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Trade Diversion Effects from Global Tensions—Higher Than We Think

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Trade Diversion Effects from Global Tensions—Higher Than We Think

Prepared by Mengqi Wang* and Swarnali Ahmed Hannan**

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ABSTRACT: The paper builds a unique industry-level dataset by combining Mexico's nationally sourced input-output data (INEGI) with cross-country sources (WIOD, UN Comtrade). Using this dataset to exploit higher supply linkages across a larger number of industries than what is available in cross-country sources, the paper estimates the trade diversion effect on Mexico's exports to the U.S. from two episodes, with a focus on the first: the U.S.-China trade tension in 2018 and the U.S. sanctions on Russia in 2014. Difference-in-differences, local projections and few other empirical methodologies are used. For the first episode, the paper finds higher trade diversion effects than estimates in literature. Output tariff plays an important role, and there is some evidence of a positive impact through downstream tariffs. The effects are stronger when nationally sourced input-output data is used compared to those derived from cross-country sources. Importantly, the magnitude of trade diversion across industries does not depend on Mexico's industry-level trade exposure to the U.S., but rather on the U.S. tariff changes on Chinese goods, the decrease in imports from China, product substitutability with Chinese products, and (weakly) on Mexico's GVC integration. Similarly, for the second episode, the paper finds positive trade diversion effects. Overall, the findings suggest that trade diversion effect might be higher than previously thought and the proper accounting of dataset and supply linkages makes a difference.

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WORKING PAPERS

Trade Diversion Effects from Global Tensions—Higher Than We Think

Prepared by Mengqi Wang and Swarnali Ahmed Hannan[1]

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[1] The authors would like to thank: Gaston Gelos, Rishi Goyal, Thomas Helbling, and Bikas Joshi for their invaluable comments and guidance during different stages of this paper; and, Directorate of Economic Measurement (Banxico), Martin Tobal (Director of Macrofinancial Risk Analysis, Banxico), IMF's Western Hemisphere Department (WHD) Seminar participants and Camila Casas, Flavien Moreau, Rafael Machado Parente for their helpful comments. All remaining errors are ours.

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1. Introduction

Using Mexico as an example, this paper sheds light on the likely impact of global trade tensions for countries with high trade exposure and supply linkages. Events in recent years (e.g., the U.S.-China trade tensions of 2018, the global chip shortages, the Covid-19 pandemic) have shown the significance of supply chains and intricate linkages across countries in propagating global shocks. The paper studies two episodes, with a focus on the first: (i) the 2018 U.S.-China trade tensions, and (ii) the 2014 U.S. sanctions on Russia.

The contribution is threefold.

First, the paper builds a unique industry-level dataset for Mexico that exploits input-output and supply chain linkages to quantify channels through which input-output linkages may play a role during global tensions. Compared to cross-country sources, this allows for accounting of higher supply linkages across a larger number of industries (258 industries versus cross-country coverage of 56 industries). To preview the results, we find that nationally sourced input-output tables show higher trade diversion effects than the results from typically used cross-country sources (e.g., WIOD). Hence, the proper accounting of supply linkages matters.

Second, the paper builds upon literature on input/output tariffs and uses difference-in-differences method to estimate the impact on Mexico's exports during U.S.-China trade tensions. While Mexico's trade diversion effect has been studied previously (e.g., Lovely et al. 2021; more recently, Utar et al. 2023 using firm-level trade data), as far as we are aware, this is the first attempt to capture both direct and indirect industry-level exposure across a large number of industries. Importantly, the paper is also the first attempt to explore the determinants of the variation in trade diversion effects across Mexico's industries. As such, the paper contributes some interesting insights and provides a good complement to cross-country studies (e.g., Freund et al. 2023, Alfaro et al. 2023, Fajgelbaum et al. 2023) related to the recent policy interest on how the global supply chain could evolve following the Covid-19 pandemic and any potential geoeconomic fragmentation.

Third, though literature has focused on the effect of sanctions on targeted sectors/firms in Russia (Ahn and Ludema, 2017; Bělín and Hanousek, 2019), the impact on third countries has not been widely studied. To our knowledge, this is the first attempt to understand the impact on Mexico from the 2014 U.S. sanctions on Russia.

We combine three datasets: (i) input-output table of Mexican economy from INEGI, (ii) granular trade data (HS-6 digit from UN Comtrade), and (iii) cross-country input-output table from World Input-Output Database (WIOD). This allows to obtain the following new information: (i) granular data on input-output linkages matched with trade data, (ii) detailed information on the sources of imported inputs for a specific industry, and (iii) comprehensive usage of each industries' products in all industries across countries.

The paper estimates the impact on Mexico's exports to the U.S. from the first three rounds of the U.S. tariffs on China imposed on July 6, August 23, and September 24 of 2018 (Bown 2021). When the U.S. imposes a higher tariff on one product produced in China, the U.S. could divert its imports of this product from China towards Mexico. Besides the direct trade diversion effect from output tariffs, the indirect effect through upstream and downstream tariffs is also considered.[1] Difference-in-differences method is used to exploit the variation of tariff exposure across industries. The first dimension of differences is to compare Mexican exports to the U.S. of industries in which a higher U.S. import tariff was imposed on Chinese products with that of those less affected, and the second dimension is before and after the trade tensions.

The results suggest an overall positive trade diversion effect on Mexico's exports. A one-standard deviation increase in net tariff change (5.8 percentage points) on Chinese products increases Mexican exports to the U.S. by 6.4 percent. We find that output tariff plays a more important role with some evidence on a positive impact through downstream tariffs. Finally, the industry-level trade diversion effect does not vary according to Mexico's trade exposure to the U.S., but rather according to the size of the changes of U.S. tariffs on Chinese products, the decrease in the U.S. imports from China, and the degree of substitutability of Mexico's products vis-à-vis China. There is some weak evidence that higher global value chain (GVC) integrated industries benefitted more.

To offer some implications on the potential impact on Mexico's exports to the U.S. from the recent U.S. sanctions on Russia, we conduct an event study using the U.S. sanctions on Russia in 2014. We employ dynamic regressions and local projection methods, using monthly U.S. imports from Mexico at HS 6-digit level. We find a positive impact of U.S. sanctions on Mexico's exports to the U.S., with the size of about 10 percent increase four months after sanctions.

The structure of this paper is as follows. Section 2 discusses the dataset. Section 3 reviews literature on trade diversion and discusses our contribution. Section 4 lays out the various empirical methodologies. Section 5 presents results on *overall* trade diversion effects from the 2018 U.S.-China trade tensions. Section 6 presents the *industry-level* results from the 2018 U.S.-China trade tensions. Section 7 compares the results from nationally sourced data versus those from cross-country sources. Section 8 shows the results from the 2014 U.S. sanctions on Russia. Section 9 concludes.

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[1] Upstream tariff is the weighted average of tariffs faced by the upstream industries, and it affects one industry through input availability channel. Downstream tariff is the weighted average of tariffs exposed by the downstream industries, and it affects one industry through input demand channel.

2. Data

This paper uses three sets of data. The first set is the input-output table of the Mexican economy from INEGI.[2] The annual input-output table contains production structure information of 258 industries at NAICS 4-digit level, over the period 2003–18. This data set gives information on input-output linkages across industries, the integration of global value chain of each industry and how much Mexico relies on imported inputs. Besides input-output linkages across industries, the paper uses information on total production and exports from this source.

The second dataset is the granular trade data at HS 6-digit level from UN Comtrade.[3] We use annual and/or monthly exports and imports between Mexico and the U.S., and between Mexico and other countries. Combining with INEGI input-output dataset, we can trace the sourcing and the destination countries for each industry's input and output. UN Comtrade data set is also used for data on the U.S. imports from Mexico in trade diversion analysis.

The third dataset is the cross-country input-output table from World Input-Output Database (WIOD).[4] This source provides input-output linkage information from 43 countries (28 European Union countries and 15 other major countries, including Mexico), covering 56 industries at the ISIC 2-digit level. For our research purpose, WIOD dataset provides sourcing country information of imported inputs in Mexican production and destination country information of final goods exported from Mexico. Compared with the UN Comtrade, WIOD distinguishes the intermediate input and final goods and more importantly, inputs used in a specific industry in Mexico, which gives more accurate information on the sourcing country structure for a specific industry. However, UN Comtrade has more granular data structure as well as a longer coverage.

We use INEGI dataset as the base of our constructed database. Specifically, the analysis is based on 258 industries from INEGI dataset, and the variables from the other datasets are aggregated or disaggregated into these industries. This base is chosen for two reasons. First, INEGI dataset provides higher granular industries than WIOD and covers more recent periods. Second, INEGI has detailed input-output structure based on these 258 industries.

As mentioned above, each dataset used is coded in a different indicator system. One challenge of data construction is to match WIOD and UN Comtrade data to the INEGI industry level. For UN Comtrade, which is at HS 6-digit product level, we match it with NAICS 4-digit industry code following Pierce and Schott (2009).[5] When one industry produces multiple products with different HS codes, we add up trade values of these products to industry level. For WIOD, which is coded in ISIC 2-digit industry code, we use the concordance table between 2017 NAICS to ISIC Rev. 4 from the U.S. Census website.[6] In the matching process, there are 215 cases where one NAICS 4-digit code is matched with multiple ISIC 2-digit codes. In those cases, we sum

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[2] INEGI source is https://www.inegi.org.mx/investigacion/mcsm/#Tabulados.

[3] UN Comtrade data website is https://comtrade.un.org/data/ .

[4] WIOD can be downloaded from http://www.wiod.org/database/wiots16 .

[5] See https://faculty.som.yale.edu/peterschott/international-trade-data/ for data and codes. Chiquiar and Tobal (2019) show that the variation in the subjective criterion imposed to allocate HS code matched with multiple NAICS 4-digit codes does not alter results much.

[6] See https://www.census.gov/naics/?68967. In particular, we use the concordance table of 2017 NAICS to ISIC Rev. 4. We have double checked with the concordance table of ISIC Rev. 4 to 2017 NAICS, which will generate the same matching result.

up import and export values from all matched ISIC-coded industries to one NAICS industry. The detailed matching process is summarized in Appendix I.1-I.3.

Overall, the combination of the three datasets helps to shed the following new information: granular information on input-output linkages matched with trade data. While not used in our analysis, the constructed dataset also sheds new detailed information on (i) the sources of imported inputs for a specific industry; and (ii) the specific usage of each industry's product in other industries and countries, which would be useful in future studies.

Apart from the empirical analysis, the constructed dataset is useful to gather insights on different aspects of Mexico's trade structure. We highlight several features in Appendix II. Namely: Mexican industries rely increasingly on international market, especially on the U.S. market, for product exporting and input sourcing. China's role as a trade partner has been increasing. Motor vehicle manufacturing is the largest exporting industry in Mexico, and semiconductors industry is the largest importing industry.

3. Literature Review on Trade Diversion and Contribution

Traditional trade theory predicts that trade increases after countries form a free trade agreement (FTA), following tariff reduction. This is known as trade creation. At the same time, trade decreases between a member country and a non-member country since member countries replace high tariff products from non-member countries with low tariff products from member countries. This is the trade diversion effect. Trade diversion can also happen when tariffs increase between two countries, which is the opposite of the creation of FTAs. Given the tariff increase on Chinese products during 2018 and early 2019, the U.S. would import less from China and import more from other countries (trade diversion).

Higher trade policy uncertainty could be another reason for trade diversion during periods of trade tensions. Literature has documented the negative effect of trade policy uncertainty on trade volume (Handley, 2014; Handley and Limao, 2015; Alessandria et al., 2019). During the 2018 trade tensions, trade policy uncertainty rose to a historically high level (IMF, 2018; Benguria et al., 2022), leading to the U.S. importing less from China and more from a third country, say Mexico.

Some recent papers study the trade diversion effects of tariffs imposed on Chinese products on the U.S. imports from other countries. Cigna et al. (2020) uses the monthly product-level U.S. imports data from its top 30 trade partners during 2016/01–2019/05 and uses difference-in-differences approach as the identification method. The first difference is the time dummy variable indicating trade tensions and the second difference is the product-level treatment dummy indicating whether one product is exposed to tariff increase or not. Their paper finds a significant decline in U.S. imports from China for tariff-exposed products, compared to those not. However, there is no significant trade diversion effect shown yet in the short run, as the U.S. imports of exposed products from a third country did not increase more than non-exposed products. Deng (2021) uses the monthly trade flows during 2014–19 between China and its top 10 trade partners besides the U.S. The paper uses country-month level difference-in-differences estimation, comparing trade volume between China and the U.S. with that between China and other countries. They find that Chinese imports are affected more than its exports to the U.S., by showing the magnitude of the decrease in China's imports from the U.S. is greater than the decrease in China's exports to the U.S., after controlling for time trend. Moreover, trade diversion effects in China's imports are more pronounced when the third country is a developing country rather than a developed country.

Our paper is closely related with Lovely et al. (2021), studying the trade diversion effect of the U.S.-China trade tensions on Mexican exports.[7] Lovely et al. (2021) find that Mexican sales in the U.S. market rose by 3.4 percent on average, with heterogeneity in benefits across sectors in Mexico. They estimate first how much trade diversion to an exporting country and an exporting sector depends on the preexisting share of this sector and country in the U.S. market and the size of the tariff change imposed on Chinese products. They find that if the U.S. increases tariffs on one Chinese product by 10 percentage points, a country with a preexisting 10 percent share of the U.S. market for that product would expect a 0.46 percentage point increase in the value of its exports of that product to the U.S. Using this estimate, they then calculate the benefits of each sector in

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[7] Fajgelbaum et al. (2022) find an increase in Mexico's exports to the U.S. after the trade tensions, showing a substitution relationship between China's exports and Mexico's exports in the U.S. market. Chiquiar et al. (2007) and Chiquiar and Tobal (2019) find a similar substitution relationship following China's accession to the WTO.

Mexico and get an average of 3.4 percent in terms of sales. Their paper estimates the trade diversion effect using a panel data of monthly U.S. imports from the universe of countries and HS10 product and applies the estimated coefficients to obtain an in-sample prediction for Mexican exports.

Different from this approach, our method is based on a cross-industry estimation using only Mexican exports to the U.S. market, based on variation in exposure to tariff increases across industries. In other words, our paper emphasizes the industrial heterogeneity in U.S.-China tariff exposure in forms of both output and input (upstream and downstream) tariffs, taking into account the input-output linkages.[8] To preview our results, there are two significant contributions: (i) we find that the trade diversion effects on Mexico during U.S.-China trade tensions have been stronger than that found in Lovely et al. (2021) when input-output linkages are accounted for; and (ii) the effect is stronger when country-sourced richer input-output tables are used, as opposed to a common cross-country source database with limited information than country-sourced data.

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[8] Conconi et al. (2018) finds that the rules of origin in NAFTA led to a trade diversion of intermediate goods from third countries to NAFTA partners through input-output linkages.

4. Empirical Strategy

To estimate the trade diversion effect, difference-in-differences methods are employed where the identification strategy is as follows: if the U.S. imposes a higher import tariff on Chinese products in one industry during the trade tensions, then Mexico would export more products of this industry to the U.S. market compared to another industry from Mexico where the U.S. had imposed lesser tariff on Chinese products. The tariff exposure of an industry is captured using both direct (output) and indirect (upstream, downstream) channels. We use these measures of tariff exposure to identify the average trade diversion effects based on an industry-month panel data set. Furthermore, we use an alternative approach where we document the differentiated trade diversion effect across industries and explore the correlation between trade diversion magnitude and other characteristics (e.g., tariff exposure, trade structure, product substitutability, GVC integration).

4.1 Difference-in-Differences Method

We use the variation in tariff exposure among industries to identify the trade diversion effects, following the difference-in-differences method as in Cigna et al. (2020). The trade diversion that we want to identify is the increase in U.S. imports from Mexico of products that the U.S. imposed tariffs on Chinese exports. This increase can be calculated as the difference in average U.S. imports from Mexico before and after the tariff enaction. However, this difference could also capture the effect of other factors happening during this period. To eliminate effects of other factors, we utilize a control group, which includes industries that were not affected by the U.S.-China tariff. We assume that the change in U.S. imports from Mexico of unaffected products reflects the effect of other factors. Then when we take a second difference between changes in the U.S. imports of affected industries and that of unaffected industries before and after the tariff change, this difference-in-differences captures only the effect of the U.S.-China tariff.

The difference-in-differences method is straightforward and neat, while relies on the assumption of parallel trend. As explained above, the difference-in-differences method can eliminate the effect of other simultaneous factors in a neat way. However, this requires that industries more exposed to tariff increase and those less exposed exhibit a similar export growth pattern, without tariff changes. We test this parallel trend assumption by checking if the estimated monthly trade diversion effect is close to zero before the announcement of the tariff increase in section 5.2. One caveat is that, while this method has been extensively used in academic work, Chaisemartin et al. (2022) discuss potential biases and propose alternative estimates, notably Gardner (2022) method. However, the Gardner method does not come across applicable in our set-up. Since most industries were treated after three months, there is limited time period to estimate the treatment effect using this method. In addition, the numerous robustness checks and exercises performed in this paper provide further support to the results.

4.1.1 Construction of Tariff Exposure Measure

The tariff exposure in each industry j is measured by a continuous variable $\Delta\tau_j$ which is the size of the tariff increase in this industry j in 2018. To calculate the tariff increase in each industry j, we use the tariff on products at HS 6-digit level and the input-output linkage from INEGI to capture output, upstream, and downstream tariffs. The upstream tariff incorporates the indirect effect of the tariff increase on one product through tariffs imposed on inputs of this product via a limited/enlarged input availability channel. The downstream tariff considers the indirect effect on one product due to its increased demand as inputs in other products.

$$\Delta\tau_j = \Delta\tau_j^{output} + \Delta\tau_j^{up} + \Delta\tau_j^{down}$$
$$= \left(\tau_{j,2018}^{output} - \tau_{j,2017}^{output}\right) + \left(\tau_{j,2018}^{up} - \tau_{j,2017}^{up}\right) + \left(\tau_{j,2018}^{down} - \tau_{j,2017}^{down}\right).$$

Output tariff $\tau_{j,2018}^{output}$ is the direct U.S. import tariff imposed on Chinese products in industry j after tariff change during the trade tensions. $\tau_{j,2017}^{output}$ is the tariff in 2017, which we choose as the MFN tariff rates on January 1, 2018. In other words, output or direct tariffs are essentially what is reported as the tariff of a particular item/product. We aggregate the output tariffs from HS 6-digit products p to each industry j by taking a weighted average, with weight being the import value share of this product among all products in industry j, $\frac{m_{p,2017}}{\sum_{q\in j} m_{q,2017}}$, where $m_{p,2017}$ and $m_{q,2017}$ are the U.S. import value of product p and q from China in 2017, i.e.,

$$\tau_{j,t}^{output} = \sum\nolimits_{p\in j} \tau_{p,t}^{output} \cdot \frac{m_{p,2017}}{\sum_{q\in j} m_{q,2017}}.$$

The upstream tariff $\tau_{j,2018}^{up}$ captures the indirect impact of the U.S.-China tariffs on Mexican products via the input availability channel. An increased demand for Mexican products in upstream industry k from the U.S. will increase its exports to the U.S. This might lead to two consequences. First, given the limited supply of domestic product k in the short run, this could reduce the availability of product k used as an input to produce in industry j. And this restriction is more pronounced if the U.S. demand for Mexican product k is higher. Hence, for industry j, the production will be lessened due to the lack of all inputs. Second, due to a higher demand for product k from the U.S., there will be more production of product k and hence a higher availability of inputs for industry j if production surpasses the U.S. demand. This heightened availability of inputs increases as the U.S. imports more from Mexico for input k. The aggregate impact from these two opposite channels depends on whether domestic production of input k can grow or not. The former negative channel dominates if production reacts. Otherwise, the latter positive channel dominates.

$$\tau_{j,2018}^{up} = \sum_{k=1}^{N} \tilde{d}_{kj} \tau_{k,2018}^{output}\, s_{k,2017}^{US}.$$

The corresponding *upstream* tariff $\tau_{j,2018}^{up}$ is calculated as the weighted average of tariffs on all upstream industries k relative to industry j, as in the above equation. $\tau_{k,2018}^{output}$ is the output tariff on Chinese product k. The weight contains two parts, the input-output linkage $\tilde{d}_{kj}$ and U.S. demand $s_{k,2017}^{US}$. $\tilde{d}_{kj}$ is the total input value share of domestic products in industry k used in production of industry j, after applying the Leontief-type inverse matrix on the input-output table from INEGI.[9] The demand part, $s_{k,2017}^{US}$, captures the intuition that the input availability

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[9] Assume d_{kj} is the input value share of domestic products in industry k used in production of industry j, from the input-output table. We use the IO table in the year of 2015 to alleviate the potential endogeneity problem that the input-output structure could have changed due to input and/or tariffs. Increase in tariffs in industry k affects input availability for industry j. Furthermore, this impact on availability of product k affects the other inputs l, which uses product k as inputs and itself becomes inputs in industry j. Following this logic, there are infinite iterations of input-output table as follows.

$$\tau_{j,2018}^{up} = \sum_{k=1}^{N} d_{kj} \tau_{k,2018}^{output} s_{k,2017}^{US} = \sum_{k=1}^{N}\sum_{l=1}^{N} d_{kl} d_{lj} \tau_{k,2018}^{output} s_{k,2017}^{US} = \cdots$$

The matrix method is used to solve for $\tau_{j,2018}^{up}$, which considers how many units of product k are required to produce one unit of product j, measured by the Leontief-type inverse matrix, see Appendix I.4 for details.

impact is stronger when the U.S. demand for Mexican product k is higher. $s_{k,2017}^{US}$ is the value of U.S. imports from Mexico in industry k in 2017, divided by the total imports of the U.S. from Mexico in 2017, $s_{k,2017}^{US} = 100 * \frac{V_{k,2017}^{US}}{\sum_m V_{m,2017}^{US}}$. The last part, the *downstream* tariff $\tau_{j,2018}^{down}$, captures the indirect impact of the U.S.-China tariffs on Mexican economy via the indirect input demand channel. For any downstream industry k that experienced an increase in the U.S. tariff level on China, its demand from the U.S. may increase, hence its production got boosted. This enlarged production raises demand for domestic input from industry j. Hence, for industry j, this indirect effect of U.S. tariffs comes from this increased domestic input demand from each industry k. This production enlargement is more pronounced if the U.S. demand for product k is higher.

