\sigma}}(\omega_f)}{\varepsilon}\right) \frac{P_d}{D_d} = \frac{\sigma}{\sigma - q_d^{\frac{\varepsilon}{\sigma}}(\omega_f)} MC_d(\omega_f) \\
& W_f = (1-\alpha) MC_f(\omega_f) z(\omega_f) k^{\alpha}(\omega_f) l^{-\alpha}(\omega_f) \\
& R_f + \delta = \alpha MC_f(\omega_f) z(\omega_f) k^{\alpha-1}(\omega_f) l^{1-\alpha}(\omega_f)
\end{aligned}
\tag{3.79}
$$

The associated complementary slackness conditions are given by:

$$
\begin{aligned}
& MC_f(\omega_f)(z(\omega_f) k^{\alpha}(\omega_f) l^{1-\alpha}(\omega_f) - \tau_{fd} y_d(\omega_f) - y_f(\omega_f)) = 0 \\
& q_d(\omega_f) \left(\frac{\sigma-1}{\sigma} \exp\left(\frac{1 - q_d^{\frac{\varepsilon}{\sigma}}(\omega_f)}{\varepsilon}\right) \frac{P_d}{D_d} - \frac{\sigma}{\sigma - q_d^{\frac{\varepsilon}{\sigma}}(\omega_f)} MC_d(\omega_f)\right) = 0
\end{aligned}
\tag{3.80}
$$

We use (3.79) to calculate marginal cost of exporters to d in the domestic market in domestic currency

$$
MC_d(\omega_f) = \text{RER} \frac{\tau_{fd}}{z(\omega_f)} \frac{W_f^{1-\alpha}(R_f+\delta)^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}. \tag{3.81}
$$

After that, we can calculate $y_d(\omega_f)$ consistent with profit maximization for each point in G_z. Dividing $y_d(\omega_f)$ by Y_d we receive $q_d(\omega_f)$; we solve for $y_d(\omega_f)$ as a non-zero root of (3.82) (if such

[34]In order to simplify exposition, here we express $p_d(\omega_f)$ and $MC_d(\omega_f)$ in domestic currency. Note, that in 3.3 we instead express $p_d(\omega_f)$ in foreign currency

[35]Note, that given the absence of credit constraints, production for the foreign market is irrelevant for the optimal output decisions for the domestic market

root exists):

$$q_d(\omega_f)\left(\frac{\sigma-1}{\sigma}\exp\left(\frac{1-q_d^{\frac{\varepsilon}{\sigma}}(\omega_f)}{\varepsilon}\right)\frac{P_d}{D_d\text{RER}}-\frac{\sigma}{\sigma-q_d^{\frac{\varepsilon}{\sigma}}(\omega_f)}\frac{\tau_{fd}}{z(\omega_f)}\frac{W_f^{1-\alpha}(R_f+\delta)^{\alpha}}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}}\right)=0 \tag{3.82}$$

Foreign entrepreneurs for whom the left-hand side of the expression in brackets is less than the right-hand side do not sell anything. For other entrepreneurs, we use the resulting value of $q_d(\omega_f)$ to calculate $\mu_d(\omega_f)=\frac{\sigma}{\sigma-q_d^{\frac{\varepsilon}{\sigma}}(\omega_f)}$ and $p_d(\omega_f)=\mu_d(\omega_f)MC_d(\omega_f)$.

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Eidesstattliche Erklärung

Hiermit erkläre ich, die vorliegende Dissertation selbstständig angefertigt und mich keiner anderen als der in ihr angegebenen Hilfsmittel bedient zu haben. Insbesondere sind sämtliche Zitate aus anderen Quellen als solche gekennzeichnet und mit Quellenangaben versehen.

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Curriculum Vitae

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Education

- Sep 2012 - Jul 2016, BA in Accounting and Auditing (honors), Sumy State University;
- Sep 2016 - Jun 2018, MA in Economic Analysis, Kyiv School of Economics, joint degree with MA in Economics from the University of Houston;
- Sep 2019 - Jul 2025, Ph.D. in Economics, CDSE GESS, University of Mannheim.

Work Experience

- Sep 2017 - Jun 2018, Voluntary Teaching Assistant at Kyiv School of Economics;
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