The downstream tariff is computed as the weighted average of tariffs on all downstream industries k relative to industry j, as the following:[10]

$$\tau_{j,2018}^{down} = \sum_{k=1}^{N} \tilde{d}_{jk} \tau_{k,2018}^{output}\, s_{k,2017}^{US}.$$

$\tau_{k,2018}^{output}$ is the output tariff on Chinese product k . The weight contains two parts, the input-output linkage $\tilde{d}_{jk}$ and the U.S. demand $s_{k,2017}^{US}$. $\tilde{d}_{jk}$ is the total input value share of domestic products in industry j used in production of industry k, element in the Leontief-type inverse matrix based on the input-output table from INEGI.[11] The

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$$\begin{pmatrix} \tau_{1,2018}^{up} \\ \vdots \\ \tau_{j,2018}^{up} \\ \vdots \\ \tau_{N,2018}^{up} \end{pmatrix} = \tilde{L} \begin{pmatrix} \tau_{1,2018}^{output} s_{1,2017}^{US} \\ \vdots \\ \tau_{j,2018}^{output} s_{j,2017}^{US} \\ \vdots \\ \tau_{N,2018}^{output} s_{N,2017}^{US} \end{pmatrix}, \qquad \tilde{L} = \left(I - \tilde{B}\right)^{-1}, \qquad \tilde{B} = \begin{pmatrix} d_{11} & \cdots & d_{j1} & \cdots & d_{N1} \\ \vdots & \ddots & \vdots & \cdots & \vdots \\ d_{1j} & \vdots & d_{jj} & \vdots & d_{Nj} \\ \vdots & \cdots & \vdots & \ddots & \vdots \\ d_{1N} & \cdots & d_{jN} & \cdots & d_{NN} \end{pmatrix}$$

Where $\tilde{B}$ is the $N \times N$ matrix with the (j,k)th element being d_{kj}, which is the value share of domestic input from industry k in producing in industry j. $\tilde{L}$ is the Leontief-type inverse of input-output table with domestic share being the element of the IO table. I is the $N \times N$ identity matrix. $\tilde{d}_{kj}$, the total input value share, used in calculating the upstream tariff is element in matrix $\tilde{L}$.

[10] This method is inspired by Ahn et al. (2019), who use input-output table to calculate input tariff as the tariffs imposed on imported inputs and domestic inputs that use imported input for production. Studies on trade liberalization have been using the effective rate of protection (ERP) which is the difference between output and input tariffs, where input tariffs measure the tariffs on intermediate inputs. (Corden, 1996; Topalova and Khandelwal, 2011) Topalova and Khandelwal (2011) find that the reduction in input tariffs has a greater positive impact on firm productivity compared to the reduction in output tariffs. Different from these measures, where the tariffs are imposed directly on the country of interest, tariffs here are imposed on China, while we are interested in Mexico. Our measure of tariffs is meant to capture different effects.

[11] Assume d_{jk} is the input value share of domestic input from industry j used in production of industry k, from the input-output table in INEGI. We use IO table in the year of 2015 to alleviate the potential endogeneity problem that input-output structure could be adjusted due to input and/or tariffs. The U.S. increased demand for product k, inducing increased indirect demand for input j. Furthermore, this increased demand for product k raised demand for each domestic input in producing k, which in turn uses inputs from industry j. Following this logic, there are infinite iterations based on the input-output table as follows.

$$\tau_{j,2018}^{down} = \sum_{k=1}^{N} d_{jk} \tau_{k,2018}^{output} s_{k,2017}^{US} = \sum_{k=1}^{N}\sum_{l=1}^{N} d_{jl} d_{lk} \tau_{k,2018}^{output} s_{k,2017}^{US} = \cdots$$

It boils down to a simple question, which is, to produce one unit of product in industry k, how many units of inputs from industry j are needed, and the answer is the Leontief-type inverse of input-output table. Hence, the matrix method is used to solve for $\tau_{j,2018}^{down}$,

$$\begin{pmatrix} \tau_{1,2018}^{down} \\ \vdots \\ \tau_{j,2018}^{down} \\ \vdots \\ \tau_{N,2018}^{down} \end{pmatrix} = L \begin{pmatrix} \tau_{1,2018}^{output} s_{1,2017}^{US} \\ \vdots \\ \tau_{j,2018}^{output} s_{j,2017}^{US} \\ \vdots \\ \tau_{N,2018}^{output} s_{N,2017}^{US} \end{pmatrix}, \qquad L = (I - B)^{-1}, \qquad B = \begin{pmatrix} d_{11} & \cdots & d_{1j} & \cdots & d_{1N} \\ \vdots & \ddots & \vdots & \cdots & \vdots \\ d_{j1} & \vdots & d_{jj} & \vdots & d_{jN} \\ \vdots & \cdots & \vdots & \ddots & \vdots \\ d_{N1} & \cdots & d_{Nj} & \cdots & d_{NN} \end{pmatrix}$$

Where B is the $N \times N$ matrix with the (j,k)th element being d_{jk}, which is the value share of domestic input from industry j in producing in industry k. L is the Leontief-type inverse of input-output table with domestic share being the element of the IO table. I is the $N \times N$ identity matrix. $\tilde{d}_{jk}$, the total input value share used in calculating downstream tariff, is element of matrix L.

demand part reflects the idea that this indirect input demand channel is more pronounced if the U.S. demand for Mexican products is higher. $s^{US}_{k,2017} = 100 * \frac{V^{US}_{k,2017}}{\sum_m V^{US}_{m,2017}}$.

Once output, downstream, and upstream tariffs are calculated, we compute *total* tariffs as the sum of these three tariff measures, and *net* tariffs as the sum of output plus downstream minus upstream tariffs.[12]

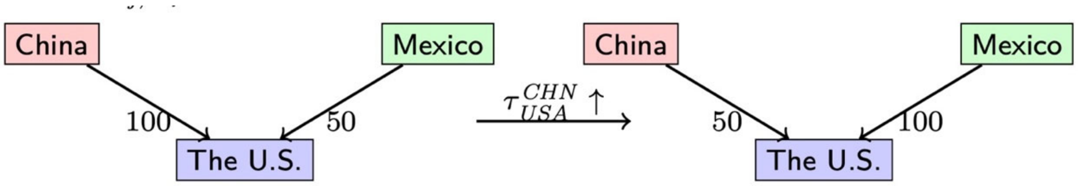
In the analysis, we implicitly assume that the pass-through of tariffs to import price is close to complete. By assuming so, a higher tariff on Chinese products leads to increase in the import price of Chinese products, hence the reduction in demand for Chinese products, rising the demand for products from other countries, specifically, from Mexico. This assumption is based on empirical findings on the price effect of tariff during the trade tension period in the recent literature. A surprisingly complete pass-through of U.S. import tariffs onto importers has been documented by Amiti et al. (2019), Cavallo et al. (2021), Fajgelbaum and Khandelwal (2022) and Fajgelbaum et al. (2023), among others. This result is surprising since both the U.S. and China are considered large players in the world market. When the demand of a large player decreases, the world (export) price will decrease in response, leading to incomplete pass-through. However, given the well-documented fact on complete pass-through, our assumption is empirically supported.

4.1.2 An Illustrative Example of the Tariff Exposures

To further illustrate the above three tariffs, we use motor vehicle parts (industry j) as an example.

Output tariff. When the U.S. imposed tariffs on motor vehicle parts from China, the U.S. could directly import more motor vehicle parts from Mexico instead. Figure 1 shows this direct impact using arbitrary numbers. The U.S. imports 100 motor vehicle parts from China and 50 from Mexico before tariff increases. After increasing tariffs on Chinese products, the U.S. buys 50 from China and 100 from Mexico. This increase in imports from Mexico is the direct trade diversion effect captured by the output tariff.

Figure 1. Illustration of Direct (Output) Tariff Effect



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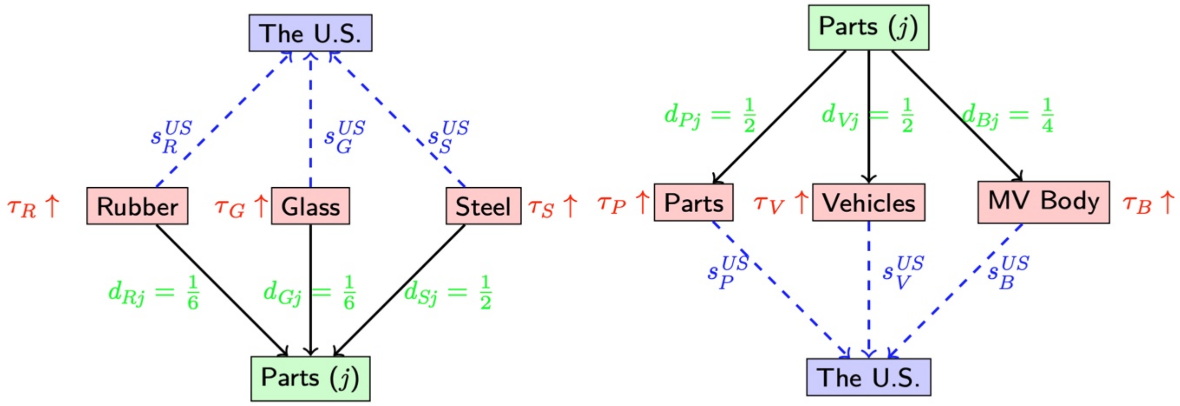
[12] We follow Topalova and Khandelwal (2011) to sum up these three measures of tariff changes. In their paper, this is called the effective rate of production. We also include three measures separately in one regression as an alternative way.

Figure 2. Illustration of Indirect Tariff Effect, Upstream (left) and Downstream (right) Tariffs



Indirect tariffs. Due to input-output linkages in the economy, there are indirect effects through the upstream and downstream industries.

- Upstream tariff captures the indirect effect of tariffs on upstream industries through input linkages. Consider an upstream industry of motor vehicle parts, for example, the rubber industry. In other words, the motor vehicle parts industry would require rubber as an input to produce motor vehicle parts (e.g., tires). As a higher tariff is imposed on the Chinese rubber product, τ_R, more Mexican rubbers are exported to the U.S. There are two possible implications. First, the volume of domestically produced rubbers that can be used as an input for the motor vehicle parts industry is reduced, dampening the production and the exports in motor vehicle parts industry. Second, if the domestic production of rubbers increases because of higher U.S. demand, more domestic rubbers could be potentially available to produce domestic motor vehicle parts, expanding the production and the exports of motor vehicle parts industry. This input availability channel works through all inputs used in producing motor vehicle parts, including rubbers, glass, and steel in the illustrative graph in the left panel of Figure 2. The upstream tariff aggregates the impact of all inputs of motor vehicle parts by taking a weighted average of tariffs on all upstream industries. The impact of tariffs for one upstream industry, rubber, on motor vehicle parts increases when the production of domestic motor vehicle parts requires more rubbers as an input, or the U.S. demands more Mexican rubbers. As a result, weights are chosen to be the total input value share of each input in producing motor vehicle parts, d_{kj}, and the demand share in the U.S. market.

- Downstream tariff captures the indirect effects of tariffs on downstream industries through indirect input demand. Consider a downstream industry of motor vehicle parts, for example, the motor vehicle manufacturing industry. In other words, the motor vehicle industry uses motor vehicle parts as an input to the production of motor vehicles. When a higher tariff is imposed on the Chinese motor vehicle manufacturing industry, more Mexican motor vehicles are produced and exported to the U.S. Hence, more motor vehicle parts used as inputs in producing motor vehicles are demanded. The increased indirect input demand will boost the production and the exports of motor vehicle parts. Moreover, this indirect input demand channel plays a role through all downstream industries of motor vehicle parts industry, as shown in the right panel of Figure 2. This downstream and input demand channel is captured by the downstream tariff. Downstream tariff takes a weighted average of all downstream tariffs, for example, τ_P, τ_V, τ_B, in the illustrative figure, with the weight being the input share of domestic motor vehicle parts in each of the downstream industry, d_{jk}, and the U.S. demand share for each downstream industry, s_k^{US}.

4.1.3 Using Tariff Exposures to Create Treatment Effects

Based on the tariff calculated above, we propose several variables that measures the treatment of each industry from U.S.-China trade tensions. The first set includes dummy variables, indicating whether the industrial tariff has increased during the trade tensions. Output tariff dummy is defined as $T_j^{output} = 1(\Delta\tau_j^{output} > 0) = 1$ if the output tariff increases. The upstream tariff dummy is defined to be $T_j^{up} = 1(\Delta\tau_j^{up} > 0) = 1$ if the upstream tariff increases. The downstream tariff dummy is defined to be $T_j^{down} = 1(\Delta\tau_j^{down} > 0) = 1$ if the downstream tariff increases. The total tariff dummy is defined as $T_j = 1(\Delta\tau_j > 0) = 1$ if total tariff increases, which is the sum of the output-, upstream-, and downstream tariff increases. Since we expect the upstream tariff to have a negative (or mixed) impact on production and exports in Mexico, we also define the net tariff variable, which is the sum of the output and the downstream tariffs net the upstream tariffs, $\tau_{j,t}^{net} = \tau_{j,t}^{output} - \tau_{j,t}^{up} + \tau_{j,t}^{down}$. And the corresponding net tariff dummy is defined as $T_j^{net} = 1(\Delta\tau_j^{net} > 0) = 1$. The second set contains continuous variables measuring the size of the tariff increase. Output tariff change is the difference in the output tariff before and after the trade tensions, $\Delta\tau_j^{output} = \tau_{j,2018}^{output} - \tau_{j,2017}^{output}$. Upstream tariff change is the difference in upstream tariff before and after the trade tensions, $\Delta\tau_j^{up} = \tau_{j,2018}^{up} - \tau_{j,2017}^{up}$. Downstream tariff change is the difference in downstream tariff before and after the trade tensions, $\Delta\tau_j^{down} = \tau_{j,2018}^{down} - \tau_{j,2017}^{down}$. Total tariff change is the sum of output, upstream, and downstream tariff change, $\Delta\tau_j = \Delta\tau_j^{output} + \Delta\tau_j^{up} + \Delta\tau_j^{down}$. Net tariff change is the sum of output and downstream net upstream tariff change, $\Delta\tau_j^{net} = \Delta\tau_j^{output} - \Delta\tau_j^{up} + \Delta\tau_j^{down}$. These two sets of variables are used in the regressions for estimating trade diversion effects.

4.1.4 Estimating Trade Diversion Effect

We rely on the variation in the tariff exposure among industries to identify the trade diversion effects, following the difference-in-differences method as in Cigna et al. (2020). The first difference is at time dimension, before and after higher tariffs were imposed on Chinese products, and the second difference is at industry dimension, between industries that were more exposed to tariff changes and those less exposed.

The difference-in-differences regression equation is the following.

$$Y_{j,t} = \alpha + \beta T_j \cdot Post_{j,t} + \rho Y_{j,t-1} + \eta_j + \xi_t + \varepsilon_{j,t} \tag{1}$$

where $Y_{j,t}$ is the U.S. imports from Mexico (in logarithms) in sector j in month t, covering 2016/01–2019/05. We calculate the U.S. imports from Mexico in each industry by aggregating the product-level trade flow data from UN Comtrade (see detailed method and steps in Appendix I.2). We consider output, upstream, downstream, total, and net tariff changes separately. $Post_{j,t}$ is the *time* dummy which equals 1 after tariff increases for industry j. Since three rounds of tariffs are considered, industries are treated in different months. Hence $Post_{j,t}$ varies across industries. Moreover, if one industry is affected in multiple rounds, the first month being affected is picked as its treatment period. T_j is the industry-level treatment dummy which equals 1 if industry j is subject to the tariff increase imposed by the U.S. on Chinese goods, i.e., $T_j = 1$ if $\Delta\tau_j > 0$ for either output or upstream or downstream tariffs. Since almost all industries experienced input hence total tariff increase, we also define $T_j = 1$ if $\Delta\tau_j > median$ to explore the difference in exports to the U.S. between industries with higher tariff increase and those with lower tariff increase.

To consider the persistence of the U.S. imports, we add the lagged imports to the right-hand side in the level regression.[13] Adding lagged terms could introduce endogeneity between the lagged term and the error term, we hence estimate this dynamic panel model with Arellano-Bond estimator, which is based on general method of moments estimation.[14] It takes the first difference of the regression equation to eliminate individual fixed effects. And the lagged term further serves as instrument variable for the differenced lagged term of dependent variable. We also control for the industry fixed effects, η_j, and the month fixed effect ξ_t. We report results without lagged U.S. import value in Tables A1 in Appendix III. We also use the U.S. import growth rate from Mexico in sector j in month t as the dependent variables for robustness check. Results are reported in Table A2 in Appendix III.

The coefficient of the interaction term, β, measures the aggregate trade diversion effects. We expect β to be positive if the U.S. buys more from Mexico, instead of China, for products that face an increase in tariffs, compared with those without tariff increases.

Furthermore, the treatment dummy T_j can be replaced by the continuous variable $\Delta\tau_j$ measuring the size of the tariff increase in industry j in 2018, which is defined above. The tariff-increase-size based regression is:

$$Y_{j,t} = \alpha + \beta\Delta\tau_j \cdot Post_{j,t} + \rho Y_{j,t-1} + \eta_j + \xi_t + \varepsilon_{j,t} \tag{2}$$

$$Y_{j,t} = \alpha + \beta_1\Delta\tau_j^{output} \cdot Post_{j,t} + \beta_2\Delta\tau_j^{down} \cdot Post_{j,t} + \beta_2\Delta\tau_j^{up} \cdot Post_{j,t} + \rho Y_{j,t-1} + \eta_j + \xi_t + \varepsilon_{j,t} \tag{3}$$

The first regression considers the changes in output, upstream, downstream, total, and net tariffs separately, while the second regression takes into consideration all three tariffs for each industry. Other variables and model choices are the same as in the dummy-variable regressions.

To verify that any positive coefficient found captures the trade diversion effect caused by the trade tensions between the U.S. and China, we use the difference-in-differences identification with more flexible specification (essentially estimate time-varying treatment effect) to estimate the coefficient for each month.

$$Y_{j,t} = \alpha + \sum_{t=2}^{T} \beta_t T_j \cdot 1_t + \eta_j + \xi_t + \varepsilon_{j,t} \tag{4}$$

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[13] We have tried regressions with two and three lagged dependent variables. The coefficients of the second and the third lagged terms are insignificant. The coefficients of the tariff change measures, the variables of our interest, are similar to those from regressions including only one lagged dependent variable.

[14] As a robustness check, we use a static panel model including lagged dependent variable to estimate equation (1), and the result is qualitatively the same as that using the dynamic panel model, Arellano-Bond estimator, and quantitatively smaller.

where $Y_{j,t}$ is the U.S. imports from Mexico (in logarithms) in sector j in month t, covering 2016/01–2019/05. 1_t is the time dummy which equals 1 if time is t, T_j is the industry-level treatment dummy which equals 1 if industry j is subject to a tariff increase imposed by the U.S. on Chinese goods that was above its median level.

The coefficient of the interaction term, β_t, measures the aggregate trade diversion effects at time t, which is the average difference between the treated industry and the untreated industry, in terms of the change in the U.S. imports from industry j at time t from its value at time 1 (January 2016). We expect β_t to be zero before trade tensions and positive after trade tensions occurred in 2018, when the U.S. buys more from Mexico instead of China for products that face a higher tariff, compared to those without tariff increase. Industry fixed effects η_j and month fixed effects ξ_t are included.

4.2 An Alternative Approach Exploiting Industry-Level Trade Diversion Effects

We examine the heterogeneity in the trade diversion effect across industries, using the following regression specification for each industry j using monthly time-series data during 2016/01–2019/05.

$$Y_{j,t} = \alpha_j + \beta_j Post_t + \rho_j Y_{j,t-1} + \gamma_j X_{j,t} + \varepsilon_{j,t} \tag{5}$$

where $Y_{j,t}$ is the U.S. imports from Mexico (in logarithms) in sector j in month t, $Post_{j,t}$ is the time dummy which equals to 1 after tariffs increased. Control variables $X_{j,t}$ include GDP growth rate of the U.S. and Mexico,[15] CPI growth rate (inflation rate) of two countries,[16] and exchange rate of peso against dollars.[17] We also control for lagged imports. This equation can be applied to both industries that were affected and unaffected by the tariffs. If the unaffected industries also reflect trade diversion effect by showing growth in exports to the U.S., besides the time fixed effect, it could mean that these industries that are not directly affected could be indirectly affected through input-output linkages from the directly affected industries. This reinforces the importance of considering the upstream and downstream tariffs in estimating the trade diversion effect. Omitting the role of upstream or downstream tariffs might lead to a bias of the trade diversion effect. Considering this issue, in our difference-in-differences estimation with dummy variable, as in equation (1), we would focus on the dummy variable for total and net tariff changes. However, we only have one industry that had no total tariff change. We thus use the tariff change size instead of dummy treatment variable in equation (2) and regard this result as the main finding.

After obtaining the estimated trade diversion effect $\widehat{\beta_j}$ for each industry j above, we further explore explanations for its heterogeneity. We run the following regressions to study how the estimated coefficients $\widehat{\beta_j}$ vary due to the tariff exposure of each industry.

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[15] Quarterly GDP growth rate of the U.S. is from FRED, Gross Domestic Product (A191RP1Q027SBEA): https://fred.stlouisfed.org/series/A191RP1Q027SBEA. Quarterly GDP growth rate of Mexico is from FRED, Gross Domestic Product by Expenditure in Constant Prices: Total Gross Domestic Product for Mexico (NAEXKP01MXQ657S): https://fred.stlouisfed.org/series/NAEXKP01MXQ657S

[16] Monthly CPI growth rate (inflation rate) of the U.S. is from FRED, Consumer Price Index: Total All Items for the United States (CPALTT01USM657N): https://fred.stlouisfed.org/series/CPALTT01USM657N. Monthly CPI growth rate (inflation rate) of Mexico is from FRED, Consumer Price Index: Total All Items for Mexico (CPALTT01MXM659N): https://fred.stlouisfed.org/series/CPALTT01MXM659N.

[17] Peso/USD exchange rate is from FRED, Mexico / U.S. Foreign Exchange Rate (EXMXUS): https://fred.stlouisfed.org/series/EXMXUS.

$$\widehat{\beta_J} = \alpha + \beta T_j + \varepsilon_j$$
$$\widehat{\beta_J} = \alpha + \beta \Delta\tau_j + \varepsilon_j \qquad (6)$$

For tariff increase dummy variable, T_j, and tariff increase size measure, $\Delta\tau_j$, in two regressions separately, we consider separately output, upstream, downstream, total, and net tariffs as explanatory variables.

5. Results Using Difference-in-Differences Method

When studying the impact of U.S.-China trade tensions in 2018, the focus of the paper is on the first three rounds of tariff imposed by the U.S., till the end of 2018 (Bown, 2021).[18] The first one is the 25 percent duties covering $34 billion imported products (known as List 1), imposed on July 6, 2018. The second round is the 25 percent duties on $16 billion of imports (List 2), imposed on August 23, 2018. The third round is the 10 percent tariff on $200 billion of imports (List 3), enacted on September 24, 2018. Since different industries face tariff increase on different dates, the corresponding time variable $Post_{j,t}$ later is defined accordingly.[19] By concentrating on the first three rounds, the tariff change is fixed for each industry since there is no additional tariff imposed on the same good.[20] To keep the tariff change fixed, only monthly data during 2016/01–2019/05 is used.[21]

Tariffs of the U.S. on Chinese products increased during the trade tensions, on average and in most of industries. Table 1 summarizes the mean, standard deviation, minimum and maximum of tariff measures defined in the previous section.[22] On average, during the time period of interest, there is an increase of 3.43 percentage points in output tariffs, an increase of 0.88 percentage points in upstream tariffs, 0.97 percentage points in downstream tariffs, 5.28 percentage points in total tariffs, and 3.35 percentage points in net tariffs. Almost all industries face an increase in their upstream or downstream tariff and therefore total tariffs, among which only 38 percent of industries face direct output tariff increase. This shows that computing upstream or downstream tariffs using input-output tables helps to better capture the whole picture of trade diversion. The correlation coefficients among the changes in output, upstream, and downstream tariffs are positive, ranging from 0.05 to 0.77.[23]

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[18] The fourth round is the increase in tariffs on $200 billion of imports (List 3) from 10 percent to 25 percent on June 1, 2019. The fifth round is the 15 percent on $101 billion of imports (List 4A) on September 1, 2019.

[19] Due to matching across industry and product codes and aggregation, there are cases that for one industry coded in NAICS as in INEGI, multiple industries coded in HS10-digit that have different dates of tariff increase are matched. In this case, we pick the first date when one industry is affected.

[20] Increasing tariff on the same product only happened on June 1, 2019, which is not considered in our paper.

[21] With tariff change being fixed, our treatment variable $\Delta\tau_j$ does not vary over time, hence is free from time subscript.

[22] The industries that are not matched with any HS 10 code have all tariff being zero, which lowers the average levels.

[23] The correlation coefficient between $1(\Delta\tau_j^{output} > 0)$ and $1(\Delta\tau_j^{up} > 0)$ is 0.05, between $1(\Delta\tau_j^{output} > 0)$ and $1(\Delta\tau_j^{down} > 0)$ is 0.14, and that between $1(\Delta\tau_j^{up} > 0)$ and $1(\Delta\tau_j^{down} > 0)$ is 0.35. The correlation coefficient between $\Delta\tau_j^{output}$ and $\Delta\tau_j^{up}$ is 0.38, between $\Delta\tau_j^{output}$ and $\Delta\tau_j^{down}$ is 0.32, and that between $\Delta\tau_j^{up}$ and $\Delta\tau_j^{down}$ is 0.77.

Table 1. Summary Statistics of Tariff Exposure Measure

Variables	Obs	Mean	S.D.	Min	Max
Output tariff 2017 $\tau_{j,2017}^{output}$	258	1.17	3.23	0	34.05
Output tariff 2018 $\tau_{j,2018}^{output}$	258	4.61	7.16	0	38.93
Output tariff difference $\Delta\tau_j^{output}$	258	3.43	5.56	0	25.00
Upstream tariff 2017 $\tau_{j,2017}^{up}$	258	0.46	1.56	0	15.77
Upstream tariff 2018 $\tau_{j,2018}^{up}$	258	1.34	3.59	0	37.91
Upstream tariff difference $\Delta\tau_j^{up}$	258	0.88	2.24	0	176.35
Downstream tariff 2017 $\tau_{j,2017}^{down}$	258	0.33	1.34	0	16.24
Downstream tariff 2018 $\tau_{j,2018}^{down}$	258	1.30	2.82	0	40.36
Downstream tariff difference $\Delta\tau_j^{down}$	258	0.97	1.73	0	24.12
Total tariff 2017 $\tau_{j,2017}^{output} + \tau_{j,2017}^{down} + \tau_{j,2017}^{up}$	258	1.97	5.36	0	62.08
Total tariff 2018$\tau_{j,2018}^{output} + \tau_{j,2018}^{down} + \tau_{j,2018}^{up}$	258	7.25	11.14	0	117.20
Total tariff difference $\Delta\tau_j$	258	5.28	7.74	0	70.44
Net tariff 2017 $\tau_{j,2017}^{output} - \tau_{j,2017}^{down} + \tau_{j,2017}^{up}$	258	1.31	3.32	-1.96	33.98
Net tariff 2018 $\tau_{j,2018}^{output} - \tau_{j,2018}^{down} + \tau_{j,2018}^{up}$	258	4.65	7.53	-2.78	37.84
Net tariff difference $\Delta\tau_j^{net}$	258	3.35	5.80	-1.95	25.77
Dummy output tariff increase $1(\Delta\tau_j^{output} > 0)$	258	0.38	0.49	0	1
Dummy upstream tariff increase $1(\Delta\tau_j^{up} > 0)$	258	0.97	0.17	0	1
Dummy downstream tariff increase $1(\Delta\tau_j^{down} > 0)$	258	1.00	0.06	0	1
Dummy total tariff increase $1(\Delta\tau_j > 0)$	258	1.00	0.06	0	1
Dummy net tariff increase $1(\Delta\tau_j^{net} > 0)$	258	0.46	0.50	0	1

5.1 Aggregate Trade Diversion Effect

Table 2 shows the results of regression (1) using monthly data from 258 industries in INEGI during 2016/01–2019/05. We are interested in the estimated coefficient $\hat{\beta}$ reported in the first four rows. Given the dependent variable is in logarithm, the difference in the increase of export value to the U.S. from before to after the trade tensions between the treated and control group is estimated to be $(100\hat{\beta})$ percent on average. Columns (1)–(6) use regression (1) with standard difference-in-differences setup with dummy treatment variable but varying treatment time for different industries. Treatment variable T_j in column (1) is defined as one if industry j is exposed to output tariff increase during the trade tensions.

The results point towards positive trade diversion effect, mainly due to output tariffs. There is also some evidence of a positive impact through downstream tariffs. Compared with industries that are not subject to output tariff increase during the trade tensions, industries affected in Mexico experience on average 16.1 percent larger increase in U.S. imports after the trade tensions (Column 1 of Table 2). We add the lagged term of log U.S. imports in the right-hand side and adapt the Arellano-Bond dynamic panel estimator, which applies for all columns here. About 40 percent of industries experienced output tariff increase, hence the rest forms a comparable control group. Columns (2) and (3) suggest that both upstream and downstream tariffs increased exports, but the former is not statistically significant. Putting together output, upstream, and downstream tariffs , column (4) shows positive effects for output and downstream tariffs and mildly negative effect of upstream tariffs, with only output tariffs statistically significant. Having said that, the Wald test for joint significance of three variables rejects the null with significance 1 percent, suggesting that these variables are jointly significant. We find the same result for Wald tests in all specifications with three variables in one regression in the tables.

We then proceed to understand the impact of *total* and *net* tariffs. We find positive effect for both, but only the latter is statistically significant. The estimation in column (5) uses a dummy variable indicating whether one industry is exposed to total tariff change, including output, upstream, and downstream tariffs.[24] Compared to industries that did not face any tariff increase in terms of all three tariffs, those whose tariff increased had a larger increase in their exports to the U.S. by 8.5 percent. Column (6) considers the net tariff change, which is the change in the sum of output and downstream net upstream tariffs. Compared to industries that were exposed to no net tariff increase, those exposed to a positive net tariff change increased their exports to the U.S. by 16.3 percent higher.

Instead of tariff increasing or not at all, we estimate results comparing tariff exposure above- and below-median. There is only one (three) industry(ies) that did not experience any change in total or upstream (or downstream) tariff which raises the problem of insufficient observation within the control group. We tackle this issue by comparing industries that experience tariff increase above its median with those below the median. Columns (7)-(12) report results of regression (1) with treatment variable T_j indicating whether one industry's tariff increase size is above or below its median level, in terms of output, upstream, downstream, total, and net tariffs respectively.[25] The results are similar to columns (1)-(6). Output tariffs and downstream tariffs are statistically significant individually, while only output tariffs are significant when all the three variables are placed together. However, the Wald tests support joint significance.[26]

Positive trade diversion effect is robust to using above-median dummy variable for total and net tariff changes. We also get similar results from different cutoff choices. Treatment variable in column (11) is defined as one if an industry had a total tariff increase that was above the median of total tariff increase. Compared to industries that had a smaller total tariff increase, those with larger total tariff increase experienced a larger increase in exports to the U.S. by 18.0 percent which is significant. Column (12) finds that compared to industries with lower net tariff change, those with net tariff changes above the median increased their exports to the U.S. by 17.4 percent more. We also used different cutoffs in tariff changes to test the robustness of this set of results, including the 25th and 75th percentiles.

Our positive trade diversion results stand firmly with continuous tariff change variables. Table 3 uses the continuous changes in tariffs before and after trade tensions instead of treatment dummy variables. The results suggest that both output and downstream tariffs have a positive trade diversion effect, while the upstream tariffs have a negative/mixed effect. If one industry's increase in output tariff of U.S. on Chinese product during the trade tensions is one standard deviation higher (5.6 percentage points), then this industry's exports to the

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[24] Since industries face any positive total tariff change overlap almost perfectly with those face any positive tariff change in upstream tariffs, column (5) has the same result as in column (2) where the treatment dummy is one when if one industry experienced any positive upstream tariff change. We also include all three tariff change dummy variables in column (4). Column (4) implies that output tariff change matters more compared to upstream or downstream tariff.

[25] Since the median of output tariff change is zero, using median as cutoff is equivalent to using zero as cutoff as in column (1). Hence column (7) is the same as column (1).

[26] We include all output dummy defined in column (7), upstream dummy defined in column (8), and downstream dummy defined in column (9) in regression (2) and report the result in column (10). Similar to column (4), we find output tariff increase induces a greater trade diversion effect than upstream or downstream tariff increase does. In fact, controlling for output tariff change, a relative increase in upstream or downstream tariff has no significant impact on U.S. imports from Mexico.

U.S. is estimated to go up by 7.2 percentage points after the start of the trade tensions (column 1). If one industry's increase in upstream tariff is one standard deviation higher (1.73), then this industry experienced a larger but insignificant increase in its exports to the U.S. by 4.0 percent (column 2). If one industry's increase in downstream tariff of U.S. on Chinese product during the trade tensions is one standard deviation higher (2.24), then this industry's exports to the U.S. is estimated to increase 4.7 percent (insignificantly) more after the trade tensions. Placing all the tariff variables in one regression (column 4), the output tariff continues to have a significant effect but upstream and downstream results are not significant, though signs are as expected. However, Wald tests support joint significance of all these tariff variables. If one industry's increase in total tariff of the U.S. on Chinese product during the trade tensions is one standard deviation higher (7.74), then its exports to the U.S. will increase 6.2 percent more after the trade tensions (column 5). An increase in the net tariff of one standard deviation (5.80) is associated with 6.4 percent increase in exports (column 6).

The results suggest that the positive trade diversion effect on Mexico is mainly coming from the direct effect of increased exports to the U.S. on products where the U.S. imposed tariffs on China. While more work is needed to flesh out the exact channels, the results suggest that some industries had an export boost when they were used as inputs for products that were directly tariffed. This could be due to the U.S. importing inputs to increase its own production of those goods. On the other hand, the domestic industries that used inputs that were tariffed did not face a statistically decline in exports (for example, due to shortage of inputs) when their inputs were directly exported to the U.S.

Table 2. Regression Results for Trade Diversion Effects, Dummy Treatment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	$1(\Delta\tau > 0)$						$1(\Delta\tau > median)$					
Output	0.161***			0.158***			0.161***			0.159**		
	(0.045)			(0.049)			(0.045)			(0.071)		
Up		0.851		-0.000				-0.015		-0.049		
		(0.852)		(0.090)				(0.126)		(0.120)		
Down			0.699***	0.075					0.185***	0.011		
			(0.269)	(0.137)					(0.062)	(0.100)		
Total					0.851						0.180***	
					(0.852)						(0.037)	
Net						0.163***						0.174***
						(0.033)						(0.035)
L.lnusimports	0.156**	0.160**	0.159**	0.156**	0.160**	0.157**	0.156**	0.160**	0.158**	0.156**	0.157**	0.157**
	(0.073)	(0.074)	(0.074)	(0.073)	(0.074)	(0.074)	(0.073)	(0.074)	(0.074)	(0.074)	(0.074)	(0.074)
Constant	5.614***	5.586***	5.591***	5.614***	5.586***	5.576***	5.614***	5.585***	5.552***	5.607***	5.561***	5.609***
	(0.659)	(0.663)	(0.663)	(0.660)	(0.663)	(0.658)	(0.659)	(0.665)	(0.667)	(0.671)	(0.658)	(0.664)
Ind. FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	10,062	10,062	10,062	10,062	10,062	10,062	10,062	10,062	10,062	10,062	10,062	10,062
No. of ind.	258	258	258	258	258	258	258	258	258	258	258	258

Notes: This table runs regression of trade diversion effects on Mexico's exports to the U.S., using 258 industries-41 months panel. The first six columns use equation (1) with the dummy variable indicating output, upstream, downstream, all output, input and indirect, total, and net tariff increase during the trade tensions. Column (7)-(12) uses equation (1) with dummy variable that indicates whether one industry's tariff increase is above or below the median level, In terms of output, upstream, downstream, all output, input and indirect, total, and net tariff respectively. All twelve columns use dynamic panel model with lagged export value term, industry and month fixed effect, and Arellano-Bond estimator to deal with the correlation between unobserved factors in error term $\varepsilon_{j,t}$ and the lagged term $Y_{j,t-1}$.

Table 3. Regression Results for Trade Diversion Effects, Continuous Treatment

	(1)	(2)	(3)	(4)	(5)	(6)
				$\Delta\tau$		
Output	0.013***			0.015**		
	(0.005)			(0.007)		
Up		0.023		-0.034		
		(0.015)		(0.038)		
Down			0.021	0.009		
			(0.014)	(0.038)		
Total					0.008***	
					(0.002)	
Net						0.011***
						(0.002)
L.lnusimports	0.158**	0.160**	0.160**	0.158**	0.159**	0.158**
	(0.074)	(0.074)	(0.074)	(0.073)	(0.074)	(0.074)
Constant	5.602***	5.608***	5.589***	5.609***	5.598***	5.599***
	(0.661)	(0.657)	(0.663)	(0.632)	(0.664)	(0.665)
Ind. FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Obs.	10,062	10,062	10,062	10,062	10,062	10,062
No. of ind.	258	258	258	258	258	258

Notes: This table runs regression of trade diversion effects on Mexico's exports to the U.S., using 258 industries-41 months panel. The first column uses equation (2) with size of increase in output tariff, the second column uses equation (2) with size of increase in upstream tariff, the third column uses equation (2) with size of increase in downstream tariff, the fourth column uses equation (3) with size of increase in all output, upstream, and downstream tariffs, the fifth column uses equation (2) with size of increase in total tariff, and the sixth column uses equation (2) with size of increase in net tariff. All six columns use dynamic panel model with lagged export value term, industry and month fixed effect, and Arellano-Bond estimator to deal with the correlation between unobserved factors in error term $\varepsilon_{j,t}$ and the lagged term $Y_{j,t-1}$.

5.2 Time-Varying Treatment Effect

Time-varying treatment effect results suggest that the positive trade diversion effect started to appear after the announcement of the trade tensions (Figure 3). We adopt an alternative flexible specification, as described in equation (4), to compute coefficient for each month, on data in the period 2016/01–2019/05. In line with the previous findings, we find that the announcement of trade tensions resulted in positive and statistically significant trade diversion effect. The treatment dummy variable is one if one industry's net tariff change is above the median of tariff change. Hence, we compare industries that are more subject to tariff change with those less affected. As expected, β_t is close to zero and insignificant before 2018[28] and starts to be positive upon the announcement of trade tensions and significantly positive during the trade tension period. As is often present during trade agreements and other policy interventions (Hannan 2016, Abadie et al. 2010), we find positive

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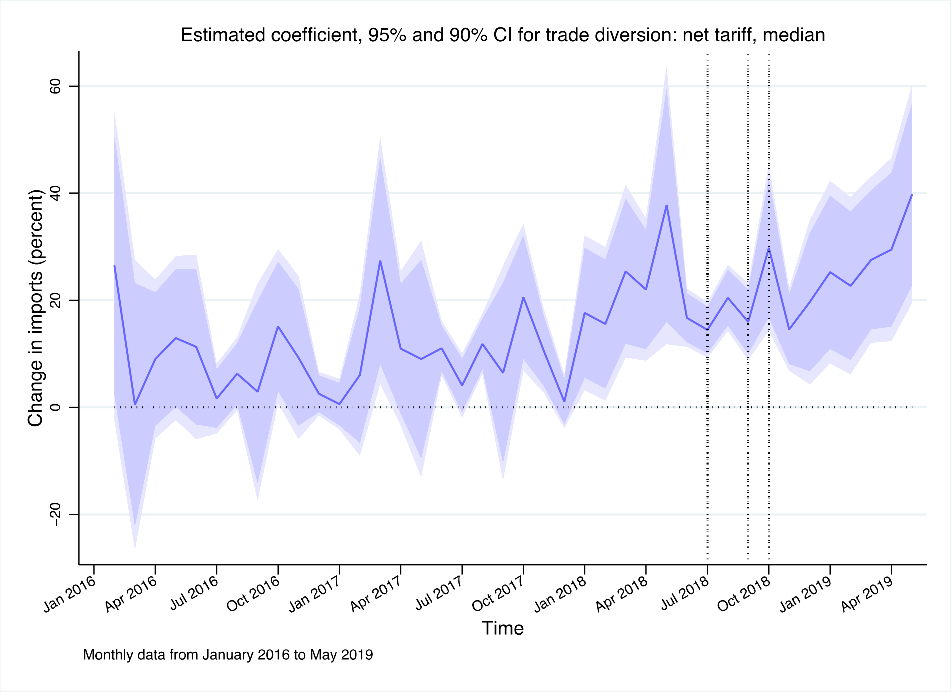
[28] As a support for the parallel trend assumption in difference-in-differences method.

and statistically significant trade diversion effect earlier than the formal policy implementation dates due to the anticipation effect.

Figure 3. Regression Results for DiD with Flexible Specification, Net Tariff Change Dummy



Notes: This figure plots the estimated coefficients (solid line) and 90 percent confidence intervals (dashed lines) in each month. The coefficient in each month measures the average difference in the U.S. (log) import values in this month between industries that are more exposed to tariff increase during the U.S.-China trade tensions and industries that are less affected by the tensions. The coefficient is estimated by a difference-in-differences method; hence, we control for the average differences in the U.S. import values between the treated and the control groups in January 2016. We consider industries to be more exposed to the U.S.-China trade tensions when the increase in the sum of output and downstream net upstream tariff imposed by the U.S. on Chinese products is larger than the median of industry-level tariff change. Vertical lines indicate the first three rounds of tariff imposing by the U.S.

5.3 Robustness Checks on DiD Results

Several robustness checks are conducted which support our core results (Appendix III). First, we run regressions (1)-(3) with a static panel model instead of the dynamic panel model by excluding the lagged term, $Y_{j,t-1}$, from regressions. Standard errors are clustered at the industry level. We find that, if one industry's total tariffs imposed by the U.S. on Chinese products increases by one standard deviation, Mexican exports to the U.S. of this industry go up by 4.6 percent more after the trade tensions, and the difference is significant. The estimated effect is slightly smaller if lagged terms are controlled. Using other tariff exposure measures, the estimated trade diversion effect is also significantly positive on Mexican exports to the U.S. but of smaller magnitude compared to those estimated in the dynamic panel model. These results are reported in table A1-A2 in Appendix III. Second, we replace the dependent variable with the monthly growth rate of Mexican exports to the U.S. in regressions (1)-(3). We run these regressions including the lagged export value, $Y_{j,t-1}$, to control for the convergence effect. We find that if one industry's total tariffs imposed by the U.S. on Chinese products increases by one standard deviation, the growth rate of Mexican exports to the U.S. of this industry will go up by 0.04 percentage points more after the trade tensions, which is significant. Other tariff exposure measures imply a positive (negative) trade diversion effect of output and downstream (upstream) tariff changes as well. Results on growth rate of exports are presented in table A3-A4 in Appendix III.

6. Determinants of Industry-Level Variation in Trade Diversion Effects

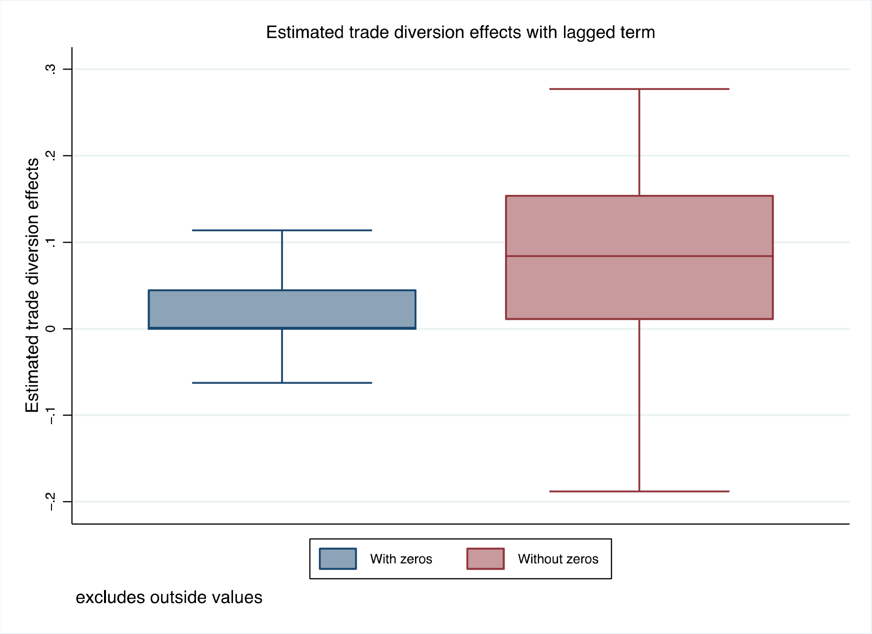
Most industries' exports to the U.S. in Mexico grew after the trade tensions, with an average growth rate of 6.25 percent. Table 4 shows summary statistics, including mean, standard deviation, minimum and maximum, of the estimated industry-specific trade diversion effects using equation (5). The average industrial trade diversion effect is 6.25 percent increase in U.S. imports.[29] Figure 4 shows the estimated distribution of industry-specific trade diversion effects from regression (5). The blue bar includes industries that never exported during the sample period, mostly in the service sector, and have estimated coefficient being zeros.[30] The red bar excludes these industries. More than 75 percent of industries' exports to the U.S. expand during the trade tension period, after controlling for some macroeconomic variables.

Table 4. Summary Statistics of Estimated Industry-Level Trade Diversion Effect

Models	Obs.	Mean	S.D.	Min	Max
U.S. import level	258	0.0625	0.4327	-1.5549	5.6514
Non-zeros	97	0.1663	0.6955	-1.5549	5.6514

Notes: This table lists summary statistics, including mean, standard deviation, minimum and maximum, of the estimated industry-specific trade diversion effects using equation (5).

Figure 4. Industry-Specific Trade Diversion Effects



Notes: this figure shows the estimated distribution of industry-specific trade diversion effects from regression (5) with lagged terms for import value (blue line-box) and those excluding zeros (red line-box).

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[29] We run robustness checks with different measures of estimated industry-level trade diversion effects which confirm our baseline findings. Specifically, we estimate regression (5) with import values excluding the lagged term, or using import value growth rates as dependent variable controlling for lagged imports. The estimated average trade diversion effect at industry level is 7.8 percent for the import value equation without lagged term.

[30] These industries are the majority of industries in the control group, where there was no output tariff change.

In this section, we explore the possible factors/industry-level characteristics that could explain the variation in the export boost due to trade diversion across Mexico's industries. We find that the positive trade diversion effect did not depend on industry-level trade exposure to the U.S., but rather on the decrease in imports from China, the tariff changes, and the degree of substitutability with Chinese products (summarized in Table 5). We find positive, though insignificant, correlation between export boost and GVC integration.

Table 5. Industry-Specific Trade Diversion Effect

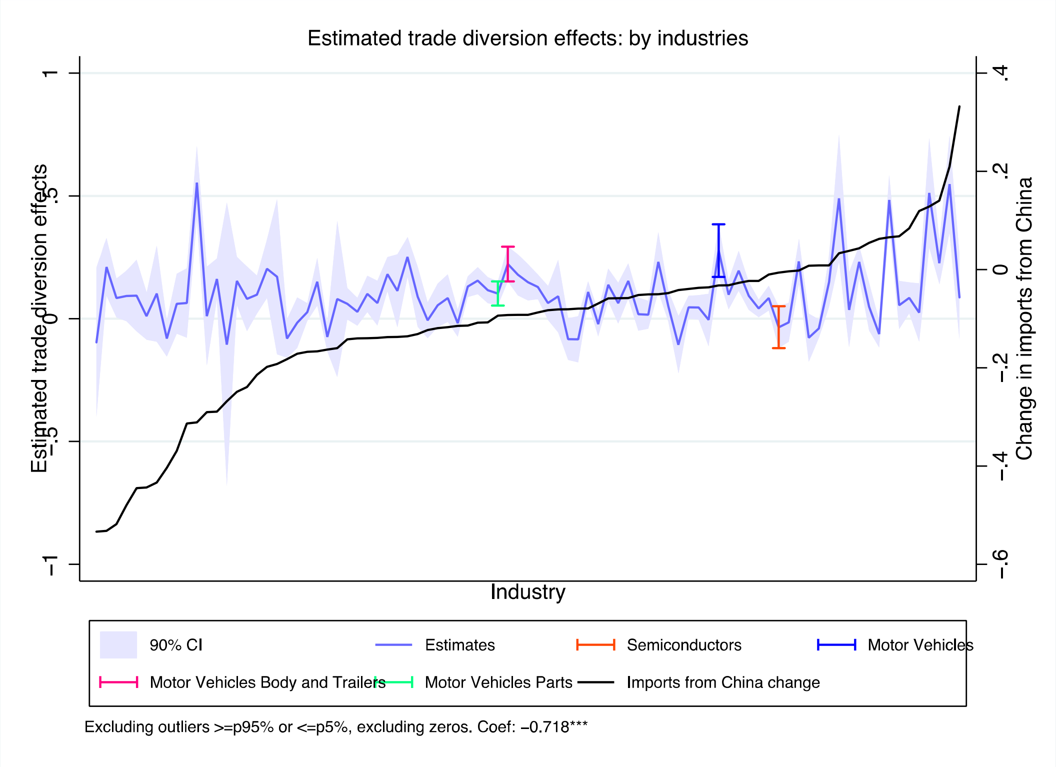
Industry characteristics	Correlation coefficient	p-value
Change in U.S. imports from China	-0.7181	0.0000
Net tariff change	0.2500	0.0196
Output tariff change	0.2742	0.0102
Export share to the U.S. in 2017	0.0149	0.8716
Imported input value share in production in 2016	0.0655	0.2956
Export share in sales in 2016	0.0624	0.3182
Product substitutability (σ)	0.2320	0.0002

Notes: This table reports the correlation coefficient and corresponding p-values between industry-level estimated export growth from Mexico to the U.S., $\widehat{\beta_J}$, and industry-level characteristics. $\widehat{\beta_J}$ is estimated to be the industry-level average increase in monthly export value to the U.S. after the trade tensions. It is estimated using monthly time-series data during 2016/01–2019/05, with specification $Y_{j,t} = \alpha_j + \beta_j Post_t + \rho_j Y_{j,t-1} + \gamma_j X_{j,t} + \varepsilon_{j,t}$, where $Y_{j,t}$ is the U.S. imports from Mexico (in logarithms) in sector j in month t, $Post_{j,t}$ is the time dummy which equals to 1 after tariffs increased. Control variables $X_{j,t}$ include GDP growth rate of the U.S. and Mexico, CPI growth rate (inflation rate) of two countries, exchange rate of peso against dollars, and lagged imports. Change in U.S. imports from China is measured by the industry-level estimated export growth from China to the U.S., $\widehat{\beta_{J,CHN}}$, using the above specification but with data on China. Net tariff change and output tariff change are the size of changes in net and total tariffs at industry-level, measuring the exposure to the U.S.-China tariff changes. Export share to the U.S. is the industry-level share of aggregate Mexican export value to the U.S. in 2017. Imported input value share in production in 2016 is the share of imported input in total production cost. Export share in sales in 2016 is the share of export value in total production. Both measure the industry-level GVC integration and are constructed from the input-output table obtained from INEGI in the year of 2016, before the trade tensions. Product substitutability (σ) at industry level comes from Broda and Weinstein (2006). The estimated product substitutability measures the substitution between varieties from different countries, for example, shoes from Mexico and China.

6.1 Decrease in Imports from China

When the U.S. imported less from China in one industry, they imported more from Mexico in that industry. To substantiate this, we run the same industry-level regression (equation 5) using data on the U.S. import from China and get the estimated increase in exports to the U.S. from China after the trade tensions, $\widehat{\beta_{J,CHN}}$. We find a significant negative correlation between $\widehat{\beta_{J,CHN}}$ and the increase in exports to the U.S. from Mexico, $\widehat{\beta_J}$. In figure 5, we rank industries by the change in the U.S. import from China, from low to high (black line in the right vertical axis). For each industry, we plot the estimated trade diversion effect, as the increase in exports to the U.S. after trade tensions, $\widehat{\beta_J}$ from regression (5), and its 90 percent confidence intervals (blue line and shared area in the left vertical axis). We highlight several important industries in the Mexican economy, including three motor vehicle related industries and the semiconductor industry. The correlation coefficient between the industry-level export growth and the change in the U.S. import from China is -0.718, negative and significant.

Figure 5. Estimated Trade Diversion Effect for Each Industry, Ranked by Change in U.S. Imports from China



Notes: this figure shows the estimated industry-specific trade diversion effects from regression (5) with lagged terms for import value (blue line) and its 90 percent confidence intervals (blue area). For each industry, this figure plots its export share to the U.S. in 2017 (percent, black line) in the right y-axis. We emphasize several important industries, including motor vehicle manufacturing (blue), motor vehicle parts manufacturing (green), motor vehicle body and trailers manufacturing (pink), and semiconductor and other electronic component manufacturing (red). Industries are ordered in terms of the change in U.S. imports from China as shown in the black line and the right y-axis.

6.2 Tariff Changes

The industry-level trade diversion effect is positively correlated with its tariff exposures. Output tariff has a larger impact than upstream, downstream, total, or net tariff.[31] Table 6 shows the results of regression (6) with estimates from different explanatory variables. Each number in the table represents one regression using equation (6), with the dependent variable being the estimated $\widehat{\beta_j}$ from regression (5), and the explanatory variable being defined by the treatment type of tariff change listed in the column and the tariff measure in the row. Positive correlation implies that industries more exposed to U.S.-China trade tensions experienced a larger increase in the U.S. imports after the trade tensions compared with those less exposed.

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[31] When regressing the estimated trade diversion effect on output, upstream, and downstream tariff changes at the same time, we find a positive correlation with output tariff changes, a negative but insignificant correlation with upstream tariff changes, and a positive but insignificant correlation with downstream tariff changes.

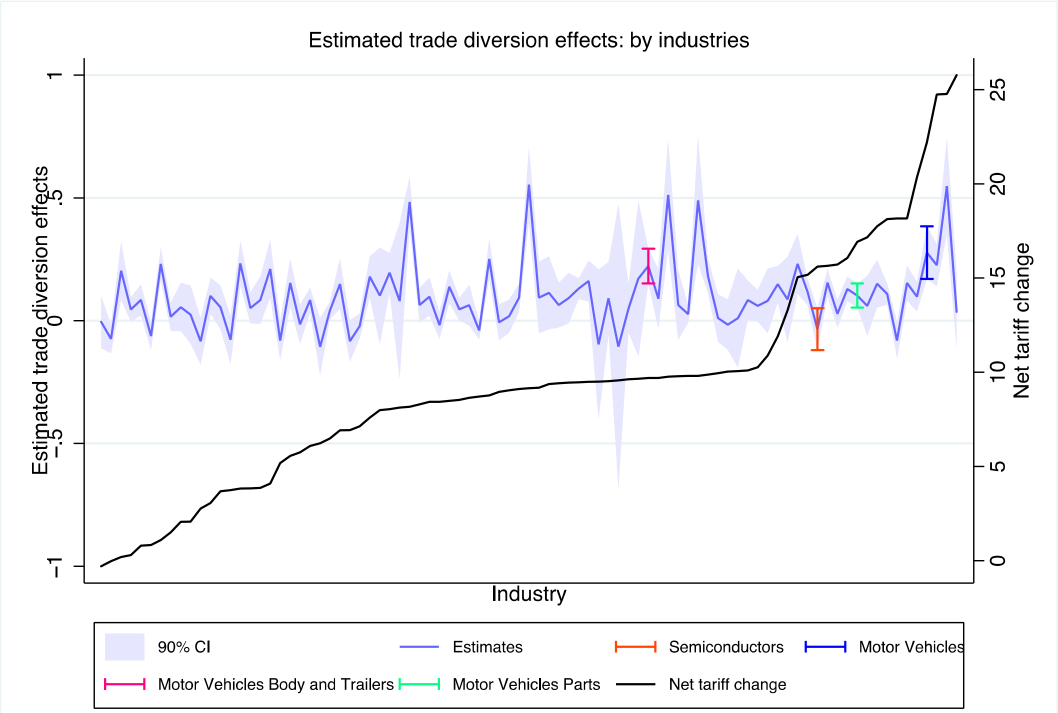
Table 6. Trade Diversion Effect and Tariff Changes

	Tariff increase dummy (1)	Tariff increase dummy of median (2)	Tariff increase levels (3)
Output tariff	0.166**	0.166**	0.012**
	(0.071)	(0.071)	(0.005)
Upstream tariff	0.063**	0.033	0.007**
	(0.027)	(0.054)	(0.004)
Downstream tariff	0.065**	0.114**	0.007
	(0.028)	(0.054)	(0.004)
Total tariff	0.063**	0.113**	0.007**
	(0.027)	(0.054)	(0.003)
Net tariff	0.128**	0.125**	0.011**
	(0.058)	(0.053)	(0.005)

Notes: This table shows the results of regression (6) with various explanatory variables. Each number represents a regression in (6), with dependent variable being the estimated $\widehat{\beta_j}$ from regression (5). The explanatory variable is defined by the treatment type of tariff change in the column and tariff measure in the row. Column (1) reports how the tariff change dummy, including output tariff increase dummy in the first row, upstream tariff increase dummy in the second row, downstream tariff increase dummy in the third row, total tariff increase dummy in the fourth row, and net tariff increase dummy in the fifth row, affects the estimated coefficients from regression (5) with U.S. import value being the dependent variable and with lagged U.S. import value. Column (2) reports how the tariff change dummy indicating whether a tariff increase is above its median, with the same row structure as in column (1). Column (3) reports how the tariff change levels, including output tariff increase level in the first row, upstream tariff increase level in the second row, downstream tariff increase dummy in the third row, total tariff increase dummy in the fourth row, and net tariff increase level in the third row, affects the estimated coefficients from regression (5) with U.S. import value being the dependent variable and with lagged U.S. import value.

This positive correlation between the estimated trade diversion effect at the industry level and the net tariff change is illustrated in Figure 6. We rank industries by the size of net tariff change, from low to high (black line in the right vertical axis). For each industry, we plot the estimated trade diversion effect, as the increase in exports to the U.S. after trade tensions, $\widehat{\beta_j}$ from regression (5), and its 90 percent confidence intervals (blue line and shared area in the left vertical axis). We highlight several important industries in the Mexican economy, including three motor vehicle related industries and the semiconductor industry. The correlation coefficient between the industry-level export growth and the net tariff change exposure is 0.25, positive and significant.

Figure 6. Estimated Industry-Level Trade Diversion Effect and Net Tariff Changes



Excluding outliers >=p95% or <=p5%, excluding zeros. Coef: 0.25**

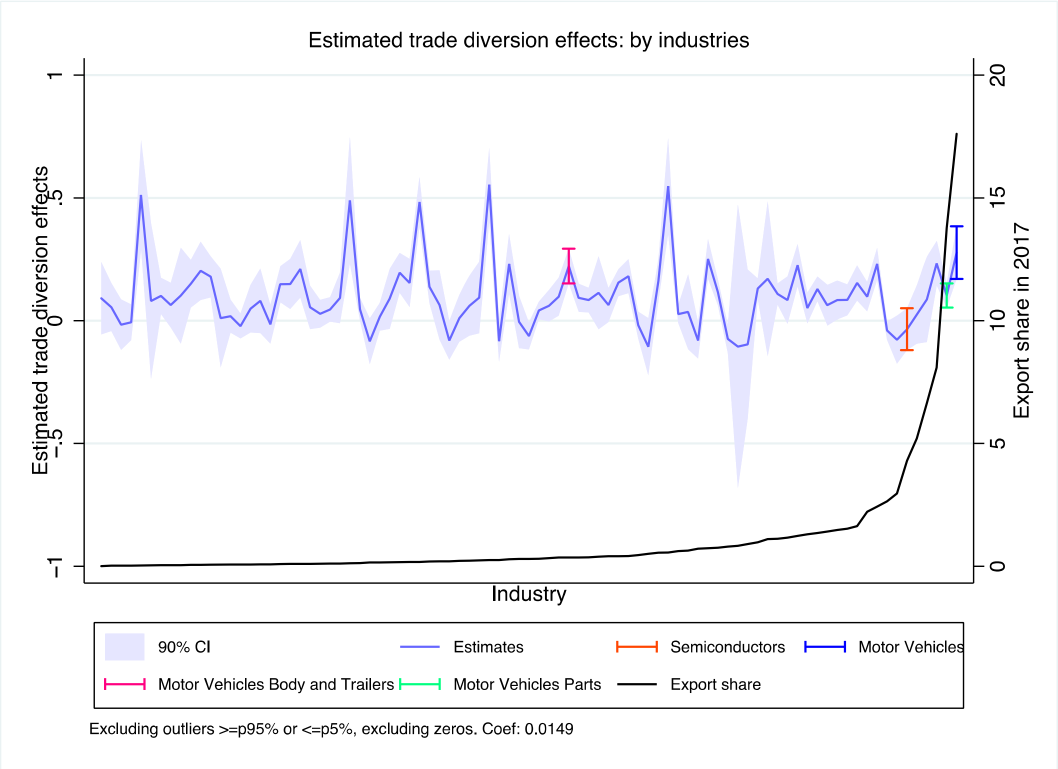
Notes: this figure shows the estimated industry-specific trade diversion effects from regression (5) with lagged terms for import value (blue line) and its 90 percent confidence intervals (blue area). For each industry, this figure plots its export share to the U.S. in 2017 (percent, black line) in the right y-axis. We emphasize several important industries, including motor vehicle manufacturing (blue), motor vehicle parts manufacturing (green), motor vehicle body and trailers manufacturing (pink), and semiconductor and other electronic component manufacturing (red). Industries are ordered in terms of the exposed net tariff change as shown in the black line and the right y-axis.

The results are robust to using estimated industry-level trade diversion effects from regression (5) but excluding the lagged import value term. We find a positive relationship between trade diversion effect and tariff change. The magnitude of this positive correlation is even greater without lagged term. We also find that the positive relationship is more pronouced for the changes in output tariff than upstream or downstream tariff.

6.3 Mexico's Industry-Level Exposure to the U.S. Market

The positive trade diversion effect was not a function of the trade exposure of Mexico's industries to the U.S. market. Figure 7 explores whether the industry-level increase in export value to the U.S. after the trade tensions is correlated with the comparative advantage structure in Mexico. We order industries based on their export share to the U.S. in 2017, in an increasing pattern from the left to right. The blue line represents the estimated coefficient, $\hat{\beta}_j$, from regression (5), and the blue shaded area plots its 90 percent confidence intervals for each industry. The black line shows the industry-level share of aggregate export value to the U.S. in 2017. We highlight several important industries, including three motor vehicle manufacturing industries and the semiconductor manufacturing industry with different colors on the estimates and confidence intervals. We find that there is no significant correlation between the size of the increase in the export value to the U.S. and the export share in 2017. In fact, the correlation coefficient is close to zero (0.01).

Figure 7. Estimated Industry-Level Trade Diversion Effect and Export Share in 2017



Excluding outliers >=p95% or <=p5%, excluding zeros. Coef: 0.0149

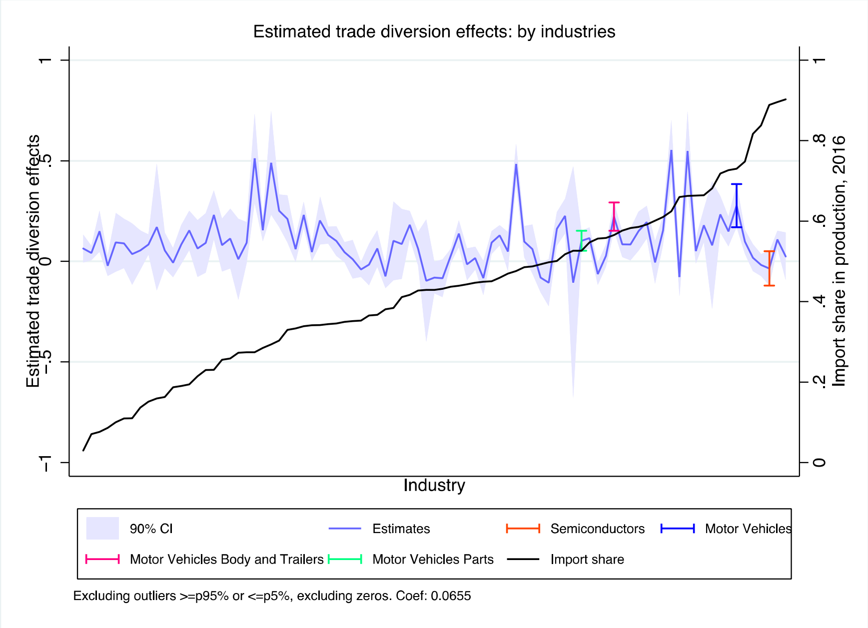
Notes: this figure shows the estimated distribution of industry-specific trade diversion effects from regression (5) with lagged terms for import value (blue line) and its 90 percent confidence intervals (blue area). For each industry, this figure plots its export share to the U.S. in 2017 (percent, black line) in the right y-axis. We emphasize several important industries, including motor vehicle manufacturing (blue), motor vehicle parts manufacturing (green), motor vehicle body and trailers manufacturing (pink), and semiconductor and other electronic component manufacturing (red). Industries are ordered in terms of the export share to the U.S. in 2017 as shown in the black line and the right y-axis.

6.4 GVC integration in Mexico

There is a positive, though not significant, relationship between the industries that benefitted from trade tensions and their integration with the GVC.

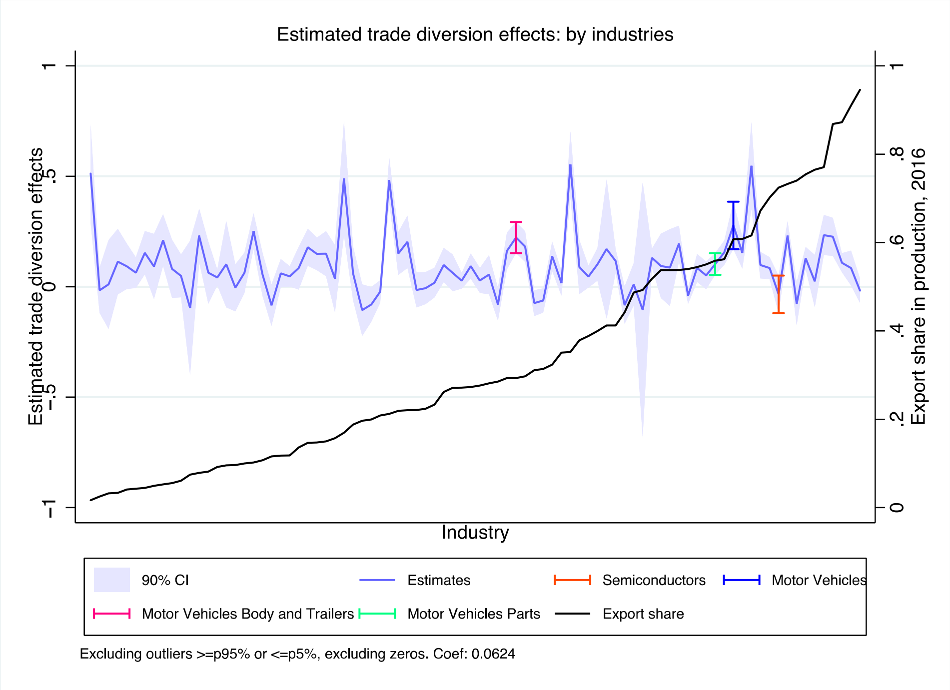
We determine whether the heterogeneous response in the change of exports from Mexico to the U.S. after the trade tensions across industries was associated with the variation in global value chain (GVC) integration across industries. The industry-level GVC integration is measured by: (i) first, the share of imported input in total production cost; and (ii) second, the share of exports in total production. Both measures are constructed from the input-output table obtained from INEGI for 2016, before the trade tensions. There is a positive, though insignificant, correlation (0.06 for both measures) between the GVC integration and the estimated increase in exports from Mexico to the U.S. after the increased tariffs on Chinese products, for both measures of GVC integration (Figures 8 and 9).

Figure 8. Estimated Trade Diversion Effect for Each Industry, Ranked by Imported Input Share in Total Production Cost



Notes: This figure plots the estimated increase in exports from Mexico to the U.S. for each industry in blue curve, with 90 percent confidence internals in the blue shaded areas. In addition, several important industries are coded in different colors. Industries are ranked based on the imported input share in total production cost, as shown in black curve.

Figure 9. Estimated Trade Diversion Effect for Each Industry, Ranked by Export Share in Total Production Value



Notes: This figure plots the estimated increase in exports from Mexico to the U.S. for each industry in blue curve, with 90 percent confidence internals in the blue shaded areas. In addition, several important industries are coded in different colors. Industries are ranked based on export share in total production value, as shown in black curve.

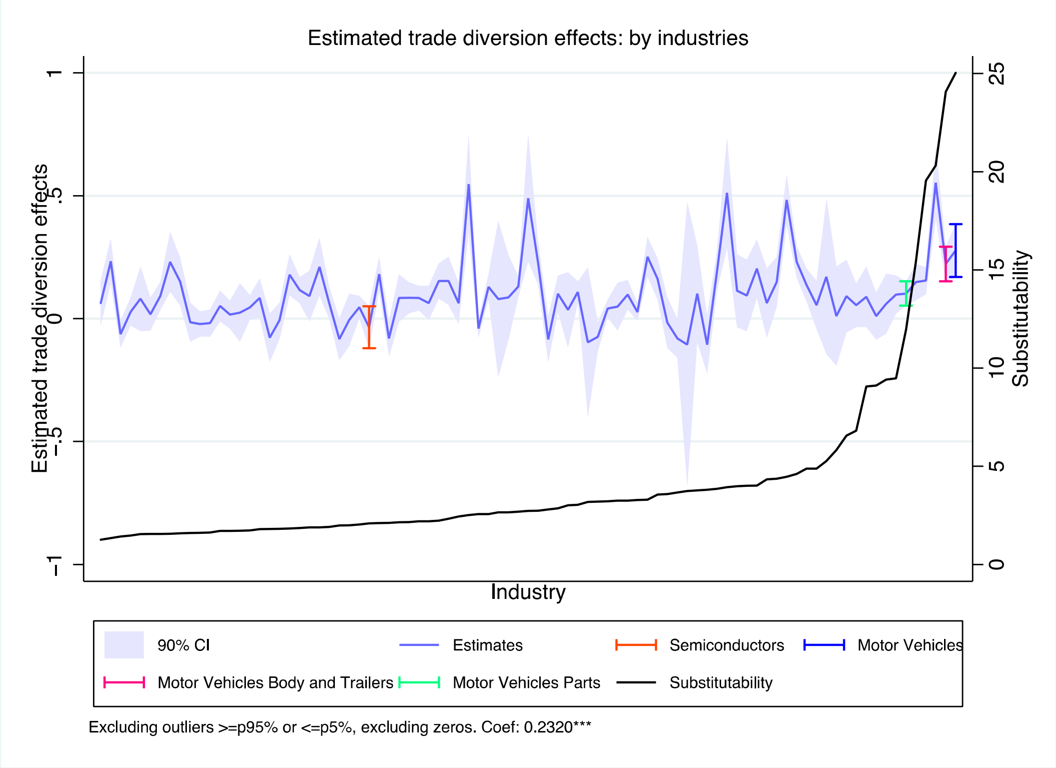
6.5 Product Substitutability

We find that higher substitutable goods benefitted more from trade diversion. This is intuitive as when a product is more substitutable, it is easier to find a substitute from another country.

The measure of product substitutability at industry level comes from Broda and Weinstein (2006). The estimated product substitutability measures the substitution between varieties from different countries, for example, shoes from Mexico and China. Specifically, it is the elasticity of substitution in the demand function, which takes a nested CES form. In the CES demand function, the first layer is across industries and the second layer is across varieties from different countries for the same industry. The estimated substitutability is the elasticity of substitution in the second layer.[32]

Figure 10 shows the estimated change in exports from Mexico along with the industry-level substitutability measure. As industries get more substitutable (from left to right), it is easier for the U.S. to buy the same products from Mexico instead of from China, the increase in exports from Mexico to the U.S. after the trade tensions gets larger. The correlation is positive and significant (0.23).

Figure 10. Estimated Trade Diversion Effect for Each Industry, Ranked by Product Substitutability Measure



Notes: This figure plots the estimated increase in exports from Mexico to the U.S. for each industry in blue curve, with 90 percent confidence internals in the blue shaded areas. In addition, several important industries are coded in different colors. Industries are ranked based on product substitutability measure, as shown in black curve.

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[32] The substitutability measure is estimated at HS 3-digit level for the U.S. market, and we aggregate it to industry level by the weighted average of product-level substitutability where the weight is chosen as the import share of each product in industry in 2016. In concordance, we assume all products at HS 6-digit level within one 3-digit level share the same substitutability and we match industry code with HS 6-digit code. A higher substitutability measure means that it is easier for the U.S. to use products from Mexico to replace products from China, leading to potentially larger trade diversion.

7. Using WIOD and UNComtrade Data Instead

To illustrate the new information gained from our matched dataset, we conduct the same exercises using a matched dataset of WIOD and UN Comtrade. Compared to our dataset matched from INEGI and UN Comtrade, the main difference is the granularity. The number of industries in the sample is 56 in WIOD and 258 in INEGI. Hence, the variation in tariff changes across industries is larger in INEGI than that in WIOD. We compare the findings on aggregate trade diversion effects using WIOD data with those reported above using INEGI data.

7.1 Overall Trade Diversion Effect

The two sets of results are qualitatively same. Quantitatively, the magnitude of the estimated trade diversion effect is larger using INEGI data than using WIOD data. Table 4 shows the percentage change in exports to the U.S. of one industry if the tariff change exposure is one standard deviation higher. The results using INEGI are based on the estimated results in Table 7 using continuous treatment variables. We find that when one industry faced a larger increase in the U.S. tariffs on Chinese products, its exports to the U.S. from Mexico increased more after the trade tensions, compared to industries with a smaller increase in tariffs. Among tariff measures, the effect of output tariffs is larger, compared to that of upstream, downstream, total, and net tariffs. Quantitatively, if one industry experienced one standard deviation increase in net tariff change, the exports from this industry to the U.S. will increase by 6.4 percent after the trade tensions, using INEGI. This number becomes 1.4 percent using WIOD.

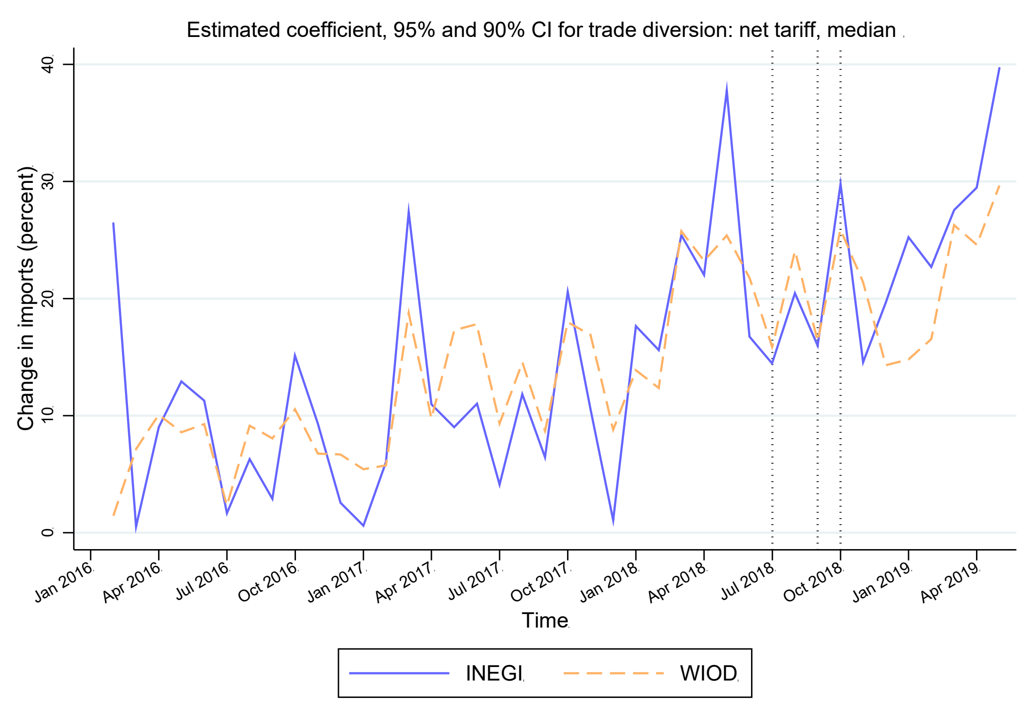
Table 7. Compare Aggregate Trade Diversion Effect, One S.D. Change, INEGI and WIOD

	(1)		(2)		(3)		(4)	
	INEGI	WIOD	INEGI	WIOD	INEGI	WIOD	INEGI	WIOD
Output	7.2***	0.7	8.34**	0.0				
Upstream			-5.9	1.2				
Downstream			2.0	0.2				
Total					6.2***	1.6		
Net							**6.4*** **	**1.4**

Notes: This table runs regression of trade diversion effects on Mexico's exports to the U.S., using 285 industries-41 months panel for INEGI case, and using 56 industries-41 months panel for WIOD case. The result shows the percentage change in export growth if one industry's tariff exposure is one S.D. higher after the trade tensions. Notice that for INEGI results, significance level is indicated with asterisk. *** for p-value of t-test being lower than 1 percent, ** for 5 percent, and * for 10 percent. For WIOD results, due to highly singularity, standard errors are not available. The first column uses equation (3) with size of increase in output tariff, the second column uses equation (4) with size of increase in all output, upstream, and downstream tariffs, the third column uses equation (3) with size of increase in total tariff, and the fourth column uses equation (3) with size of increase in net tariff. All columns use dynamic panel model with lagged export value term, industry and month fixed effect, and Arellano-Bond estimator to deal with the correlation between unobserved factors in error term $\varepsilon_{j,t}$ and the lagged term $Y_{j,t-1}$.

The estimated monthly trade diversion effects along the dynamics convey the same message using either INEGI or WIOD data. Figure 11 plots the estimated monthly trade diversion effect along the months, in blue using INEGI data and in orange using WIOD data. In both cases, the increase in exports to the U.S. from Mexico started to show up in early 2018, upon the announcement of the tariff increase on Chinese products, and stayed positive afterwards. The magnitudes are comparable between the two sets of results.

Figure 11. Compare Dynamic Trade Diversion Effect, INEGI and WIOD



Monthly data from January 2016 to May 2019.

Notes: This figure plots the estimated coefficients (blue solid line using INEGI data, and orange dashed line using WIOD data) in each month. The coefficient in each month measures the average difference in the U.S. (log) import values in this month between industries that are more exposed to tariff increase during the U.S.-China trade tensions and industries that are less affected by the tensions. The coefficient is estimated by a difference-in-differences method; hence, we control for the average differences in the U.S. import values between the treated and the control groups in January 2016. We consider industries to be more exposed to the U.S.-China trade tensions when the increase in the sum of output and downstream net upstream tariff imposed by the U.S. on Chinese products is larger than the median of industry-level tariff change. Vertical lines indicate the first three rounds of tariff imposing by the U.S.

7.2 Industry-Level Trade Diversion Effect

The estimated average of industry-level trade diversion effects, measured by the exports increase from Mexico to the U.S. after the trade tensions, is of smaller magnitude using WIOD compared to using INEGI data. Table 8 compares the mean of estimated industry-level trade diversion effects, between INEGI and WIOD estimates. Using WIOD data, out of 56 industries, 25 industries experienced changes in exports to the U.S. after the trade tensions and 23 industries had exports to the U.S. increased. The mean increase in exports is 4 percent after the trade tensions, and about 9.5 percent among industries with changes. Recall that using INEGI, the average of all 258 industries is 6.25 percent.

The estimated industry-level trade diversion effect is positively correlated with the tariff change exposure at the industry level. Table 9 compares the correlation between INEGI and WIOD results. Results using INEGI is the same as those in table 6. The positive correlation between industrial trade diversion effect and tariff exposure measure is more pronounced using INEGI, even though both are significant.

Table 8. Compare Industry-Level Trade Diversion Effect, Mean, INEGI and WIOD

	INEGI		WIOD	
	Obs.	Mean (percent)	Obs.	Mean (percent)
Industry-level trade diversion effect	258	6.25	56	4.24
Non-zeros	97	16.63	25	9.49

Notes: This table lists the mean of the estimated industry-specific trade diversion effects from (5) with lagged terms for U.S. import value, using INEGI and WIOD data.

Table 9. Compare Correlation Between Industry-Level Trade Diversion Effect and Tariff Change Exposures, INEGI and WIOD

	Tariff increase dummy		Tariff increase dummy of median		Tariff increase levels	
	(1)		(2)		(3)	
	INEGI	WIOD	INEGI	WIOD	INEGI	WIOD
Output	0.166**	0.095***	0.166**	0.095***	0.012**	0.010***
Upstream	0.063**	0.045***	0.033	0.029	0.007**	0.081***
Downstream	0.065**	0.047***	0.114**	0.055***	0.007	0.022
Total	0.063**	0.045***	0.113**	0.085***	0.007**	0.009***
Net	0.128**	0.074***	0.125**	0.085***	0.011**	0.009***

Notes: This table shows the results of regression (6) with various dependent variables and explanatory variables. Each number represents a regression in (6), with dependent variable being the estimated $\widehat{\beta_j}$ from regression (5). The explanatory variable is defined by the treatment type of tariff change in the column and tariff measure in the row. Column (1) reports how the tariff change dummy, including output tariff increase dummy in the first row, upstream tariff increase dummy in the second row, downstream tariff increase dummy in the third row, total tariff increase dummy in the fourth row, and net tariff increase dummy in the fifth row, affects the estimated coefficients from regression (5) with U.S. import value being the dependent variable and with lagged U.S. import value. Column (2) reports how the tariff change dummy indicating whether a tariff increase is above its median, with the same row structure as in column (1). Column (3) reports how the tariff change levels, including output tariff increase level in the first row, upstream tariff increase level in the second row, downstream tariff increase dummy in the third row, total tariff increase dummy in the fourth row, and net tariff increase level in the third row, affects the estimated coefficients from regression (5) with U.S. import value being the dependent variable and with lagged U.S. import value.

8. Effect of U.S.-Russia Sanctions on Mexico's Exports to the U.S.

This section provides an empirically based event study of how economic sanctions imposed by the U.S. on Russia in 2014 affected the U.S. imports from Mexico. In line with typical trade diversion effects, the U.S. may divert its imports to countries like Mexico as economic sanctions increase non-tariff trade barriers between the U.S. and Russia. While there are many differences across this event and the recent episode, not least in global developments and the scale of the sanctions, this exercise can nevertheless be useful in offering some clues on the possible impact on Mexico's exports from the current U.S. sanctions on Russia.

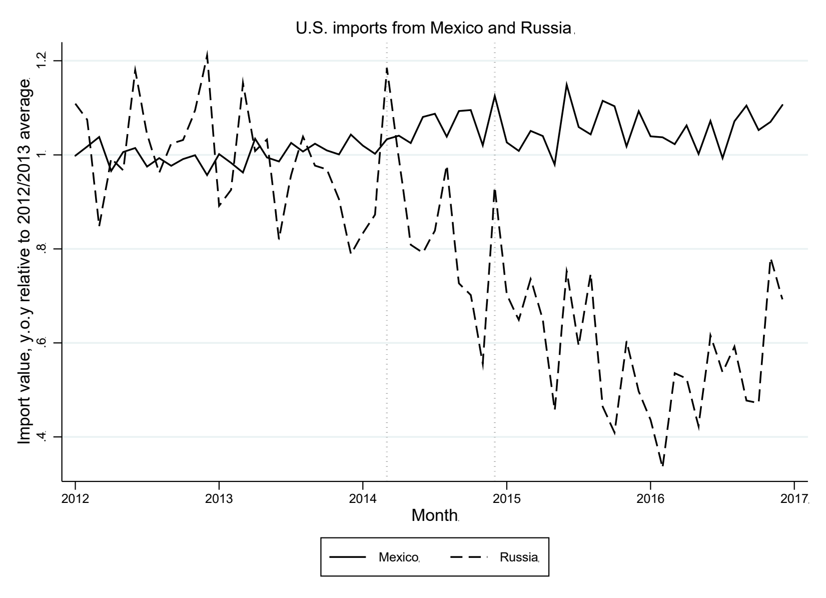
8.1 U.S. Sanctions on Russia

In 2014, following Russia's invasion of Crimea, the Obama administration issued four executive orders targeting agents that were associated with the military decision, products, and services. The first three took place in March while the last one was imposed in December. After 2014, the next sanction happened in December 2016. Hence, the analysis uses data before 2017 to avoid any potential overlapping.

8.2 Stylized Facts on Aggregate Trends

Figure 12 presents the trend of the U.S. monthly imports from Mexico (solid line) and Russia (dashed line) during 2012–16, based on a year-over-year comparison. Specifically, we divide the monthly imports by the average imports in the same month during 2012–13, to eliminate the seasonality of the U.S. imports. The two vertical lines indicate the month in which the U.S. imposed economic sanctions on Russia. In the aggregate level, the U.S. imports from Russia had been declining, especially after 2014. Following sanctions, the U.S. reduced imports from Russia immediately.

Figure 12. U.S. Monthly Import Values from Mexico (solid) and Russia (dashed), Normalized



Notes: Source, UN Comtrade.

The U.S. imported less from Russia and more from Mexico in the aggregate level. Table 10 provides the level changes in the U.S. imports from Russia and Mexico before and after the sanctions. We calculate the annual nominal imports[33] of the U.S. from Russia and Mexico during 2012–16 and take average for two sub-periods, 2012–14 and 2015–16, which are before and after the sanctions were imposed. We measure the magnitude of exports as the share of 2012 GDP for each country. We then compute changes of the average annual nominal imports. The actual data suggests that Mexico's exports to the U.S. have increased by about 0.85 billion dollars after the sanctions or 0.07 percentage points of 2012 Mexico' GDP. While Russia's exports to the U.S. have decreased by 0.93 billion dollars or 0.04 percentage points of 2012 GDP, comparing 2015–16 average to 2012–14 average.

Table 10. Nominal U.S. Imports from Russia and Mexico, from 2012–14 to 2015–16

Country	Pre-sanction U.S. imports (billion $, percent in 2012 GDP)	Post-sanction U.S. imports (billion $, percent in 2012 GDP)	Change in U.S. imports (billion $, percent in 2012 GDP)
Mexico	23.89	24.74	0.85
	1.99%	2.06%	0.07%
Russian Federation	2.29	1.36	-0.93
	0.10%	0.06%	-0.04%

Notes: Source, UN Comtrade and FRED. This table shows the average U.S. imports from Russia and Mexico before and after sanctions, and the changes. Imports are measured by billion dollars in nominal term. In the first row of each country, and in the second row, imports are normalized by 2012 GDP of each exporting country for comparison.

8.3 Empirical Approach and Results 1: Dynamic Regressions

We conduct regression analysis on granular product-level trade flow data to estimate the additional U.S. imports from Mexico after sanctions to Russia. We want to estimate the evolution of the average U.S. imports from Mexico at the industry level before and after the sanctions were imposed.

$$lnY_{i,t} = \beta_0 + \sum_{\tau=2}^{T} \beta_{1,\tau} 1_\tau + \beta_2 \tau_{i,t} + \theta_i + \varepsilon_{i,t}. \tag{7}$$

In equation (7), $lnY_{i,t}$ is the logarithm of nominal U.S. import value of product i from Mexico in month t. We choose product i at HS 6-digit level, and time t covers 2012/01-2016/12. 1_τ indicates the period of month $\tau, \tau = 2, \ldots, T$, which equals to one when time is τ. Following a set-up similar to the standard gravity equation,[34] we control for the U.S. tariff level at the product level, $\tau_{i,t}$, to separate out the effect of tariff changes on import values.[35] We also include product fixed effects, θ_i, to eliminate the effect of potentially unobservable factors. For instance, the former excludes the time-invariant trade value level difference among products. Standard

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[33] Throughout this analysis, we use nominal import values. When we use real import values instead, all results are qualitatively the same and quantitatively similar. In the real import value analysis, nominal import values are deflated with monthly U.S. CPI. The CPI data is from FRED, https://fred.stlouisfed.org/series/CPIAUCSL.

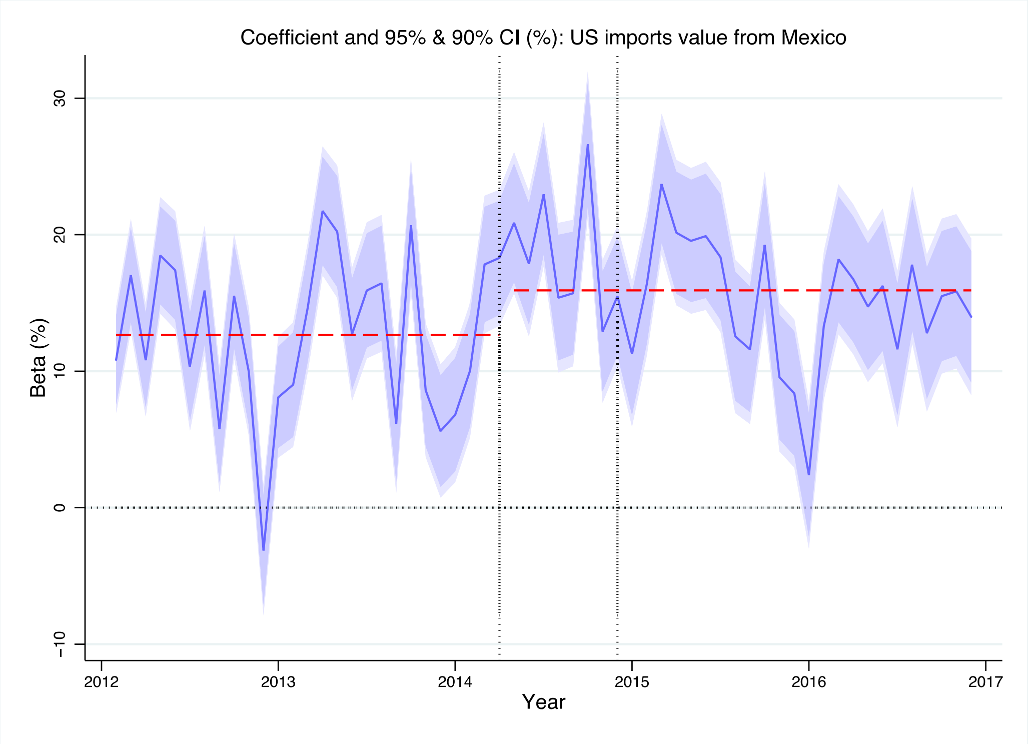
[34] The gravity equation states that the volume of bilateral trade between two economies is proportional to their economic sizes, measured by their GDP, and inversely proportional to their trade frictions, including geographic distance, trade policies, and language barriers. In our equation, exporting countries' GDP and importing country, the U.S.'s GDP is captured by the time fixed effects, 1_τ. In addition, we control for trade frictions by including U.S. tariff levels, $\tau_{i,t}$, and product fixed effects.

[35] The U.S. tariff level comes from DataWeb, USITC, and is calculated by the duties divided by the dutiable values. When dutiable value is zero, tariff level is set to be zero. We plot changes in the aggregate tariff levels imposed by the U.S. on Mexican and Russian products in Figure A5 in Appendix IV.

errors are clustered at the product level. Our parameter of interest, $\beta_{1,\tau}$, captures the average U.S. imports from Mexico over time, compared to the level in January 2012.[36] We expect β_1 to be higher after March 2014 and December 2014, implying the U.S. imported more from Mexico rather than from Russia after the sanctions.[37]

Figure 13 presents the estimated $\beta_{1,\tau}$ values (in scatters) and its 95 and 90 percent confidence intervals (in dotted vertical lines) for $\tau = 2, \dots, T$. The vertical line indicates the period when sanctions were imposed, in March and December 2014. As we expected, the estimated coefficient of time dummy increases in the months following the U.S. sanction, indicating positive trade diversion effects.

Figure 13. Trade Diversion Effect of U.S. Sanctions, Dynamic Results



Notes: This figure plots the estimated coefficients (solid line, percent) 95 percent confidence intervals (darker area), and 90 percent confidence intervals (shallower area) in each month based on equation (7). The coefficient in each month τ measures the average level (in percentage change) of U.S. import value from Mexico in period τ, relative to the import level in January 2012. Vertical lines indicate March 2014 and December 2014, when sanctions were imposed against Russia. Red horizontal lines plot the average estimates before and after sanctions.

8.4 Empirical Approach and Results II: Local Projections

We estimate the responses of the U.S. imports from Mexico after a sanction shock, using the following local projection specification. In equation (8), $lnY_{i,t+k} - lnY_{i,t-1}$ is the accumulated change in the log of U.S. imports from Mexico of product i from month $t-1$ to $t+k, k = 0,1, \dots, 6$. The key explanatory variable, $\Delta shock_t$, is one

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[36] We cannot rule out the effect of other events that happened at the same time with sanctions, which would affect U.S. imports from Mexico, for example, U.S. GDP level and/or global factors.

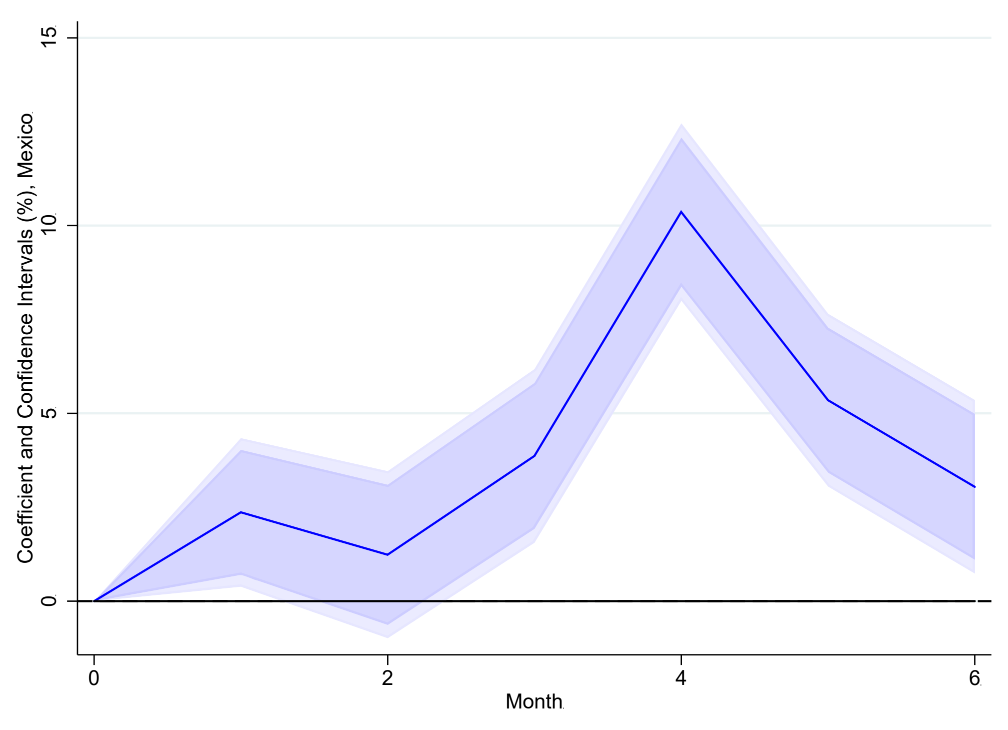
[37] Notice that $\beta_{1,\tau}$ does not capture the trade diversion effect on U.S. imports shifting from Russia to *all other countries*, instead, we focus only on *Mexico*. Hence, we carefully interpret $\beta_{1,\tau}$ as the change in U.S. import value from Mexico over time after sanctions were imposed, without attempting to generalizing it to a global context. However, our methodology can be applied to study the impact on other countries.

when t is March or December 2014, otherwise zero. Besides shocks in the current period, we also include shocks in the past three periods. We control for the lagged import level changes in the past three periods, $\Delta lnY_{i,t-p}, p = 1,2,3$, to account for the persistence of the imports. We also include current and lagged three periods of changes in Mexico's GDP level and U.S. tariffs on Mexico at the product level, as well as product fixed effects. The coefficient in each horizon $k, \beta_{2,0,k}, k = 0, \dots, 6$, measures the percentage changes in the level of the U.S. import value from Mexico after k months of sanction shocks.

$$lnY_{i,t+k} - lnY_{i,t-1} = \sum_{p=1}^{3} \beta_{1,p,k} \Delta lnY_{i,t-p} + \sum_{p=0}^{3} \beta_{2,p,k} \Delta shock_{t-p} + \sum_{p=0}^{3} \beta_{4,p,k} \Delta \ln GDP_{t-p} + \sum_{p=0}^{3} \beta_{5,p,k} \Delta \ln(1+\tau)_{i,t-p} + \theta_{i,k} + \varepsilon_{i,t,k}. \tag{8}$$

Figure 14 shows the impulse responses of the U.S. imports from Mexico to sanction shocks, which is the estimated coefficient, $\beta_{2,0,k}, k = 0, \dots, 6$. This suggests a positive statistically significant effect with nominal exports from Mexico increasing by about 10 percent four months after the sanction.

Figure 14. Trade Diversion Effect of U.S. Sanctions, Local Projection Results



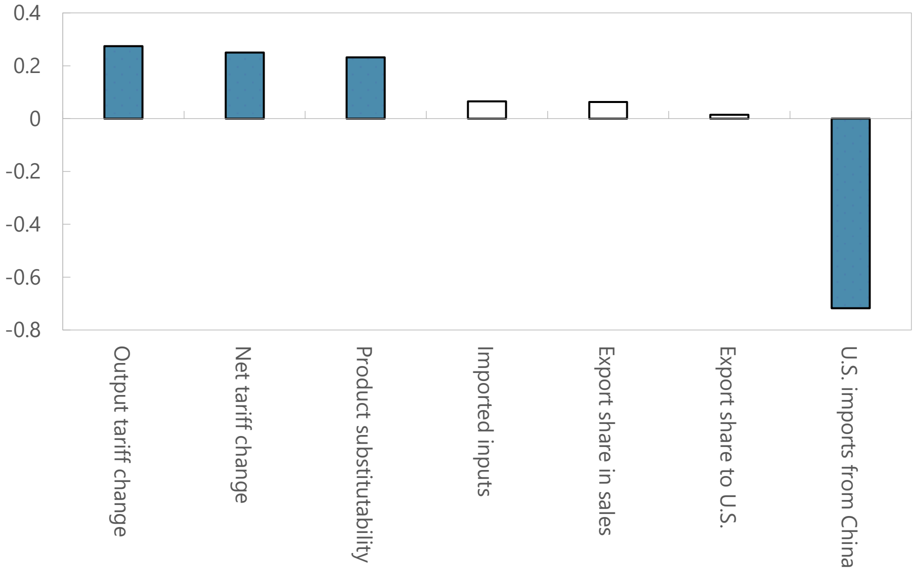
Notes: This figure plots the estimated coefficients (solid line) 95 percent confidence intervals (darker area), and 90 percent confidence intervals (shallower area) in each month based on equation (8). The coefficient in each horizon k measures the percentage changes in the level of U.S. import value from Mexico after k months of sanction shocks.

9. Conclusion

The paper sheds light on whether Mexico experienced trade diversion effects during two shocks, namely the U.S.-China trade tensions in 2018 and the U.S. sanctions on Russia in 2014. We consider output-, upstream-, and downstream- tariffs constructed using input-output linkages across industries. In both the episodes, we find positive trade diversion effects for Mexico's exports to the U.S, emanating mainly from output tariffs and also from downstream tariffs. The effects are stronger when nationally sourced input-output data are used compared to those derived from cross-country sources.

A key finding of the paper, in the light of the recent policy interest on how supply chains could evolve following the Covid-19 pandemic and any potential geoeconomic fragmentation, is that the magnitude of trade diversion across industries depends on the U.S. tariff changes on Chinese goods, the decrease in the U.S. imports from China, product substitutability with Chinese products, and (weakly) on its GVC integration (Figure 15). Our paper implies that easily substitutable products might have a market in the U.S., during global trade tensions or negative shocks, even if their initial exposure to the U.S. market is not substantial. The findings of our paper are in line with and provide a good complement to those of Freund et al. (2023) who use cross-country analysis to show that China's decline in the U.S. exports was concentrated in tariffed goods and Mexico was one of the biggest winners. The authors also find some evidence of nearshoring to Mexico. Some other recent cross-country studies (Alfaro et al. 2023, Fajgelbaum et al. 2023) also identify Mexico as one of the winners during global trade tensions.

Figure 15. Correlation Coefficient with Mexico's Estimated Industry-Level Trade Diversion



Notes: See table 5 for details. The blue shaded bars are statistically significant.

The paper provides two additional messages for academic work and policy implications. Further work in these areas would be useful.

First, recent work has highlighted the risk of policy-driven geoeconomic fragmentation (GEF; e.g., Aiyar et al., IMF 2023). Our results suggest differential short-term impact across countries and industries from such occurrences. Generally speaking, it is important to bear in mind that even if some countries may benefit from trade diversion, higher tariffs and geopolitical tensions would leave the global economy worse off (IMF WEO: October 2022 and April 2019). Negative confidence effects and tighter financial conditions triggered by trade tensions would affect all countries negatively. Future work could explore how any short-term benefit shapes the long-term dynamics and how country-specific circumstances and supply linkages influence these dynamics.

Second, the paper highlights that the proper accounting of supply linkages matters. This brings into fore a broader issue on whether more work needs to be done to improve the industry-level coverage of cross-country sources. Future work could also explore in detail the differences and the reliability of country-specific versus cross-country sources.

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Appendix I. Dataset Matching Methods

A1.1 Matching WIOD and INEGI for Stylized Facts on Industry Input and Trade Schedule

We describe the procedure of the matching process between WIOD and INEGI datasets and assumptions made in these steps.

Firstly, two data sets use different coding systems of industry. INEGI uses NAICS 4-digit 2017 version and WIOD adapts ISIC Rev 4 in the 2-digit level. We match these two datasets using the concordance table between ISIC Rev. 4 to 2017 NAICS from U.S. Census website and take average when encountering an aggregation issue.[38]

Here are the steps to show the input and import structure of one industry. *Notice that we use the input-output table as the Leontief inverses.*

- Step 1: to construct the input structure, we use INEGI IO tables with the total values. We keep the column for the motor vehicle industry, which contains information on its required input value from all industries. Each row in the first 258 rows represents one industry as an input, and the rest of rows are aggregate level domestic, imports and total production values. We calculate the total production cost value by summing up all input values from 258 industries and the value share of each industry by taking ratio of input value in each industry and the total value. Ranking the industry value share, we can easily find the top 10 inputs in producing motor vehicles.

- Step 2: to show the imported value share for each input, we use INEGI IO tables with the imported values and total values. After combing these two tables, we can calculate the imported value share for each input by taking ratio of its imported value and total value.

- Step 3: to find the top sourcing countries for each input, we use WIOD IO table to match with INEGI IO tables. Basically, we want to know for each NAICS 4-digit coded input industry in INEGI IO tables, what are the sourcing countries as in WIOD IO table.
    - Step 3.0: we use NAICS and ISIC Rev 2 to match two databases. However, WIOD has a slightly aggregation over ISIC Rev. 4, so we first need to prepare WIOD database for merging by linking their codes to the standard ISIC Rev. 4. We refer to UN Statistics Division documents for ISIC Rev.4 to conduct this matching.[39] There are four remarkable details. First, we match at IndustryCode and Country level, where IndustryCode and Country lists are from WIOD. This will give us unique identification of WIOD rows and make sure the matched result contains all Countries and ISIC industries. Second, after matching, we will get a panel at ISIC and Country level, where several ISIC code could refer to one WIOD IndustryCode. For example, For WIOD IndustryCode B, there are 5 ISIC codes, 05, 06, 07, 08, 09 matched with it. We evenly distribute the input values to each ISIC code. Third, since the WIOD format has a matrix shape, we reshape it to a long panel with output, input, and

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[38] See https://www.census.gov/eos/www/naics/concordances/concordances.html. Especially, we use 2017 NAICS to ISIC Rev. 4. We have double checked with ISIC Rev. 4 to 2017 NAICS, which will generate the same matching result.

[39] See https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf .

country as three dimensions. Forth, after reshaping, we need to link the output code with ISIC Rev.4 2-digit codes. Here we do not have any averaging or aggregation as in the second point.

- Step 3.1: since we focus on the production of one industry, let's say manufacturing of motor vehicles (NAICS 3361), we first need to find the corresponding output industries in the ISIC codes as in WIOD. There are more than one ISIC coded industries from WIOD are matched to the vehicle industry. Hence, we take average of input values among all these industries from each industry and each country.

- Step 3.2: for each input industry from INEGI, we find the corresponding industries from WIOD and match the import structure. First, there is also a slightly aggregation in the INEGI IO tables on NAICS 4-digit code, hence, we need to match code from INEGI to NAICS 4-digit code. Second, we match NAICS 4-digit code to ISIC 2-digit code. Third, we match these ISIC coded industries to WIOD IO tables from Step 3.0. Hence, we get for each industry at NAICS 4-digit code, the import structure from sourcing countries using WIOD IO table. Notice that in the second step, for some industries, one NAICS code can be matched with multiple ISIC codes. In this case, we sum up input values and imported input values of all ISIC coded industries matched for each country, and then calculate the imported share as an average.

A1.2 Imports from the U.S. in Each Industry

We calculate the exports to U.S. in each industry at NAICS 4-digit level by matching imports from the U.S. from the production level trade flow data in UN Comtrade to each industry.

Steps of matching with UN Comtrade:

- Step 1: for each industry j from INEGI at and each year, calculate imports from the U.S. from UN Comtrade trade flow data at HS 6-digit level. This requires 2 steps of matching industry codes.
  - Step 1.1: The first matching step is to match NAICS 4-digit code with INEGI industry codes due to the slight difference between the two.
  - Step 1.2: The other matching step is to match NAICS 4-digit with HS 6-digit as used in UN Comtrade. The latter is provided by Pierce and Schott (2009).[40]

A1.3 Exports to the U.S. in Each Industry

We calculate the exports to U.S. in each industry at NAICS 4-digit level by matching exports to the U.S. from WIOD and UN Comtrade to each industry.

Steps of matching with UN Comtrade:

- Step 1: for each industry j from INEGI at and each year, calculate exports to the U.S. from UN Comtrade trade flow data at HS 6-digit level. This requires 2 steps of matching industry codes.

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[40] See https://faculty.som.yale.edu/peterschott/international-trade-data/ for data and codes.

  - Step 1.1: The first matching step is to match NAICS 4-digit code with INEGI industry codes due to the slight difference between the two.
  - Step 1.2: The other matching step is to match NAICS 4-digit with HS 6-digit as used in UN Comtrade. The latter is provided by Pierce and Schott (2009).[41]

Steps of matching with WIOD, notice that we can distinguish intermediate input and final goods from WIOD:

- Step 1: for each industry j from INEGI at and each year, calculate exports to the U.S. from WIOD input-output table. This requires three steps of matching industry codes.
  - Step 1.1: The first step is to match ISIC 2-digit code with WIOD industry codes due to the slight difference between the two. For each ISIC 2-digit industry, calculate the exports to the U.S. by summing up all exports across industries in the U.S. Notice that WIOD distinguish exports of intermediate inputs and final goods, hence both exports can be calculated.
  - Step 1.2: The second step is to match NAICS 4-digit code with INEGI industry codes due to the slight difference between the two, for both *input* and *output* industries.
  - Step 1.3: The third step is to match NAICS 4-digit industry j from INEGI with ISIC 2-digit industry j from WIOD. Notice that this step of matching requires averaging across industries from WIOD when multiple ISIC industries are matched with one NAICS industry.

A1.4 Leontief Inverse of Input-Output Table

The basic idea is that the amount of production in each sector must be the sum of its final demand and its intermediate input demand. This requires,

$$X_i = \sum_{j=1}^{n} Z_{ij} + Y_i = \sum_{j=1}^{n} a_{ij} X_j + Y_i \, , i = 1, \dots , n,$$

where X_i is the total amount of product i produced, Z_{ij} is the interindustry flow from sector i to sector j as in the input-output table, and Y_i is the final demand for product i. Assume that the ratio of a sector's inputs to its output is constant, $a_{ij} = \frac{z_{ij}}{X_j}$, which is called the fixed technical coefficients (Miller and Blair, 2009).

In matrix form,

$$X = AX + Y$$

where X is the vector of total amount produced, A is the fixed technical coefficient matrix, and Y is the final demand vector, including domestic demand for final goods plus the exported final goods and minus imported final goods.

$$X = AX + Y,$$

$$(I - A)X = Y,$$

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[41] See https://faculty.som.yale.edu/peterschott/international-trade-data/ for data and codes.

$$X = (I - A)^{-1}Y = LY$$

Assume $(I - A)$ is invertible and $Y \neq 0$. $L = (I - A)^{-1}$ is called the Leontief inverse.

This equation can answer the question what is the amount of each product needed to meet the final demand, given the input-output linkage.

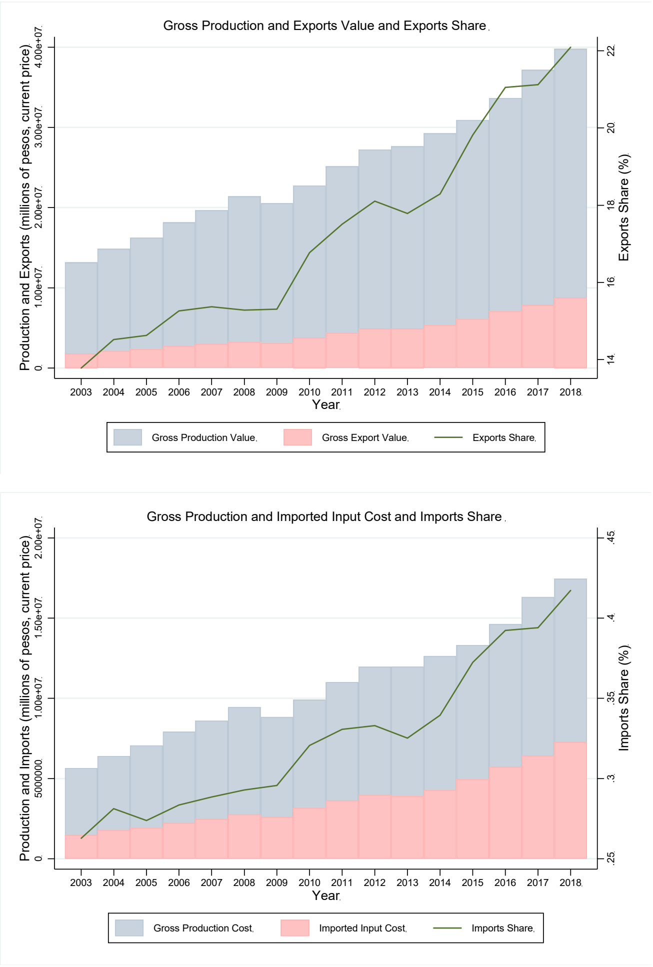
Appendix II. Aggregate Trade Structure in Mexico

This appendix explores how the aggregate production and trade structure in Mexico evolved during 2003–18, from several dimensions, including external market dependence, linkage with the U.S. market, top trading partners and top trading sectors. The findings suggest that Mexico is increasingly dependent on external markets in both product exporting and input sourcing of its industries, especially on the U.S. market. Having said that, China's importance as a trading partner has grown over time.

A2.1 Gross Exports and Imports, as Share of Production

Mexico's reliance on the external market has increased, for both product exporting and input sourcing. During 2003–18, the export share increased from 14 percent in 2003 to 22 percent in 2018 (Figure A1). The import share in production has gone up from 26 percent in 2003 to 42 percent in 2018. The rising pattern in both export and import shares implies that Mexico has become more integrated into the global market and international trade.

Figure A1. Gross Production, Exports, and Export share (top), Gross Production Cost, Imported Inputs, and Import Share (bottom)

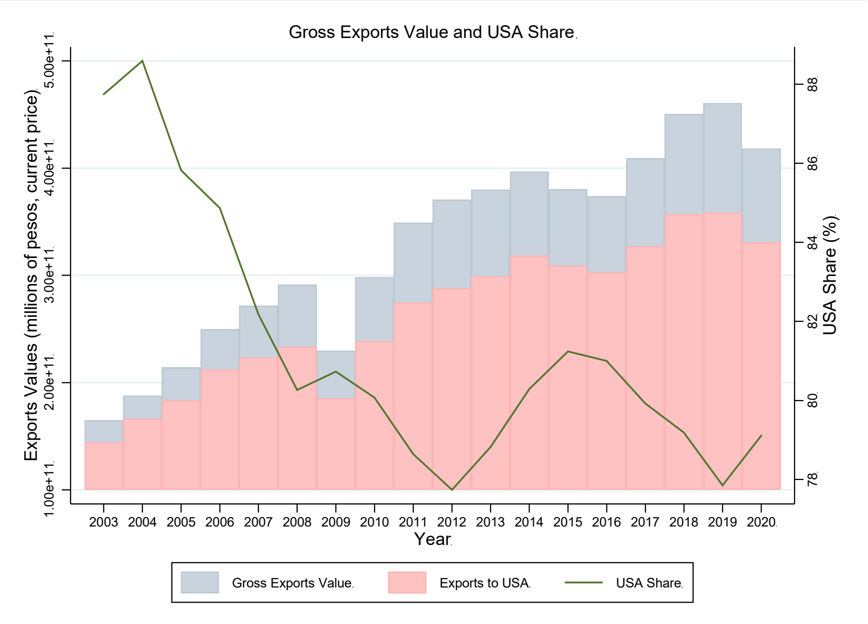


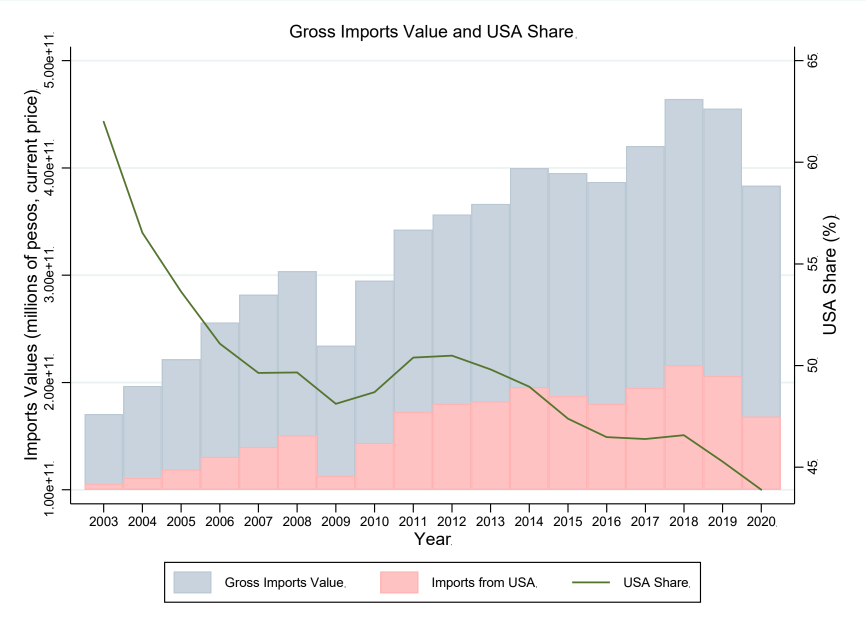
Notes: Source. INEGI input-output tables.

A2.2 Share of the U.S. in Exports and Imports

The trade dependence on the U.S. market remains high, though it has been declining over time. The U.S. is the largest destination and supplier for Mexico, accounting for 79 percent of exports and 44 percent of imports in 2020. Over time, the U.S. share in Mexico's exports has declined from 88 percent in 2003 to 79 percent in 2020, while the U.S. share in Mexico's imports has decreased from 62 percent in 2003 to 44 percent in 2020.

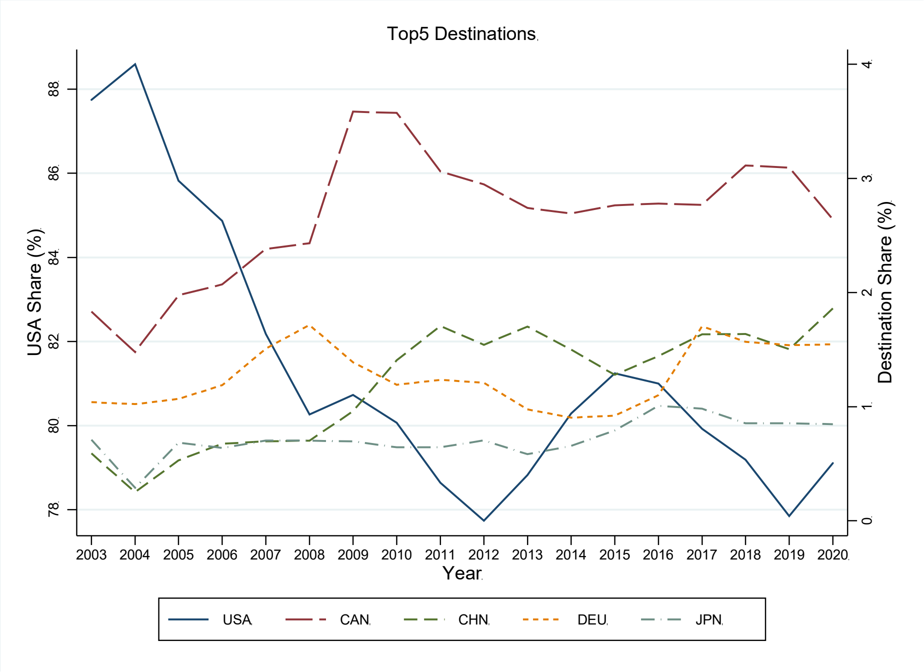
Figure A2. Gross Exports, Exports to the U.S., and the U.S. Share (top), Gross Imports, Imports from the U.S., and the U.S. Share (bottom)

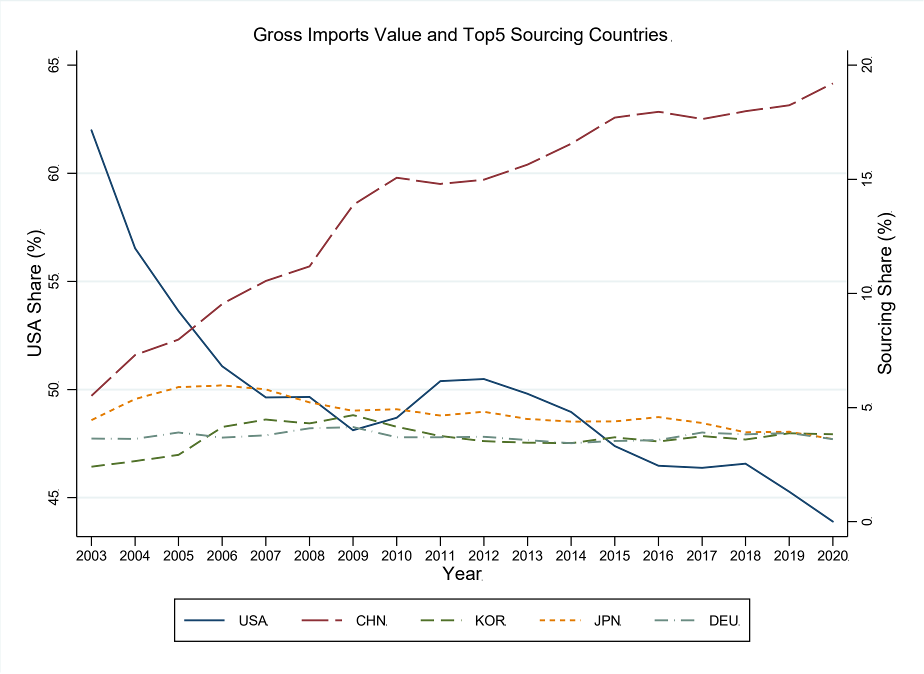




Notes: Source. UN Comtrade.

Figure A3. Export Share of Top Five Destination Countries, as in 2020 (top), Import Share of Top Five Sourcing Countries, as in 2020 (bottom)





Notes: This figure draws the export shares of top 5 destination countries fixed as they are in 2020 during 2003–20 in the top subfigure, and the import shares of top 5 import sourcing countries fixed as they are in 2020 during 2003–20 in the bottom subfigure. Source. UN Comtrade.

A2.3 Top Five Trade Partners

As the U.S. share in exports and imports declined, Mexico has built more connection with China. Using UN Comtrade annual trade flow data, the top five export destinations of Mexico in 2020 are the U.S., Canada, China, Germany, and Japan (top chart of Figure A3).[42] Similarly, the top five trade partners in terms of Mexico's imports in 2020 are the U.S., China, South Korea, Japan, and Germany (bottom chart of Figure A3).[43] A noticeable change is Mexico's growth in trade with China. The export share to China has tripled in the past two decades, from 0.6 percent in 2003 to 1.9 percent in 2020; while the import share from China has increased nearly fourfold from 5.5 percent to 19.2 percent. This is broadly in line with China's increased trade shares globally.

A2.4 Top Five Trading Sectors

To document the top trading sectors, the whole set of sectors as the 258 industries categorized in INEGI dataset is used. This is then matched with UN Comtrade for the period 2003–18 to document trade flows across sectors.[44]

Motor vehicle related industries, including motor vehicle manufacturing, motor vehicle parts manufacturing, motor vehicle body and trailers manufacturing have the highest export shares, in total accounting for 32 percent of exports in 2018 following an increasing trend since 2003 (top chart in Figure A4).[45] Semiconductor and other electronic component manufacturing, and computer and peripheral equipment manufacturing in total comprise another 11 percent of exports. Semiconductor sector has become one of the top five exporting industries since 2012 and has been growing in its export share. The expanding role of semiconductors has replaced the share of oil and gas extraction industry.[46]

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[42] In this figure, we fix the top five exporting destinations as it is in 2020, while from the dataset, we find top 5 destinations have been changing over time as well. We also plot the export share change over time for time-varying top five destinations, which is available upon request. The main message stays the same, which is, share of the U.S. has been decreasing while that of Asian countries, especially China has been growing. China has become one of top 5 destinations for Mexico since 2008.

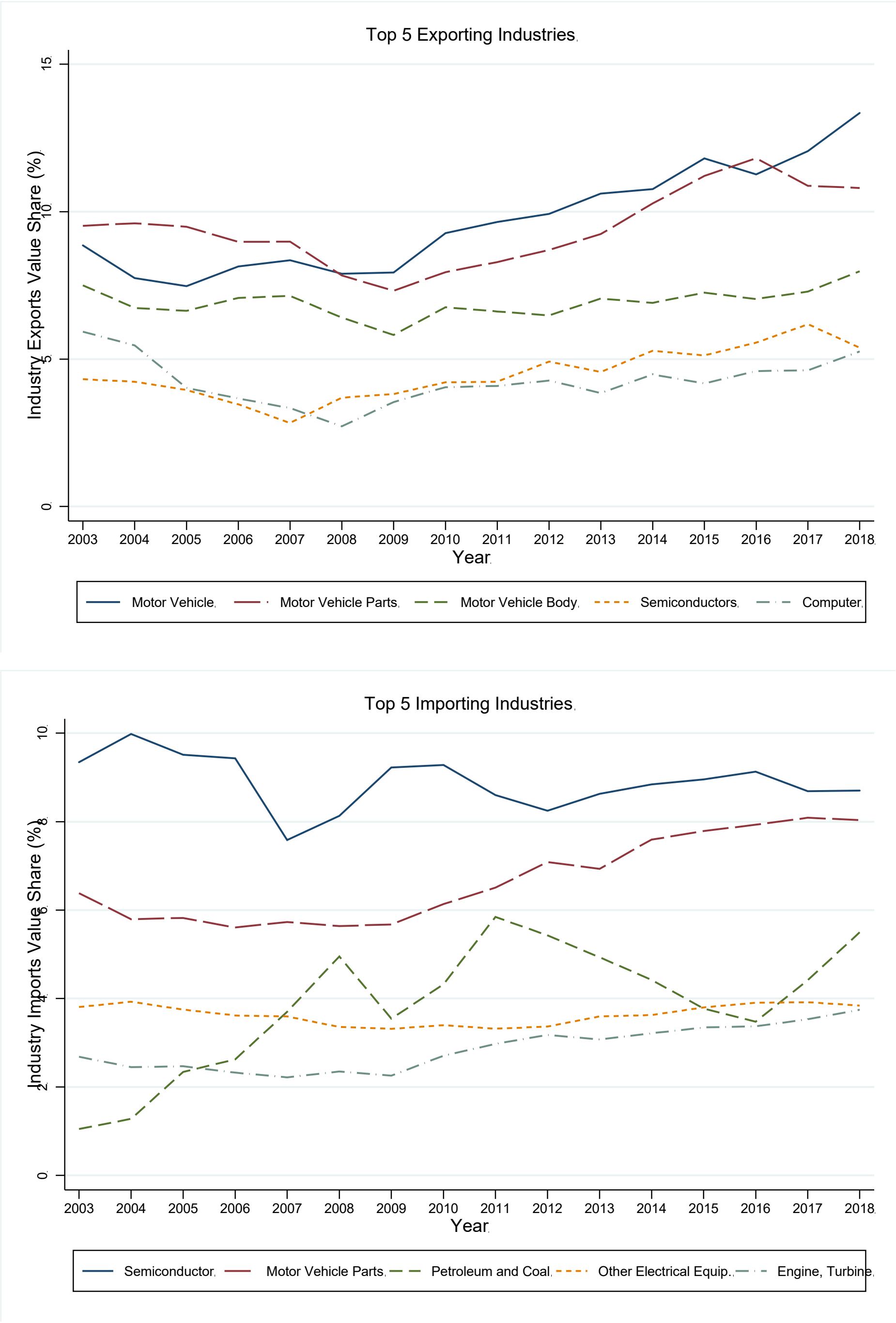
[43] In this figure, we fix the top five import sourcing countries as it is in 2020. In the dataset, we find that top five import sourcing countries have been changing over time as well. The import share change over time for time-varying top five sourcing countries is available upon request. The main message stays the same, which is, share of the U.S. has been decreasing while that of Asian economies, especially China has been growing. The variation of top five sourcing countries is smaller than that of top five destinations.

[44] We match INEGI industries with product-level export and import value from UN Comtrade using the concordance table provided by Pierce and Schott (2009). See more detailed method and steps in Appendix I.2-I.3. For industries that are matched with multiple products, we sum up all export and import values of all matched products to construct the export/import value at industry level.

[45] In this figure, we fix the top 5 exporting industries as it is in 2018, while from the dataset, we find top 5 exporting industries have been evolving over time as well. The export share change over time for time-varying top 5 exporting industries is plotted as well and available upon request. The main message stays the same, which is, shares of auto vehicle manufacturing industries have been high all the time and even increasing over time. Semiconductor sector joined top-5 since 2012.

[46] We also use only INEGI dataset to draw a similar set of figures for top 5 exporting industries. Since the U.S. is the largest export destination, we further characterize the top five exporting industries to the U.S. market. They convey similar messages.

Figure A4. Export Share of Top Five Exporting Industries, as in 2018 (top), Import Share of Top Five Importing Industries, as in 2018 (bottom)



Notes: This figure plots the export shares of top 5 exporting industries fixed as they are in 2018 during 2003–18 in the top subfigure, and the import shares of top 5 importing industries fixed as they are in 2018 during 2003–18 in the bottom subfigure. Source. A matched sample of INEGI input-output tables and UN Comtrade.

Semiconductor industry is the largest importing industry in Mexico. The bottom chart of Figure A4 plots imports share trends of top five importing industries which are fixed as those in 2018, during 2003–18 from the matched datasets of UN Comtrade and INEGI.[47] Mexico imports semiconductor and other electrical component the most, accounting for about 9 percent of total imports, followed by motor vehicle parts which contributes to 8 percent of total imports in 2018. There is a rising trend of import share in petroleum and coal industry, while those of other electrical equipment manufacturing and engine, turbine, and power transmission equipment manufacturing are relatively stable.[48]

These top five importing industries provide the main inputs to produce motor vehicles and electrical equipment. For motor vehicle production, the top inputs are motor vehicle parts; and engine, turbine, and power transmission; semiconductor and other electrical component manufacturing. Though not shown here, electrical equipment related sectors, including audio and video equipment, communications equipment, and computers have been another important part of imports during 2003–18. This implies that the nature of imports in Mexico is mainly for production rather than consumption. Moreover, the export shares of motor vehicles and electrical equipment are also significantly high (top chart of Figure A4). The high export share and import share of these two sectors—motor vehicles and electrical equipment—imply that Mexico is located in the bottom of global value chain in these sectors, focusing on the auto parts assembly task. Bolio et al. (2014) reports that transportation equipment (auto parts and assembly) represents 13 percent of Mexico's manufacturing value added. They also find Mexican auto assembly plants are considered world-class with faster expansion. Crossa and Ebner (2020) demonstrate that Mexico occupies the most labor-intensive and least value-added tasks in the auto production chain.

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[47] In this figure, we fix the top 5 importing industries as it is in 2018, while from the dataset, we find top 5 importing industries have been evolving over time as well. The export share change over time for time-varying top 5 importing industries is available upon request. The main message stays the same. The Petroleum and Coal sector joined top 5 since 2007.

[48] Like exports, since the U.S. is the biggest supplier, we further characterize the top five importing industries from the U.S. market. These figures convey similar messages. One notable observation is that there is a recent rapid increasing trend in petroleum and coal imports, especially from the U.S., from less than 1% in 2003 to 11% and the top importing industry in 2018.

Appendix III. Trade Diversion Effects: Additional Results

Table A1. Regression Results for Trade Diversion Effects, Dummy Treatment Variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	$1(\Delta\tau > 0)$						$1(\Delta\tau > median)$					
Output	0.171***			0.171***			0.171***			0.171***		
	(0.052)			(0.052)			(0.052)			(0.057)		
Up		0.061***		-				0.002		-0.002		
		(0.015)		-				(0.030)		(0.026)		
Down			0.063***	0.008					0.059**	0.002		
			(0.016)	(0.010)					(0.030)	(0.030)		
Total					0.061***						0.091***	
					(0.015)						(0.030)	
Net						0.109***						0.119***
						(0.031)						(0.029)
Constant	6.584***	6.584***	6.584***	6.584***	6.584***	6.584***	6.584***	6.584***	6.584***	6.584***	6.584***	6.584***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Ind. FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	10,578	10,578	10,578	10,578	10,578	10,578	10,578	10,578	10,578	10,578	10,578	10,578
R-squared	0.017	0.011	0.011	0.017	0.011	0.014	0.017	0.011	0.012	0.017	0.013	0.014
No. of ind.	258	258	258	258	258	258	258	258	258	258	258	258

Notes: This table runs regression of trade diversion effects on the exports values to the U.S. in Mexico, using 258 industries-41 months panel. The first six columns use equation (1) with the dummy variable indicating output, upstream, downstream, all output, upstream, and downstream, total, and net increase during the trade tensions, excluding the lagged import value term (same for all other columns). Column (7)-(12) use equation (1) with dummy variable indicating whether the tariff change was above its median, in terms of output, upstream, downstream, all output, upstream, and downstream, total, and net tariffs. All twelve columns adopt static fixed effect panel model with industry and month fixed effect and clustered standard error at industry level.

Table A2. Regression Results for Trade Diversion Effects, Continuous Treatment Variable

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES			$\Delta\tau$			
Output	0.012***			0.013***		
	(0.004)			(0.005)		
Up		0.006		-0.014		
		(0.004)		(0.010)		
Down			0.006	-		
			(0.004)	-		
Total					0.006***	
					(0.002)	
Net						0.010***
						(0.002)
Constant	6.584***	6.584***	6.584***	6.584***	6.584***	6.584***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Ind. FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Obs.	10,578	10,578	10,578	10,578	10,578	10,578
R-squared	0.015	0.011	0.011	0.015	0.013	0.014
No. of ind.	258	258	258	258	258	258

Notes: This table runs regression of trade diversion effects on the exports values to the U.S. in Mexico, using 258 industries-41 months panel. The first column uses equation (2) with size of increase in output tariff, the second column uses equation (2) with size of increase in upstream tariff, the third column uses equation (2) with size of increase in downstream tariff, the fourth column uses equation (3) with size of increase in all output, upstream, and downstream
(omitted) tariffs, the fifth column uses equation (2) with size of increase in total tariff, and the sixth column uses equation (2) with size of increase in net tariff. All six columns adopt static fixed effect panel model with industry and month fixed effect and clustered standard error at industry level.

Table A3. Regression Results for Trade Diversion Effects, Growth Rate, Dummy Treatment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	$1(\Delta\tau > 0)$						$1(\Delta\tau > median)$					
Output	0.144***			0.144***			0.144***			0.145***		
	(0.041)			(0.041)			(0.041)			(0.045)		
Up		0.051***		0.000				0.001		-0.003		
		(0.012)		(0.000)				(0.026)		(0.023)		
Down			0.053***	0.006					0.048*	0.000		
			(0.012)	(0.009)					(0.025)	(0.026)		
Total					0.051***						0.076***	
					(0.012)						(0.024)	
Net						0.091***						0.100***
						(0.025)						(0.023)
L.lnimp	-0.850***	-0.846***	-0.846***	-0.850***	-0.846***	-0.847***	-0.850***	-0.846***	-0.846***	-0.850***	-0.847***	-0.848***
	(0.066)	(0.067)	(0.067)	(0.066)	(0.067)	(0.067)	(0.066)	(0.067)	(0.067)	(0.066)	(0.067)	(0.067)
Cons.	5.731***	5.706***	5.706***	5.731***	5.706***	5.717***	5.731***	5.705***	5.709***	5.731***	5.713***	5.719***
	(0.473)	(0.480)	(0.480)	(0.473)	(0.480)	(0.477)	(0.473)	(0.480)	(0.480)	(0.473)	(0.477)	(0.476)
Ind. FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Mon FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	10,320	10,320	10,320	10,320	10,320	10,320	10,320	10,320	10,320	10,320	10,320	10,320
R-sqd	0.425	0.423	0.423	0.425	0.423	0.424	0.425	0.423	0.423	0.425	0.424	0.424
# ind.	258	258	258	258	258	258	258	258	258	258	258	258

Notes: This table runs regression of trade diversion effects on the exports growth rates to the U.S. in Mexico, using 258 industries-41 months panel. The first five columns use equation (1) with the dummy variable indicating output, upstream, downstream, all output, upstream and downstream, total, and net tariff increase during the trade tensions Column (7)-(12) use equation (1) with the dummy variable indicating if the tariff change is above the median level, in terms of the output, upstream, downstream, all output, upstream and downstream, total, and net tariff change. All twelve columns adopt static fixed effect panel model with industry and month fixed effect and clustered standard error at industry level.

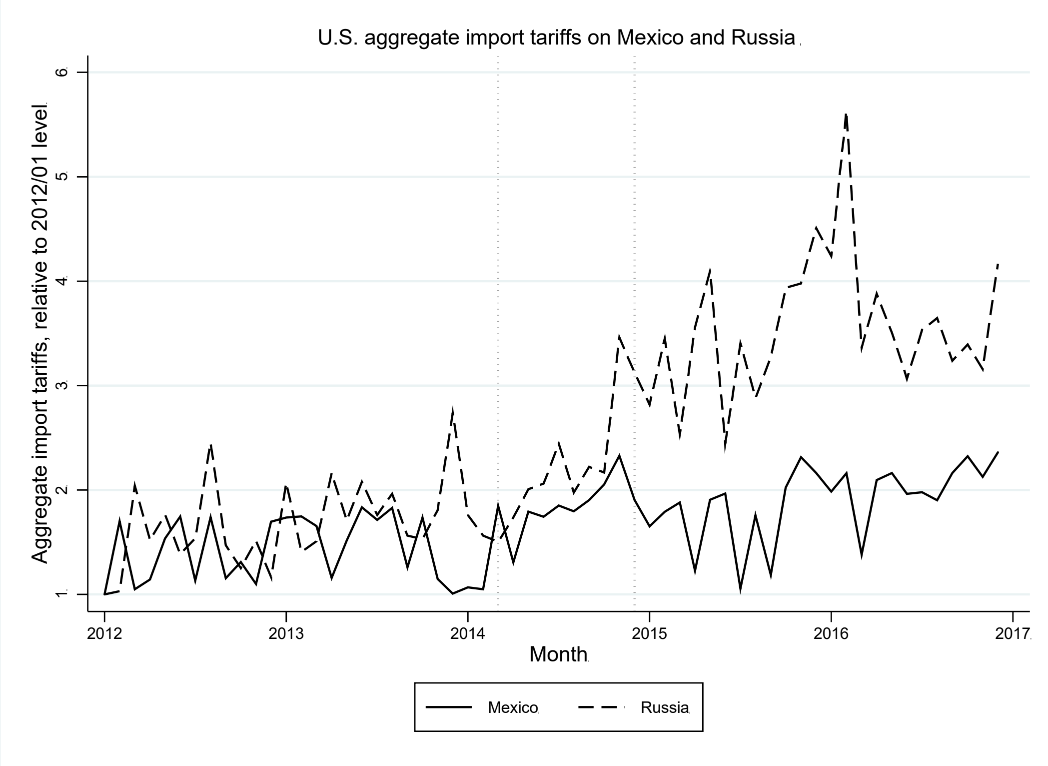
Table A4. Regression Results for Trade Diversion Effects, Growth Rate, Continuous Treatment

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES			$\Delta\tau$			
Output	0.010***			0.011***		
	(0.003)			(0.004)		
Up		0.004		-0.012		
		(0.004)		(0.008)		
Down			0.004	0.003		
			(0.003)	(0.006)		
Total					0.005***	
					(0.001)	
Net						0.008***
						(0.002)
L.lnusimports	-0.848***	-0.846***	-0.846***	-0.848***	-0.847***	-0.848***
	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)
Constant	5.722***	5.706***	5.706***	5.723***	5.714***	5.718***
	(0.478)	(0.480)	(0.480)	(0.477)	(0.480)	(0.479)
Ind. FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Obs.	10,320	10,320	10,320	10,320	10,320	10,320
R-squared	0.424	0.423	0.423	0.424	0.424	0.424
No. of ind.	258	258	258	258	258	258

Notes: This table runs regression of trade diversion effects on the exports growth rates to the U.S. in Mexico, using 258 industries-41 months panel. The first column uses equation (2) with size of increase in output tariff, the second column uses equation (2) with size of increase in upstream tariff, the third column uses equation (2) with size of increase in downstream tariff, the fourth column uses equation (3) with size of increase in all output, upstream, and downstream tariffs, the fifth column uses equation (2) with size of increase in total tariff, and the sixth column uses equation (2) with size of increase in net tariff. All six columns adopt static fixed effect panel model with industry and month fixed effect and clustered standard error at industry level.

Appendix IV. The U.S. Tariff Changes During 2012–16

Figure A5. U.S. Monthly Import Tariff on Mexico (solid) and Russia (dashed), Normalized



Notes: Source, USITC. This figure plots the monthly U.S. aggregate import tariffs on Mexico (solid) and Russia (dashed) during 2012–17. Tariffs are normalized to be one in January 2012.

PUBLICATIONS

Trade Diversion Effects from Global Tensions—Higher Than We Think

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